EFFECT OF IMPROVED MANAGEMENT PRACTICES ON FACTOR OF PRODUCTIVITY ON GROUNDNUT (*Arachis hypogaea* L.) CULTIVATION

M.Sc. (Ag.) Thesis

by

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DEPARTMENT OF AGROMOMY
COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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Thesis

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Basavaraj Baraker

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CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"** submitted in partial fulfillment of the requirements for the degree of "**Master of Science in Agriculture**" of the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) is a record of the bonafide research work carried out by **Mr. Basavaraj Baraker** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date: 27/06/2017

Dr. S.K.Jha
(Chairman of the Advisory Committee)

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CERTIFICATE - II

This is to certify that the thesis entitled **"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"** submitted by **Mr. Basavaraj Baraker** to Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **M.Sc. (Ag.)** in the Department of **Agronomy** has been approved by the external examiner and Student's Advisory Committee after an oral examination.

Signature External Examiner

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Date: 30/06/17

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Approved/Not approved

Director of Instructions ____________________

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Date: 27-06-2017

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%	Per cent
@	At the rate
°C	Degree Celsius
B:C	Benefit cost ratio
CD	Critical difference
cm	Centimeter
i.e.	That is
viz.	For example
cm^{-2}	Centimeter square
et al.	And others/ co-worker
No.	Number
day^{-1}	per day
ha^{-1}	Per hectare
m	Meter
m^{-2}	Per meter square
g	Gram
kg	Kilogram
q	Quintal
Fig.	Figure
NS	Non-Significant
S	Significant
P= 0.05	Probability at 5%
SEm±	Standard error of mean
₹	Rupees

LIST OF ABBREVIATIONS

max.	Maximum
min.	Minimum
BBF	Broad Bed and Furrow
FB	Flat Bed
DAS	Days after sowing
HI	Harvest index
N	Nitrogen
P	Phosphorus
K	Potash
S	Sulphur
Zn	Zinc
B	Boron
OC	Organic carbon

THESIS ABSTRACT

a)	Title of the Thesis	:	"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"
b)	Full Name of the Student	:	Basavaraj Baraker
c)	Major Subject	:	Agronomy
d)	Name and Address of the Major Advisor	:	Dr. S. K. Jha, Scientist, Department of Agronomy, College of Agriculture, IGKV, Raipur (C.G.)
e)	Degree to be awarded	:	Master of Science in Agriculture (Agronomy)

B.R. Barker
Signature of Student

Signature of Major Advisor

Date: 27-06-2017

Signature of Head of the Department

ABSTRACT

The present investigation entitled **"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"** was conducted at farmer's field *i.e.* in five location of the same village Hiregundgal, District: Tumkur (Karnataka) under the project of Bhoo Samruddhi collaboration between KSDA (Karnataka State Department of Agriculture) and ICRISAT (International Crop Research Institute for Semi-Arid Tropics Agriculture), Hyderabad during *kharif* season 2016. The soil of the experiment plots was sandy to sandy loam. Medium available nitrogen in three plots and two plots were recorded lower available nitrogen, phosphorus was medium at all plot except one plot, potassium was high in one plot and medium in remaining plots, relatively lower available sulphur recorded in all plots, zinc and boron were recorded relatively optimum. The experiment was laid out in factorial

randomized block design (FRBD) with control in five replications comprising eight treatment combination. Treatment combination consisting of three factor at two levels *viz.,* recommended dose of fertilizer and recommended dose of fertilizer + Micro nutrients in first factor, broad bed & furrow and flat bed in second factor and third factor consisting of variety ICGV 91114 and K 6. Farmer's practice as control treatment. Groundnut variety ICGV 91114 and K 6 were used as test crops. Sowing was done on August 07, 2016 harvesting was done on November 18, 2016.

Recommended dose of fertilizer (25:50:25 NPK+ Gypsum @ 500kg ha^{-1} at 30 DAS) + micro nutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1} at basal application) treatment (N_2) recorded the maximum growth parameters *viz.*, plant height, leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, relative growth rate as well as yield and yield attributing characters *viz.,* number of pods $plant^{-1}$, weight of pods $plant^{-1}$, pod yield, haulm yield and quality attributes of groundnut crop *viz.*, shelling percent, oil percent and oil yield.

Soil available nutrients *viz.*, available zinc and boron was recorded higher in soil at harvest and uptake of nutrients in haulm *viz.*, nitrogen, phosphorus, potassium, sulphur, zinc and boron was recorded maximum with recommended dose of fertilizer and application of micro nutrients *viz.*, $ZnSO_4$@ 25 kg ha^{-1} & Borax @ 10 kg ha^{-1} at basal application. Whereas, recommended dose of fertilizer (25:50:25 NPK+ Gypsum @ 500kg ha^{-1} at 30 DAS) treatment (N_1) recorded minimum value.

Broad bed and furrow (L_1) recorded higher growth parameters, yield & yield attributing characters and quality parameters. Similar result was also recorded in uptake of nutrients in haulm *viz.*, nitrogen, phosphorus, potassium, sulphur, zinc and boron. Soil moisture characteristics *viz.*, moisture at field capacity and permanent wilting point was higher in broad bae and furrow than flat bed (L_2).

Cultivated variety ICGV 91114 (V_1) recorded superior growth parameters *viz.*, plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, relative growth rate, yield and yield attributing characters *viz.*, number of pods $plant^{-1}$, weight of pods $plant^{-1}$, nodules $plant^{-1}$, pod yield, harvest index. Quality parameter was also superior in improved variety ICGV 91114 as compared to local variety K 6. Relatively higher uptake of nutrients in haulm *viz.*, nitrogen, phosphorus, potassium and boron was recorded in ICGV 91114 as compared to K 6.

Regarding economics, higher gross return, net return and benefit cost ratio were superior in recommended dose of fertilizer along with micro nutrient than recommended dose of fertilizer. Broad bed and furrow was superior over flat bed. Cultivated variety ICGV 91114 superior to cultivated variety K 6. Farmer's practice registered the lowest value in regards to growth parameters at all the observational stages, yield and yield attributes, quality parameters and nutrient status in soil and haulm as compared to other treatment combinations.

शोधग्रंथ सारांश

अ) शोधग्रंथ का शीर्षक	:	''मूगंफली की खेती पर उत्पादकता के कारक पर बेहतर प्रबंधन की प्रभावों का अध्ययन"
ब) विद्यार्थी का पूरा नाम	:	बसावराज बारकेर
स) प्रमुख विषय	:	सस्य विज्ञान
द) प्रमुख सलाहकार का नाम एवं पता	:	डॉ. एस के. झा, वैज्ञानिक सस्य विज्ञान विभाग, कृषि महाविद्यालय, इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर (छ.ग.)
ई) प्रदान की जाने वाली उपाधी	:	एम.एस.सी. (कृषि) सस्य विज्ञान

B.R. Barkes

विद्यार्थी के हस्ताक्षर

प्रमुख सलाहकार के हस्ताक्षर

दिनांकः 27-06-2017

विभागाध्यक्ष के हस्ताक्षर

सारांश

वर्तमान शोध शीर्षक ''मूगंफली की खेती पर उत्पादकता के कारक पर बेहतर प्रबंधन की प्रभावों का अध्ययन" किसान के खेत में आयोजित किया गया था। यह परीक्षण वर्ष 2016 के खरीफ मौसम में जिला–तुमकुर (कर्नाटक) में के. एस. डी. ए. (कर्नाटक राज्य कृषि विभाग) एवं आई. सी. आर. आई, एस. ए. टी. (अंतर्राष्टोय अर्ध उष्ण कटिबंधीय कृषि अनुसंधान संस्थान) के तत्वाधान में गांव हिरगडगल के पांच स्थानों में किया गया। प्रयोग प्रक्षेत्र की मृदा की बनावट रेतीली दोमट थी, नाट्रोजन तीन भूखण्डों में मध्यम और दो भूखण्डों में कम, स्फुर एक भूखण्डों को छोड़कर सभी भूखण्डो पर मध्यम एवं पोटाश की मात्रा एक भूखण्ड में उच्च और शेष में मध्यम, सभी भूखण्डो पर कम सल्फर, जस्ता एवं बोरान मध्यम दर्ज किया गया। इस प्रयोग को कमशः फेक्टोरियल आर. बी. डी. डिजाइन में किया गया था। प्रयोग में तीन कारक कमशः दो पोशक तत्व दो भूमि उपचार एवं दो किस्मों का अध्ययन किया गया। प्रथम कारक में मूगंफली के लिए उर्वरक की सिफारिश मात्रा एवं उर्वरक सिफारिश मात्रा के साथ सूक्ष्म पोषक तत्व लिया गया। दूसरे कारक में भूमि उपचार में चौड़ीं ऊची शेय्या के साथ नाली एवं सपाट भूमि को समाहित किया गया तीसरे कारक में मूंगफली की दो किस्म आई. सी. जी. व्ही. 91114 और के 6 का अध्ययन किया गया। साथ ही नियंत्रण के रूप में किसानों द्वारा मूंगफली उगाने की विधि को

लिया गया। इस प्रकार कुल आठ उपचार संयोजन के साथ किसानों की पद्धति का परीक्षण इस प्रयोग में किया गया ।

मूंगफली फसल की वृद्धि माप दंड जैसे फसल वृद्धि दर, सापेक्ष विकास दर, पौधे की उंचाई, कुल शुष्क पदार्थ, पत्ती क्षेत्र सूचकांक उपज एवं उपज को प्रभावित करने वाले कारक जैसे फली की संख्या प्रति पौध, फली का वजन, तेल की मात्रा, आदि मूंगफली के लिए सिफारिश खाद की मात्रा (25:50:25 एनपीके + जिप्सम 500 किग्रा. प्रति हेक्टे., बोआई के 30 दिन बाद) के साथ सूक्ष्म पाषक तत्वों (जिंकसल्फेट 25 किग्रा. प्रति हेक्टेयर एवं बोरेक्स 10 किग्रा. प्रति हेक्टेयर बुआई के समय) में केवल सिफारिश खाद की तुलना में अधिक पाई। इसी प्रकार कटाई के समय मृदा में नाइट्रोजन, स्फुर, पोटौशियम, सल्फर, जिंक एवं बोरान तत्व का ग्रहण केवल सिफारिश पोषक तत्व की तुलना में सिफारिश पोषक तत्व के साथ सूक्ष्म पोषक तत्व का प्रयोग में अधिक रहा।

भूमि उपचार क मामले में चौड़ी शैय्या के साथ नाली उपचार विधि में उपरोक्त उल्लेखित वृद्धि माप दण्ड उपज मिट्टी विशेषता जैसे एवं मिट्टी की नमी, पौधे द्वारा ग्रहण पोषक तत्व सपाट भूमि की तुलना में अधिक पाई गई।

मूगंफली की उन्न्त किस्म आई. सी. जी. व्ही. 91114 वृद्धि मापदण्ड उपज एवं उपज को प्रभावित करने वाले कारक के साथ ही मूगंफली की गुणवता मापदण्ड एवं पौधे द्वारा पोषक तत्व ग्रहण करने की क्षमता स्थानीय प्रचलित किस्म के 6 की तुलना में अधिक पाई गइ।

आर्थिक आधार पर शुद्ध सकल लाभ, शुद्ध लाभ, लाभ लागत अनुपात चौड़ी शय्या एवं नाली उपचार के साथ सिफारिश पोषक तत्व एवं सूक्ष्म पोषक तत्व का प्रयोग किस्म आई. सी. जी. व्ही. 91114 में अन्य उपचार के तुलना में अधिक दर्ज हुआ।

प्रयोग में किसानों द्वारा मूंगफली के खेत में अपनायी जा रही पुरानी तकनीक अन्य उपचार की तुलना में कमजोर पाई।

CHAPTER - I
INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume native to South America. It is one of the principal oilseed crop of tropical and sub-tropical regions of the world belongs to the family Leguminoceae. It is commonly called as poor man's almond, wonder nut and is also called as king of oilseeds. It is the world's fourth most important source of edible oil and third most important source of vegetable protein.

Groundnut seed contain about 50% edible oil. The remaining 50% of the seed has high quality protein (21.4 to 36.4%), carbohydrates (6.0 to 24.9%), minerals and vitamins. This contains 20%, saturated and 80% unsaturated fatty acids. Poly saturated fatty acids has 2 types *i.e.* oleic (40-50%) and linoleic (24-35%). It is also fairly rich in calcium, iron and vitamin B complex like thiamine, riboflavin, niacin and vitamin A. It has multifarious usages, it is not only used as major edible oil in the preparation of various food items but also utilized in the manufacturing of soap, cosmetics, shaving cream, lubricants, *etc*. It plays a pivotal role in the oil seed economy of India. Kernels are also being used as processed foods like sweets and dry powered. Groundnut haulms and oil cake are used as either cattle feed or organic manure. The shells of groundnut are also utilized as fuel in boilers and as filler material in many organic and biological products like activated charcoal, cork substitutes and hard boards. Being a legume, groundnut plant symbiotically fixes atmospheric nitrogen and improves the soil fertility status.

The average annual production of groundnut across the world accounts for 33 million tonnes from an area of 24.7 million hectares. Asia accounts for 58 per cent of the global groundnut area and 67 per cent of the groundnut production. In India groundnut occupies an area of 52.50 lakh hectares with production of 97.14 lakh tones in 2014-2015. Major groundnut growing states are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra which accounts for 80 per cent of the total area and production. Karnataka stands fourth in an area of 7.25 lakh hectares with an annual production of 6.58 lakh tonnes and average productivity of 908 kg ha^{-1} (Gracy *et al*., 2013). In India the cultivation of groundnut is mainly confined to marginal and less fertile soil, even though it is an energy rich crop. Therefore, the nutritional requirements of this crop cannot be met under such situation. However, it is grown with irrigation and suitable chemical fertilizers in limited area.

About 88 per cent of groundnut area in India is sown in the *Kharif* season and under rainfed condition. Water is the most vital resource in crop production especially in arid and semi-arid regions. Groundnut is grown on several types of soils ranging from *Vertisols, Alfisols* to sandy soils of various fertility levels under rainfed conditions. Rain water conservation is a critical factor in stabilizing and stepping up of rainfed groundnut production. A tillage practice like sub soiling and land configuration like broad bed and furrow method of cultivation provides favorable conditions such as loose and porous seed bed, better aeration, microbial activity and good drainage for the better growth and finally results in higher pod as well as haulm yield. It was observed that the traditional methods of land treatments were of little advantage for *in situ* moisture conservation for dry land agriculture. Different land treatment practices have been developed for increasing *in situ* moisture conservation for dry land soils of India.

The raised beds should be 1.5 m wide and 15 cm high and with two furrows of 30 cm width on either side to drain out excess of water. This width of the raised bed will accommodate 4 rows of groundnut at 30 cm distance between rows. The broad bed and furrow system needs a graded slope of land, 0.8 to 2.0% and it is formed across the slope. The furrows should lead to a main drain at the end of the field. The advantages of this system is crop in raised bed showed excellent root growth and nodulation, vigorous plant growth and greener foliage than the flat bed. Raising of groundnut on broad beds reduces weed problem. Crops on BBF are more amenable for manual harvesting with fewer pods left in ground while pulling out. This system is recommended for all soils particularly for clayey soils in high rainfall areas.

India's resounding success from its past green revolution has been followed by stagnating or declining agricultural productivity, even with increased total fertilizer use in the country over the years. This declining factor productivity is largely due to imbalanced fertilizer use. Fertilizers application is highly skewed in favour of N, with relatively small use of K and P application, and rare use of secondary and micronutrients. Current generalized fertilizer recommendations are also sub-optimal and need upward refinement. So this concept of soil test based balanced nutrient application helps in getting good crop yields.

Sulphur as a plant nutrient is becoming increasingly important in dry land agriculture as it is the master nutrient of all oilseed crops and pulses and is rightly being called the “Forth Major Nutrient”. Among the field crops, oilseeds and pulses are more responsive to sulphur. The sulphur is one of the essential nutrient elements plays an important role in carbohydrate metabolism and formation of chlorophyll, glycosides, oils and many other compounds that are involved in N-fixation and photosynthesis of plants. Its nutrition to crops is vital both from quality and quantity point of view. It lowers the HCN content of certain crops, promotes nodulation in legumes and produces heavier grains of oilseeds.

Calcium is by far the most important nutrient for pod development. The crop has a very high calcium requirement; about 90% calcium is absorbed during flowering and pod formation and development. The required calcium for pod and seed development must be absorbed by the gynophores (peg) and developing pods via passive uptake through diffusion. Calcium absorbed from roots and stored in leaves cannot be moved into pods. Therefore, large quantities of calcium are required in the pod zone for direct absorption by pegs and pods. This requires continuous replenishment of calcium in the pod zone. Lack of calcium leads to unfilled pods, small pods, and high incidence of pod rot. It is recommended that calcium be supplied to groundnut cultures during flowering as top dressing with gypsum. Gypsum is easily soluble in water and should be applied at the time of flowering and incorporated into the soil in the pod zone.

Boron deficiency is a common problem for groundnut production, especially on highly weathered sandy soils. When grown in such soils it is highly advisable to apply. Boron deficiency in groundnuts is often associated with fruit damage and has been termed as ‘hallow heart’. It reduces the quality of the pod and the value of the crop. Severe boron deficiency can result in split stems and roots, shortened internodes, terminal death, and extensive secondary branching.

Now days zinc is virtually an all India problem. Zinc application increases the nodule number in nut and nodule weight. The crop yield is reduced by about half when the zinc level in the level in the soil is lower than 1.2 mg kg^{-1}. So, trace elements should be included with recommended dose of fertilizers for providing balanced nutrition to the plants which not only helps to augment the production but also to sustain the productivity of oilseed crop. But there is very little information in this regard.

Improved new varieties having advantage over traditional varieties. Replacement of traditional variety with improved cultivar is very important in respect to pod yield, haulm yield and oil yield in groundnut crop. Therefore, evaluations of improved varieties with other management practices are crucial for farmer's point of view.

Factor of productivity like balanced nutrients on the basis of soil test, land configuration and varieties of groundnut are key factor to obtain good yield, quality of kernel and haulm. Keeping the above factors in view the present experiment **"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"** is being taken up with the following objectives.

1. To compare the performance of BBF with flat landform on groundnut yield as well as soil properties in farmer's fields.
2. To study the interaction of landform treatments and soil test based balanced nutrient management recommendation on groundnut yield, nutrient uptake and quality of kernel and haulm.
3. To study the economic returns of improved management and farmer's practice of flat sowing with recommended NPK dose with improved BBF along with soil test based balanced nutrient recommendations.

CHAPTER - II

REVIEW OF LITERATURE

A brief review of literature pertaining to present investigation on "Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation" is reviewed in this chapter and presented under the following sub heads. Some references from legumes, oilseed, pulses, cereals and tuber crops have also been provided where ever necessary due to lack of literature pertaining to groundnut.

2.1 To compare the performance of broad bed and furrow with flat landform on groundnut yield as well as soil properties in farmer's fields.

2.1.1 Yield and its attributes

2.1.2 Soil properties

2.2 To study the interaction of landform treatments and soil test based balanced nutrient management recommendation on groundnut yield, nutrient uptake and quality of kernel and haulm

2.2.1 Study landform treatments on groundnut yield, nutrient uptake and quality of kernel and haulm.

2.2.2 Soil test based balanced nutrient management recommendation on groundnut yield, nutrient uptake and quality of kernel and haulm.

2.2.3 Interaction

2.3 To study the economic returns of improved management and farmer's practice of flat sowing with recommended dose of fertilizer (N, P, K) with improved broad bed and furrow along with soil test based balanced nutrient recommendations.

2.3.1 Economics of broad bed and furrow

2.3.2 Economics of balanced fertilization

2.1 To compare the performance of broad bed and furrow with flat land form on groundnut yield as well as soil properties in farmer's fields.

2.1.1 Yield and its attributes

Patil (1989) revealed that cultivation of groundnut on broad beds were markedly increased the number of effective pegs per hill and gave pod yields of 4.05 t ha^{-1} compared with 2.19 t ha^{-1} in flat bed system and 4.8 t ha^{-1} in broad bed and furrow system.

Anders *et al*. (1992) reported plant population, dry pod weight, fresh pod, fresh fodder and dry fodder weights of groundnut were significantly higher in the flat land treatment compared to broad bed and furrow.

Desai and Kenjale (1992) noticed sowing of groundnut in ridges and furrows produced greater dry pod yield (2.75 t ha^{-1}) than in borders (2.31 t ha^{-1}) and broad bed and furrow (2.17 t ha^{-1}).

Bhoi *et al*. (1993) noticed sowing groundnuts in a flat bed and 60, 90 and 120 cm broad bed and furrows produced pod yields of 1.47, 1.93, 1.94 and 1.59 t ha^{-1}, respectively.

Nalawade and More (1993) reported in BBF, narrow beds and furrows (NBF) and flat beds without furrows (FBWF) gave pod yields of 1.33, 1.25 and 1.11 t ha^{-1}, respectively in groundnut crop.

Bheemappa *et al*. (1994) reported the broad bed and furrow method in groundnut was found to give an increased pod yield of 290 kg ha^{-1} over flat bed method of cultivation.

Patra *et al*. (1995) reported sowing of groundnut in flat beds with earthing-up recorded the highest yields (2497 kg pod, 1738 kg kernel and 840 kg oil ha^{-1}) in *Kharif* but the broad bed and furrow method recorded the highest yields (2660 kg pod, 1851 kg kernel and 896 kg oil ha^{-1}) in summer.

Vairavan and Sankaran (1996) pod yield of groundnut was highest with sowing in ridges and furrows against broad beds and furrows and basins.

Patra *et al*. (1996) reported in two groundnut cultivars were grown on flat beds, earthed up flat beds and broad beds and furrows. Pod yields in the seedbed preparation treatments were 2.33, 2.51 and 2.66 t ha^{-1}, respectively.

Shelke *et al*. (1997) revealed groundnut grown on broad bed furrow (BBF) and flat bed pod yields were not affected by seedbed preparation.

Ingole *et al*. (1998) reported sowing groundnuts in broad bed furrows gave 37.8% higher pod yield than the traditional practice.

Chavan *et al*. (1999) revealed sowing on broad beds and furrows gave higher yield than ridges and furrows, or flat bed sowing in groundnut crop.

Kadam *et al*. (2000) reported broad beds and furrows recorded the highest total dry matter per plant, leaf area per plant, mature pods per plant, protein content, dry pod (46.4 q ha^{-1}) and haulm (86.3 q ha^{-1}) yields over border method and ridges & furrows methods in groundnut crop.

Nalawade and Patil (2000) reported poly mulching on broad beds and furrows increased pod yield over flat beds and broad bed furrows (BBF) in groundnut crop.

Samui and Ambhore (2000) reported pod yield on flat beds was 1351 and 2038 kg ha^{-1} without and with mulching, respectively, while corresponding yields on broad beds and furrows were 1518 and 2136 kg ha^{-1} in groundnut crop.

Sanjeev Kumar and Shivani (2001) reported at Manipur, the highest groundnut pod yield was found in flat bed system with poly mulch (2181 kg ha^{-1}), and the lowest was in ridge and furrow system without poly mulch (433 kg ha^{-1}). In Sikkim, the highest pod yield was found in broad bed and furrow system with poly mulch (1882 kg ha^{-1}), and the lowest was in flat bed system without poly mulch (569 kg ha^{-1}).

Subrahmaniyan (2003) noticed the treatment broad bed and furrow + polyethylene mulch resulted in the maximum values for the yield attributes and a pod yield of 2239 kg ha^{-1}, which was 31.8% higher than the yield under normal flat sowing conditions in groundnut crop.

Ashok Kumar and Rana (2004) reported yield and quality of groundnut in broad bed + furrow method of planting produced better performance compared to flat bed planting.

Subrahmaniyan and Kalaiselvan (2006) studied the performance of groundnut under two land configuration systems (broad bed and furrow and flat bed). Results revealed that flat bed system registered significantly higher number of matured pods per plant and pod yield (3067 kg ha^{-1}) compared to broad bed and furrows (2397 kg ha^{-1}).

Patil *et al*. (2007) reported in groundnut dry pod yield and haulm yield were also significantly best in the broad bed and furrow, followed by the ridge and furrow with 30×10 cm spacing and flat system. Growing groundnut on the broad bed and furrow at 30×10 cm spacing was found beneficial proposition for achieving higher productivity.

Vaghasia *et al*. (2007) reported that in groundnut crop between-row subsoiling and broad bed and furrow also increased root volume, plant height and dry matter $plant^{-1}$ and resultantly produced significantly higher pod and haulm yields over flat bed in both the years and pooled results on an average, between-row subsoiling and broad bed and furrow increased pod yield by 22.8 and 20.4% and haulm yield by 21.3 and 19.1% over flat bed respectively.

Dhadage *et al*. (2008) reported broad bed and furrow (BBF) produced significantly higher dry pod (2763 kg ha^{-1}), dry haulm (7485 kg ha^{-1}) and kernel yield (1739 kg ha^{-1}) than flat bed (FB) and ridges furrow (RF) layouts in groundnut crop.

Vaghasia *et al*. (2008) noticed between-row subsoiling and broad bed and furrow were statistically equivalent and resulted in significantly higher pod yield of 17.5 and 17.1 q ha^{-1} and haulm yield of 27.9 and 27.4 q ha^{-1}, respectively over flat bed (14.2 and 23.0 q ha^{-1}) in groundnut crop.

Kathmale *et al*. (2009 a) reported yield of groundnut over flat bed (FB) and broad bed furrow (BBF) mean dry pod yield of 5150 and 5280 kg ha^{-1}, dry haulm yield of 5790 and 5670 kg ha^{-1}, kernel yield of 3830 and 3920 kg ha^{-1} and oil yield of 1870 and 1920 kg ha^{-1} was recorded under flat bed and broad bed and furrow, respectively.

Kathmale *et al*. (2009 b) reveled polythene mulched *Rabi* groundnut gave equal pod and haulm yield on both the seed beds, *i.e.* flat bed and broad bed and furrow.

Shrinivasraju (2012) noticed maximum pod yields of groundnut ICG (FDRS) 10 and ICGS-11 varieties were observed in broad bed and furrow and it was more by 11.9 at 20.5 per cent than with ridges and flat bed systems, respectively.

Vekariya *et al*. (2015) revealed pooled results revealed significantly highest pod (932 kg ha^{-1}) and haulm (3234 kg ha^{-1}) yield under the broad bed (90 cm width) and furrow (45 cm) as compared to flat bed control of groundnut crop.

Sinare *et al*. (2016) reported broad bed and furrow + polythene mulch recorded significantly higher dry pod and haulm yield in groundnut.

Paulpandi *et al*. (2008) reported the broad bed and furrow method in sunflower crop resulted in higher head diameter (14.5 cm), increased number of filled seeds $head^{-1}$ (428), seed yield (983 kg ha^{-1}) and stalk yield (3388 kg ha^{-1}) over compartmental bunding and flat bed methods.

Let *et al*. (2014) reported in sunflower crop among the treatments broad bed and furrow recorded higher number of filled seeds $head^{-1}$ (913) over flat bed sowing at 60 cm x 30 cm (771), ridge and furrow sowing at 60 cm x 30 cm (785) and flat bed with paired row planting at 45 cm x 40 cm (897). Stalk yield and total dry matter was higher in broad bed and furrow as compared with other treatment.

Tomar (2005) reported grain yield, straw yield of soybean was higher in case of broad bed and furrow as compared to flat planting and tide ridge and furrow but lower as compared with ridge and furrow method of planting.

Hati *et al*. (2008) revealed that the grain yield of soybean in sole soybean, soybean/maize intercropping and soybean/pigeon pea intercropping systems under broad bed and furrow was greater than that under flat on grade for every year of the experimentation. On an average over four years, broad bed and furrow registered 12.7-18.0% greater grain yield of soybean than flat on grade under sole soybean. Grain yield of maize in sole maize treatment under broad bed and furrow was 11.8-16.0% greater than the same treatment under flat on grade land configuration. In soybean/maize and maize/pigeon pea intercropping systems, grain yield of maize was also greater inbroad bed and furrow than flat on grade.

Paliwal *et al*. (2011) reported in soybean and wheat sequence cropping yield attributing characters like pods plant^{-1}, seeds pod^{-1}, seed index and seed yield of soybean showed remarkable improvement by adopting changed land configuration over flat bed planting.

Singh *et al*. (2013) reported that there was an increase in yield of soybean to the extent of 14–25% (average being 19%) in broad bed and furrow over normal planting on flat land.

Jha and Monika Soni (2013) reported the yields of soybean crop was also highest in broad bed and furrow sowing method and lowest in flat bed sowing method (1.04 and 1.24 t ha^{-1}).

Kantwa *et al*. (2005) reported that pigeon pea planted in broad-bed and furrow system and post-monsoon irrigation based on 0.4 IW:CPE ratio produced significantly taller plants with more number of pods plant^{-1} and seeds pod^{-1} over flat planted and unirrigated pigeon pea.

Nadaf (2013) reported that broad bed and furrow (BBF) method of soil moisture conservation recorded significantly higher seed yield in pigeon pea (1322 kg ha^{-1}) compared to farmer's practice (1147 kg ha^{-1}).

Shivran *et al.* (2016) reported among the various land configuration systems broad bed and furrow + one row of linseed as intercrop produced significantly higher chickpea equivalent yield (2,098 kg ha^{-1}) followed by broad bed furrow (1,907 kg ha^{-1}), ridge furrow (1,863 kg ha^{-1}) and flat bed (1,636 kg ha^{-1}).

Wani *et al*.(2015c) reported in maize, chickpea, soybean-sorghum, groundnut-wheat and maize-pigeon pea cropping systems among the three land management *i.e.* Broad bed and furrow (BBF), conservation furrow (CF) and farmers' practice (FP) systems broad bed and furrow consistently recorded higher crop yields.

Suresh and Jawahar (2008) revealed that the reduced tillage combined with broad bed and furrow system and $ZnSO_4$ @ 25 kg ha^{-1} along with cow pea green manure incorporation recorded in cotton the highest plant height (53.8 cm), number of branches plant^{-1} (11.6), number of bolls plant^{-1} (7.7), number of squares plant^{-1} (6.1) and seed cotton yield (754 kg ha^{-1}) against conventional tillage, reduced tillage (RT)+ broad bed and furrow (BBF)+ green manure (GM) and conventional tillage (CT)+ broad bed and furrow system (BBF).

2.1.2 Soil properties

Vaghasia *et al*. (2007) reported that significantly higher moisture content in soil at 60 DAS was retained under between row-subsoiling and broad bed and furrow as compared to flat bed. While the residual availability of nutrients *viz.,* N, P, K and S remained almost equal under various moisture conservation treatments of groundnut.

Shrinivas raju (2012) reported the total porosity of soil in broad bed and furrow was higher by 4.0 and 8.3 per cent than the ridges and flat beds, respectively in the treatments of groundnut.

Kevizhalhou *et al*. (2014) noticed in the broad bed and furrow and raised bed land configurations along with residue and hedge leaves mulching under no tillage. Improved soil quality and was the most suitable for higher returns of groundnut-rapeseed system under rainfed mid-hills condition.

Vekariya *et al*. (2015) noticed higher mean soil moisture content (25.87% and 26.25%) was recorded under the both soil depths 0-15 cm and 15-30 cm, respectively under the broad bed (90 cm width) and furrow (45 cm) with 3 rows, while lowest (24.24% and 24.87%) were recorded in the flat bed control of groundnut treatments.

Devi *et al.* (1990) reported that broad bed and furrow resulted in larger moisture storage than the other tillage treatments. The residually available nitrogen content after the crop’s harvest was greatest in broad bed and furrow against deep tillage, dead furrows, ridge and furrow and flat bed in castor crop treatment.

Mathukia *et al.* (2009) reported in castor crop treatments, the highest values of soil porosity and moisture content, were obtained with in-row subsoiling and broad bed and furrow systems over flat bed system.

Paulpandi *et al*. (2008) reported among in situ moisture conservation methods, at 45 cm soil depth, broad bed and furrow method registered higher soil moisture content of 34.2, 23.1, 16.3 and 15.1 per cent at 25, 45, 65 DAS and at harvest in sunflower crop treatments.

Khambalkar *et al.* (2010) reported the sowing of safflower on broad bed and furrow resulted in conservation of moisture in soil which was observed to be 9.61 per cent more as compared to traditional method of sowing.

Tumbare and Bhoite (2000) revealed that, all the growth and yield contributing characters of chickpea were found maximum with broad bed and furrow (BBF), ridges-and-furrow (RF) moisture conservation techniques compared to border strip, compartment sowing and flat sowing due to more moisture availability in the soil during critical growth stages of crop.

Nadaf (2013) reported that broad bed and furrow (BBF) method of soil moisture conservation recorded significantly higher moisture content in 45-60 cm soil profile at all the growth stages of the pigeon pea compared to flat bed.

Venkateswarlu *et al.* (1986) evaluated two land configurations; broad bed and furrow and ridges and furrow (RF) in production of pearl millet and castor on shallow red soils of semi-arid tropics. The RF was best for pearl millet and broad bed and furrow for castor in terms soil moisture depletion.

Rathod *et al*. (2004) reported in crop gatton panic (*Panicum maximum*) treatments, soil properties like pH, EC (Electrical conductivity), ESP (Exchangeable Sodium Percentage) and bulk density were improved significantly in land configuration treatments as compared to control, whereas fertility status of the soil in respect to organic matter, total nitrogen, available phosphorus and potassium were significantly increased.

2.2 To study the interaction of landform treatments and soil test based balanced nutrient management recommendation on groundnut yield, nutrient uptake and quality of kernel and haulm.

2.2.1 Effect of landform treatment son groundnut yield, nutrient uptake and quality of kernel and haulm.

Nalawade and More (1993) reported in groundnut seed N, P, K, Ca and S contents were highest with the broad bed and furrow system and in cv. PBN-G-6.

Patra *et al.* (1995) reported sowing of groundnut in flat beds with earthing-up recorded the highest yields (2497 kg pod, 1738 kg kernel and 840 kg oil ha^{-1}) in *Kharif* but the broad bed and furrow method recorded the highest yields (2660 kg pod, 1851 kg kernel and 896 kg oil ha^{-1}) in summer.

Kadam *et al.* (2000) Compared with the other layouts, broad bed and furrow recorded the highest total dry matter plant^{-1}, leaf area plant^{-1}, mature pods plant^{-1}, protein content, dry pod (46.4 q ha^{-1}) and haulm (86.3 q ha^{-1}) yields in groundnut.

Nalawade *et al*. (2000) reported poly mulching on broad bed and furrow increased soil temperature by 3-4%, consequently increasing pod yield, and improved harvest index and oil content of groundnut.

Patil *et al.* (2007) reported in groundnut the plant growth in terms of plant height, spread, branch number and total dry matter production were maximum in the broad bed and furrow, followed by the ridge and furrow. Similarly, the protein content, hundred seed weight, kernel, oil and protein yields were all significantly highest with the broad bed and furrow layout. The yield-contributing characters such as pod weight, kernel weight, and kernel number plant^{-1}, total pod number plant^{-1}, shelling percentage, dry pod yield and haulm yield were also significantly best in the broad bed and furrow, followed by the ridge and furrow with 30×10 cm spacing. Growing groundnut on the broad bed and furrow at 30×10 cm spacing was found beneficial proposition for achieving higher productivity.

Vaghasia (2007) reported in groundnut crop between row sub-soiling and broad bed and furrow significantly increased pod and haulm yields, and resulted in higher protein and N contents compared to the flat bed control. P, K and S content in haulm were significantly less under between-row subsoiling and broad bed and furrow compared to flat bed, while the haulm N content, pod and haulm P contents, and pod K and S contents were unaffected by the moisture treatments. N, P and K uptake by pod and haulm was higher under between row subsoiling than flat bed.

Kathmale *et al*. (2009) noticed polythene mulched *Rabi* groundnut gave equal pod and haulm yields on both the seed beds *viz.*, flat bed and broad bed furrow (BBF). Mean dry pod yield of 5150 and 5280 kg ha^{-1}, dry haulm yield of 5790 and 5670 kg ha^{-1}, kernel yield of 3830 and 3920 kg ha^{-1} and oil yield of 1870 and 1920 kg ha^{-1} was recorded under flat bed and broad bed and furrow, respectively.

Mane *et al*. (2010) noticed the effect of different mulching treatment on broad bed and furrow also significantly influenced. Application of polythene mulch on broad bed and furrow contributed the highest values of N, P and K uptake in pod, haulm and total uptake and these effects were significantly superior with dry pod yield (33.57 q ha^{-1}) and haulm yield (80.12 q ha^{-1}) over BBF with no mulch (19.84 q ha^{-1} and 58.48 q ha^{-1}) and broad bed and furrow with glyricidia mulch (26.31 q ha^{-1} and 73.27 q ha^{-1}) respectively in groundnut.

Mathukia and Khanpara (2009) revealed in castor reported the broad bed and furrow and in row subsoiling significantly increased the seed and stalk yields, along with higher oil content and oil yield, over the flat bed control. The broad bed and furrow and, in row subsoiling significantly reduced the P content of seed and stalk as well as K content of stalk, while increased the uptake of N by seed and Zn uptake by stalk over the flat bed.

Patil *et al.* (2012) noticed in linseed reported as in case of quality parameters like oil content was not influenced by any treatment but oil yield was recorded maximum in treatment broad bed and furrow which was at par with furrow in every row and furrow after two rows.

2.2.2 Soil test based balanced nutrient management recommendation on groundnut yield, nutrient uptake and quality of kernel and haulm.

Ghosh *et al.* (2002) reported the present status of plant nutrient use and future needs in oilseed crops (*viz.,* groundnut, rapeseed and mustard, soybean, sesame, sunflower, safflower, niger, linseed and castor) which includes nutrient uptake and responses to applied nutrients, are discussed. Balanced nutrition is also an important factor that affects the efficiency of applied nutrients in improving oilseed productivity and quality.

Sharma *et al.* (2011) revealed that application of 100% N, P, K, S and Zn significantly enhanced the pod and haulm yields of groundnut by 25.9 and 22.4 per cent over 100 % N, P and K, 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.

Ganesh *et al.* (2015) reported in the groundnut crop yield and yield attributing characters *i.e.* pods plant^{-1}, shelling per cent (%), 100-kernel weight, pod yield (kg ha^{-1}), haulm yield (kg ha^{-1}), oil content (%) and harvest index were recorded maximum at harvest under the combined application of RDF + Mo + Zn + Rhizobium + PSB. Significantly the lowest values of these yield attributing characters were observed in control.

Narh and Naab (2015) revealed in groundnut the results from the study showed that nutrient application had a positive effect on nutrient concentration, nutrient uptake, pod yield, seed yield and total biomass. The P, K + gypsum + Zn treatment had the highest pod yield, seed yield and total biomass. Increases in pod yield of the fertilized treatments ranged between 16.6 per cent and 47.8 per cent over the control. Where micronutrients were combined, some antagonism between micronutrients was also observed. Application of the macronutrients P and K and the micronutrient Zn had the greatest impact on yield.

Chaplot and Ameta (2014) reported the application of balanced fertilization involving nutrient combinations N, P, K, S and Zn (60 kg N+40 kg P_2O_5+40 kg K_2O+40 kg S+5 kg Zn ha^{-1}) significantly increased growth and yield attributes thereby producing highest seed yield (2093 kg ha^{-1}) which was significantly higher by 22.8 and 11.7% over N, P, K and N, P, K and Zn respectively. The balanced fertilization N, P, K and S was found next in order in mustard crop.

Kumar *et al.* (2016) reported among different balanced nutrient treatments; recommended dose of nitrogen and phosphorous for both the crops, i.e. 120 kg N + 60 kg P ha^{-1} for pearl millet and 80 kg N + 30 kg P ha^{-1} for mustard along with 5.0 tonnes FYM ha^{-1} + 20 kg K_2O ha^{-1} + 200 kg gypsum +10 kg $ZnSO_4$ ha^{-1} + 10 kg Fe SO_4 ha^{-1} produced maximum pearl millet grain yield (3.91 t ha^{-1}) and mustard seed yield (2.31 t ha^{-1}), The quality traits; protein content in pearl millet, oil content and oil yield were also found superior in this treatment than all other combinations of balanced fertilizers with and without 5.0 tonnes FYM ha^{-1}.

Sharma and Jain (2012) revealed that application of 100% N, P, K, S and Zn significantly enhanced the seed and straw yields of cluster bean by 29.5 and 29.6 per cent over 100% N, P and K respectively. This treatment also recorded significantly higher concentrations and uptake of N, P, K, S and Zn as well as improved the soil fertility status.

Ramachandrappa *et al*. (2014) reported in finger millet application of Ca, Mg and B along with major nutrients (recommended dose of N and K_2O + borax at 10 kg ha^{-1}, and recommended dose of N and K_2O + lime at 300 kg ha^{-1} + $MgCO_3$ at 150 kg ha^{-1} + borax at 10 kg ha^{-1}) showed improvement in soil fertility status. Higher uptake response, nutrient use efficiency and nutrient recovery was also observed in the same treatment.

2.2.3 Interaction

Ingole *et al*. (1998) reported sowing groundnuts cv. SB XI in broad bed furrows gave 37.8% higher pod yield than the traditional practice. The application of 5 kg N + P_2O_5 ha^{-1} gave higher pod yield than the application of 25 kg N + 50 kg P_2O_5 (2.99 vs. 2.87 t ha^{-1}). The application of 10 kg zinc sulphate and 400 kg gypsum gave pod yields of 2.89 and 3.03 t ha^{-1}, respectively compared with 3.13 t obtained with the combined application of zinc sulphate and gypsum and the control yield of 2.67 t. The application of zinc sulphate and gypsum also increased seed oil and protein contents.

Wani *et al*. (2014) reported landform management to alleviate water logging proved effective intervention to manage high clay *Vertisols* for higher soybean and groundnut productivity by 13 to 27% (340 to 350 kg ha^{-1}in soybean and 160 to 250 kg ha^{-1}in groundnut) over the farmer's practice. However, the integrated approach of balanced nutrition and landform management plus improved cultivar was the best option in increasing sunflower productivity by 182% (1600 kg ha^{-1}in sunflower) over farmer's management. Adoption of these soil-water-crop interventions in target watersheds abridged yield gaps by 12 to 96% in groundnut (160 to 1280 kg ha^{-1}), 29 to 100% (240 to1130 kg ha^{-1}) in pigeon pea and 0 to 100% (0 to 1175 kg ha^{-1}) in chickpea.

Wani *et al*. (2015 b) reported in finger millet higher yields can be achieved with landform treatment and mulching operations. The effect of applying micronutrients to the traditional variety was also studied. The average yield from various field trials obtained was 2556 kg ha^{-1}, 63% higher than the traditional variety. Net income under the improved management conditions was nearly ₹ 27000 ha^{-1} compared to ₹ 8000 ha^{-1} under traditionally managed cultivation.

2.3. To study the economic returns of improved management and farmer's practice of flat sowing with recommended dose of fertilizer (N, P and K) with improved broad bed and furrow along with soil test based balanced nutrient recommendations.

2.3.1 Economics of broad bed and furrow

Bheemappa *et al*. (1993) noticed in groundnut crop 66.7% increase in the benefit: cost ratio in broad bed and furrow as compared to flat sowing.

Kathmale *et al*. (2000) reported in groundnuts cv. ICGS 11 were grown without mulching, with straw and polyethylene mulch on flat beds and broad beds and furrows. The net returns were greater with the broad bed and furrow system.

Baskaran *et al*. (2003) reported the broad bed and furrow system in groundnut recorded the maximum monetary return (₹ 18,154 and ₹ 18.829) and benefit: cost (B:C) ratio (1.73 and 1.77) in 1998 and 1999, respectively over farmer's practice.

Umesha (2004) reported that under broad bed with polythene mulched groundnut maximum gross returns and net returns were recorded. However, maximum benefit cost ratio was recorded under broad bed with groundnut shell mulching over others.

Dhadage *et al*. (2008) reported maximum gross monitory returns and highest B:C ratio (2.94) was obtained when groundnut planted in broad bed and furrow than flat bed (FB) and ridges furrow (RF) layouts in groundnut.

Vekariya *et al*. (2015) The broad bed (90 cm width) and furrow (45 cm) with 3 rows in groundnut crop gave the highest net returns of ₹ 23,662 ha^{-1} with the benefit: cost ratio of 2.69 over flat bed (45 cm row spacing), broad bed (60 cm width) and furrow (30 cm) with 2 rows, broad bed (120 cm width) and furrow (60 cm) with 4 rows.

Sinare *et al*. (2016) reported the gross monetary returns, net monetary returns and B:C ratio were significantly higher in the groundnut treatment of broad bed furrow+ polythene mulch over flat bed and broad bed & furrow (BBF) in groundnut.

Jadhav *et al*. (2011) reported in soybean significantly higher gross monetary returns, net monetary returns was found in broad bed and furrow, higher B:C ratio was also recorded in broad bed furrow method over flat bed, ridges and furrow, flat bed + opening of furrow after every two rows at 30 das, flat bed + opening of furrow after every 5 rows at 30 DAS and conventional / farmer's practice.

Hari Ram *et al*. (2011) revealed the highest net returns and B:C ratio recorded in raised bed sowing which were significantly higher than flat bed and ridge furrow methods of planting in the treatment of soybean.

Jha and Soni (2013) reported the broad bed and furrow sowing method of soybean gave maximum net monetary returns and B: C ratio (₹ 16,584 $ha^{-1}$and 1.87, respectively), against flat bed and ridge and furrow.

Paulpandi *et al.,* (2008) noticed higher net return and benefit cost ratio (₹ 4,827 and 1.74, respectively) were obtained inbroad bed and furrow method compared to compartmental bunding (₹ 4,163 and 1.58, respectively) and flat bed (₹ 2850 and 1.43, respectively) in sunflower .

Let *et al*. (2014) revealed among the treatment combination flat bed and paired row sowing recorded higher B:C ratio (2.6) over Flat bed, ridge & furrow and broad bed and furrow with paired row in sunflower.

Pramod Kumar *et al*. (2012) noticed planting systems in two year brought about considerable variation in net returns and B:C ratio. Maximum net returns (₹ 20 and ₹ 23.5 thousands ha^{-1}) and B:C ratio (2.0 and 2.3) were recorded with broad-bed and furrow planting system closely followed by paired row planting of pigeon pea + mung bean intercropping system.

Pramod Kumar *et al*. (2013) noticed net returns and B:C ratios were recorded with broad bed and furrow planting and lowest in uniform row planting of sole and inter cropped pigeon pea crop.

Nadaf *et al*. (2015) reported the broad bed and furrow given higher gross returns, net returns and B: C ratio compared to farmer's practice (flat bed) treatments of pigeon pea crop.

Chourasiya *et al*. (2016) noticed ridge-furrow method resulted in significantly higher gross monetary returns (₹ 74,794 ha^{-1}), net monetary returns (₹ 43,991 ha^{-1}) and benefit: cost ratio (2.40) over flatbed and broad bed furrow, in chickpea crop treatments.

2.3.2 Economics of balanced fertilization

Wani *et al*. (2014) revealed soil test-based balanced nutrient application of deficient S, B Zn plus N and P in fields in watersheds recorded 70 to 119% (2100 kg ha^{-1} in maize, 660 kg ha^{-1} in groundnut, 640 kg ha^{-1} in mung bean and 1070 kg ha^{-1}in sorghum) improvement in crop productivity along with additional returns varying from ₹ 16,050 ha^{-1} to ₹ 28,160 ha^{-1}over the farmer's practice (only N and P).

Das *et al*. (2015) concluded that best output can be obtained B: C ratio when the crop is fertilized with NPK (20-60-40 kg ha^{-1}) in the form of straight fertilizers like urea, single super phosphate, muriate of potash + 200 kg gypsum during 30 days after sowing + 15 kg sulphur at pegging stage in groundnut.

Wani *et al.* (2015 d) reported one farmer obtained a yield of 2450 kg ha^{-1} with net income of ₹ 61,050 using balanced nutrition including the deficient micronutrients. As compared to the previous yield of 1854 kg ha^{-1} with net income of ₹ 40682 ha^{-1} (which he was not used balanced fertilization) he has expressed the opinion that using balanced nutrition including the deficient micronutrients has proved to be a viable practice which has given him 32% higher yield with benefit cost ratio of 3.71 as against 2.98 in farmer's practice in groundnut.

Wani *et al*. (2015 b) noticed the B:C ratios of balanced fertilization ranged between 1.43 to 5.86 for maize, 1.66 to 3.32 for soybean, 3.27 to 4.76 for sorghum, and 2.60 to 15.2 for groundnut.

Wani *et al*. (2015 c) noticed in green gram a farmer achieved an increment of about 37 per cent in green gram yield by the improved method of cultivation. He obtained an additional income of ₹ 4,900 per acre.

Bhattacharya *et al*. (2004) reported an economic evaluation of each treatment reveals that the complete N, P, and K along with B and Mo treatment was most profitable in green gram. However, N P K plus B alone returned the highest profits in black gram.

Hiremath and Hosamani (2015) revealed application of 150 kg N, 75 kg P_2O_5, 37.5kg K_2O and 25 kg $ZnSO_4$ to maize and 25 kg N, 50 kg P_2O_5 and 15 kg $ZnSO_4$ to chickpea resulted in the highest net returns (₹ 59,244 ha^{-1}) and benefit: cost ratio (5.62) from maize-chickpea cropping system which was significantly superior to rest of the treatments.

Sandeep Khanwalkar and Wani (2013) reported earlier micronutrient application on one hectare had cost the farmer an additional cost of ₹ 1500. Practical experience in the project area proved that through micronutrient application the yield increases by 0.4 to 0.5 t ha^{-1}. For soybean the additional gain will be ₹ 8,000 to ₹ 10,000. For chickpea also the additional gain will be ₹ 8,000 to ₹ 10,000. This more than meets the additional cost. The residual effect of micronutrients in the next season increases productivity by 15 to 25%, earning the farmer additional ₹ 4,500 to ₹ 6,000 without additional input cost.

Anil Kumar *et al*. (2016) reported that pearl millet-mustard crop sequence produced gross returns (₹ 93 051 ha^{-1}) whereas, maximum net returns (₹ 44 529 ha^{-1}) and B:C ratio (1:93) were observed in the balanced fertilizer treatment 5.0 t FYM ha^{-1} + RD of N and P +20 kg K_2O ha^{-1} + 200 kg gypsum ha^{-1} + 10 kg $ZnSO_4$ kgha^{-1}.

Singh and Singh (2014) noticed on the rice-wheat cropping sequence after spending ₹ 44888.00 ha^{-1} farmers are getting gross income of a sum of ₹ 95475.00 ha^{-1}area by the use of balance fertilizer dose recommended as per soil nutrient status.

Ramachandrappa *et al*. (2013) revealed application of Ca, Mg and B along with major nutrients (recommended dose of N and K_2O + borax at 10 kg ha^{-1}, and recommended dose of N and K_2O + lime at 300 kg ha^{-1}+ Mg CO_3 at 150 kg ha^{-1} + borax at 10 kg ha^{-1}) showed improvement in soil fertility status. The latter treatment also recorded significantly higher grain yield of finger millet (3,706 kg ha^{-1}), B:C ratio (2.78) and sustainable yield index (0.82) compared to application of recommended fertilizer.

CHAPTER - III

MATERIAL AND METHODS

A field experiment (in farmer's field) was conducted to study the "Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation" during *kharif* 2016 at Hiregundgal District: Tumkur (Karnataka) at five location under the project of Bhoo Samruddhi collaboration between KSDA (Karnataka State Department of Agriculture) and ICRISAT (International Crop Research Institute for Semi-Arid Tropics Agriculture). The details of the materials used and the experimental techniques followed during the course of investigation are presented in this chapter.

3.1 Location of the experimental site

Hiregundgal (Village), Tumkur (District), Karnataka (State) under the project of Bhoo Samruddhi collaboration between KSDA (Karnataka State Department of Agriculture) and ICRISAT (International Crop Research Institute For Semi-Arid Tropics Agriculture). This research field comes under Eastern Dry Zone (Zone 5) of Karnataka. The five farmers name with GPS location of the field is mentioned below Table 3.1

Table 3.1 Name of farmers and GPS location of experimental plots

Sl. No.	Farmer's name	GPS location of the fields
1	Veerabhadrayya	13^{0} 43' 51" N, 77^{0} 13' 21'' E
2	Laxmipathy	13^{0} 43' 59" N, 77^{0} 13' 22'' E
3	Gurumoorthy	13^{0} 43' 34" N, 77^{0} 13' 19'' E
4	Bhimanna	13^{0} 43' 48" N, 77^{0} 13' 17'' E
5	Narasimraju	13^{0} 43' 38" N, 77^{0} 13' 38'' E

3.2 Climatic conditions

The data on climatic parameters such as rainfall, maximum and minimum temperature and relative humidity recorded at Karnataka State Natural Disaster Monitoring Centre during cropping period of the experimental year 2016 are furnished in table 3.2

The total rainfall received during crop growth period was 152 mm. The major portion of the rainfall was received during 10 Oct-16 Oct (71.84 mm). During the cropping period from August to November, the mean maximum air temperature ranged from 28.1 ^{0}C to 34.0 ^{0}C during crop growth period. The maximum monthly relative humidity ranged from 99.0 per cent to 81.6 per cent in from August to November.

3.3 Soil and its characteristics

The topography of the experimental site was uniform and leveled. The soil was well drained and 30 cm deep. It was quite suitable for growing groundnut crop. On other hand the physical and chemical properties of the soil were determined, for that a composite soil samples at surface, at 30 cm depth were collected from experimental field before sowing of crop. Soil samples of experimental site were analyzed for physical properties namely sand (%), silt (%), clay (%), moisture at field capacity (g g^{-1}) and moisture at wilting point (g g^{-1}) and chemical properties namely soil pH, electrical conductivity (d S m^{-1}), organic carbon (%), available nitrogen ,phosphorus, potassium, sulphur (kg ha^{-1}), zinc and boron (ppm). Various methods adopted for analysis of soil sample are listed in Table No.3.3 and 3.4. All five plots having the character of good drainage, moisture holding capacity, infiltration rate and water table.

3.4 Experimental details

The details of the experiment with respect to the treatments details and experiment details are furnished below.

3.4.1 Treatment Details

1. Factor I : Nutrients

N_1= Recommended Dose of Fertilizer

N_2= Recommended Dose of Fertilizer + Micro Nutrients

2. Factor II : Land configuration

L1 = BBF (Broad Bed and Furrow)

L2 = FB (Flat Bed)

3. Factor III : Varieties

V_1= ICGV 91114

V_2= K 6

4. Farmer's Practice (N, P, K fertilizer + flat bed + K6)

3.4.1.1 Treatment combinations

$N_1L_1V_1$: Recommended Dose of Fertilizer + BBF (Broad Bed and Furrow) + ICGV 91114

$N_1L_1V_2$: Recommended Dose of Fertilizer + BBF (Broad Bed and Furrow) + K 6

$N_1L_2V_1$: Recommended Dose of Fertilizer + FB (Flat Bed) + ICGV 91114

$N_1L_2V_2$: Recommended Dose of Fertilizer + FB (Flat Bed) + K 6

$N_2 L_1V_1$: Recommended Dose of Fertilizer + Micro Nutrients+ BBF (Broad Bed and Furrow) + ICGV 91114

$N_2 L_1V_2$: Recommended Dose of Fertilizer + Micro Nutrients+ BBF (Broad Bed and Furrow) + K 6

$N_2L_2V_1$: Recommended Dose of Fertilizer + Micro Nutrients+ FB (Flat Bed) + ICGV 91114

$N_2L_2V_2$: Recommended Dose of Fertilizer + Micro Nutrients + FB (Flat Bed) + K 6

3.4.1.2 Farmer's Practice

The farmer's practice treatment was used as control treatment, which was comprised flat bed method of sowing, local variety *i.e.* K 6 was used and fertilizer was applied as per the local recommendation (N, P, K 18:46:30). *Rhizobium*, *Trichograma viridae*, gypsum, zinc sulphate and borax were not applied.

3.4.2 Field Layout

The experiment was laid out in factorial randomized complete block design keeping nutrients as first factor land configuration as second factor and verities as third factor. Farmer's practice as a control treatment.

3.4.3 Details of the field experiment

Cultivars used	ICGV 91114 and K 6 (Bunch type groundnut)
Design	Factorial Randomized Block Design (FRBD) with control
Treatments	09
Replications	Five
Gross plot	10 m X 5.1 m (51 m^2)
Seed rate	125 kg ha^{-1}
Planting geometry	30 cm × 10 cm
Inoorganic fertilizers (ha^{-1})	
N : P_2O_5 : K_2O (kg)	25 : 50 : 25
Gypsum (kg)	500
Borax (kg)	10
Zinc sulphate (kg)	25
Source of fertilizer	
Nitrogen	Urea (46.0% N)
Phosphorus	Di ammonium phosphate (DAP) (46% P_2O_5, 18% N)
Potassium	Muriate of potash (MOP) (60% K_2O)
Bio fertilizer	Rhizobium (2.5 kg ha^{-1})
Bio fungicide	*Trichograma viridae* (NIPROT) 0.5% W.P
Insecticide	1. Chlorphyryphos (SULBAN) 20% E.C 2. Lambda –cyhalothrin (KARATE) 05% E.C
Herbicide	Alachlor (LASSO) 30% E.C

3.5 Test crops

3.5.1 ICGV 91114

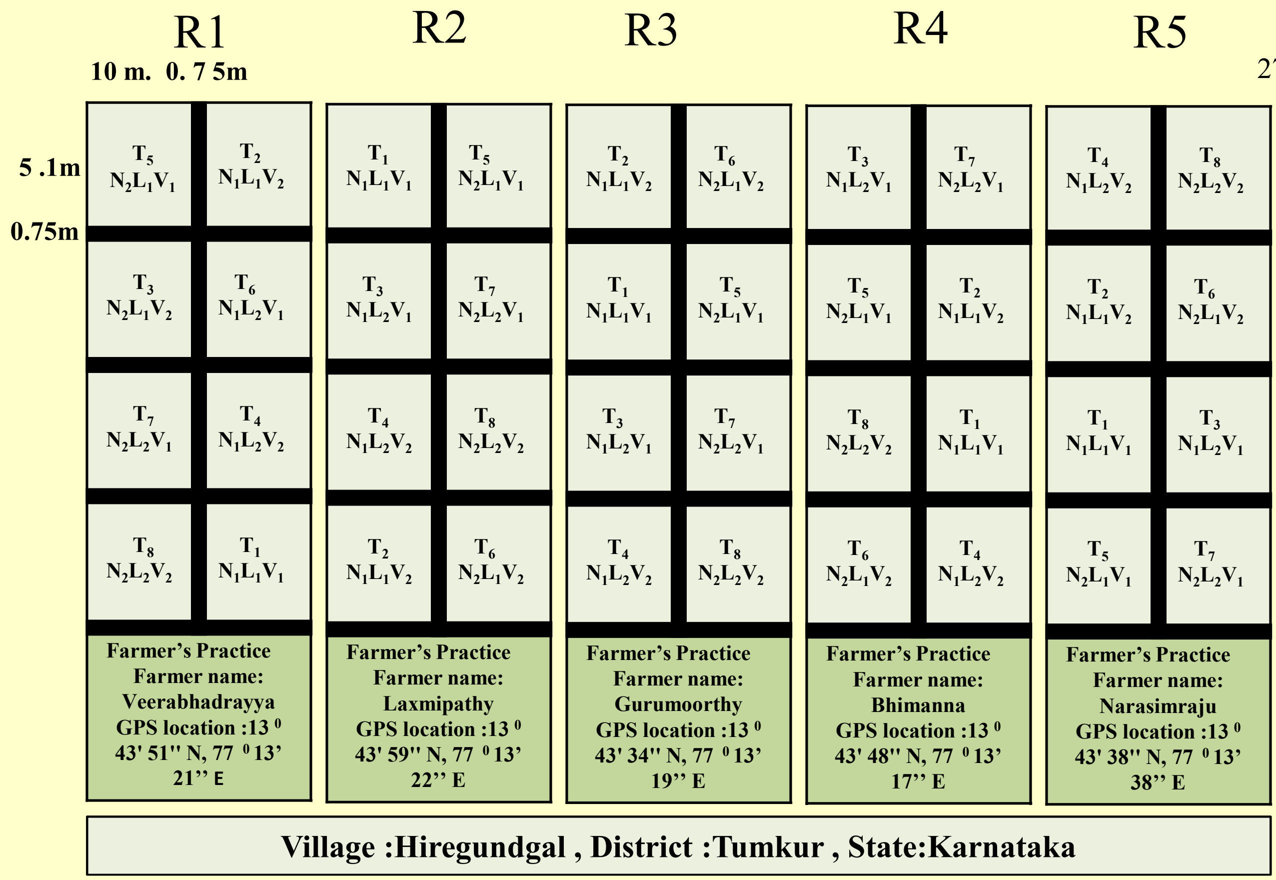
Groundnut variety ICGV 91114 was bred and developed at ICRISAT Headquarters, India. It was derived following the bulk pedigree method from the ICGV 86055 x ICGV 86533 cross. ICGV 91114 has the following features:

- High-yielding
- Matures in 90-95 days in the *Kharif* (rainy season)
- Tolerant of mid-season and end of season drought
- Average shelling turnover 75%
- Oil content 48%, protein content 27%
- Better digestibility and palatability of haulms

3.5.2 K 6

Following are the characters of local variety Kadiri 6.

- Kadiri 6 variety of groundnut will yield 3000 kg ha^{-1}
- Each plant bearing an average of 50 kernels
- It is a local variety used in Tumkur district



Treatments Details

1. Factor I : Nutrients

N_1= Recommended Dose of Fertilizer

N_2= Recommended Dose of Fertilizer + Micro Nutrients

2. Factor II : Land configuration

L1 = BBF (Broad Bed and Furrow)

L2 = FB (Flat Bed)

3. Factor III : Varieties

V_1= ICGV-91114

V_2= K-6

4. Farmer's Practice (N, P, K (18:46:30) fertilizer +flat bed + K6)

Treatment combination:

$T_1=N_1L_1V_1$
$T_2=N_1L_1V_2$
$T_3=N_1L_2V_1$
$T_4=N_1L_2V_2$
$T_5=N_2L_1V_1$
$T_6=N_2L_1V_2$
$T_7=N_2L_2V_1$
$T_8=N_2L_2V_2$
T_9= Farmer's practice

RDF: 25:50:25 NPK+ Gypsum @ 500 kg ha^{-1} at 30 DAS
Micronutrients: $ZnSO_4$@ 25 kg ha^{-1} & Borax @ 10 kg ha^{-1} at sowing
Farmer's practice :NPK (18:46:30) fertilizer+ Flat bed+ K 6

Cultivars used	:	**ICGV 91114 and K 6 (Bunch type groundnut)**
Design	:	**Factorial Randomized Block Design (FRBD) with control**
Treatments	:	**09**
Replications	:	**Five**
Gross plot	:	**10 m X 5.1 m (51 m^2)**
Seed rate	:	**125 kg ha^{-1}**
Planting geometry	:	**30 cm × 10 cm**
Nitrogen	:	**Urea (46.0% N)**
Phosphorus	:	**Di ammonium phosphate (DAP) (46% P_2O_5, 18% N)**
Potassium	:	**Muriate of potash (MOP) (60% K_2O)**
Bio fertilizer	:	**Rhizobium (2.5 kg ha^{-1})**
Bio fungicide	:	**Trichograma viridae (NIPROT) 0.5% W.P**
Insecticide	:	**1. Chlorphyryphos (SULBAN) 20% EC** **2. Lambda –cyhalothrin (KARATE) 05% E.C**
Herbicide	:	**Alachlor (LASSO) 30% E.C**

Fig: 3.1. Layout plan of experiment

Plate: 1 Layout plan of experimental field

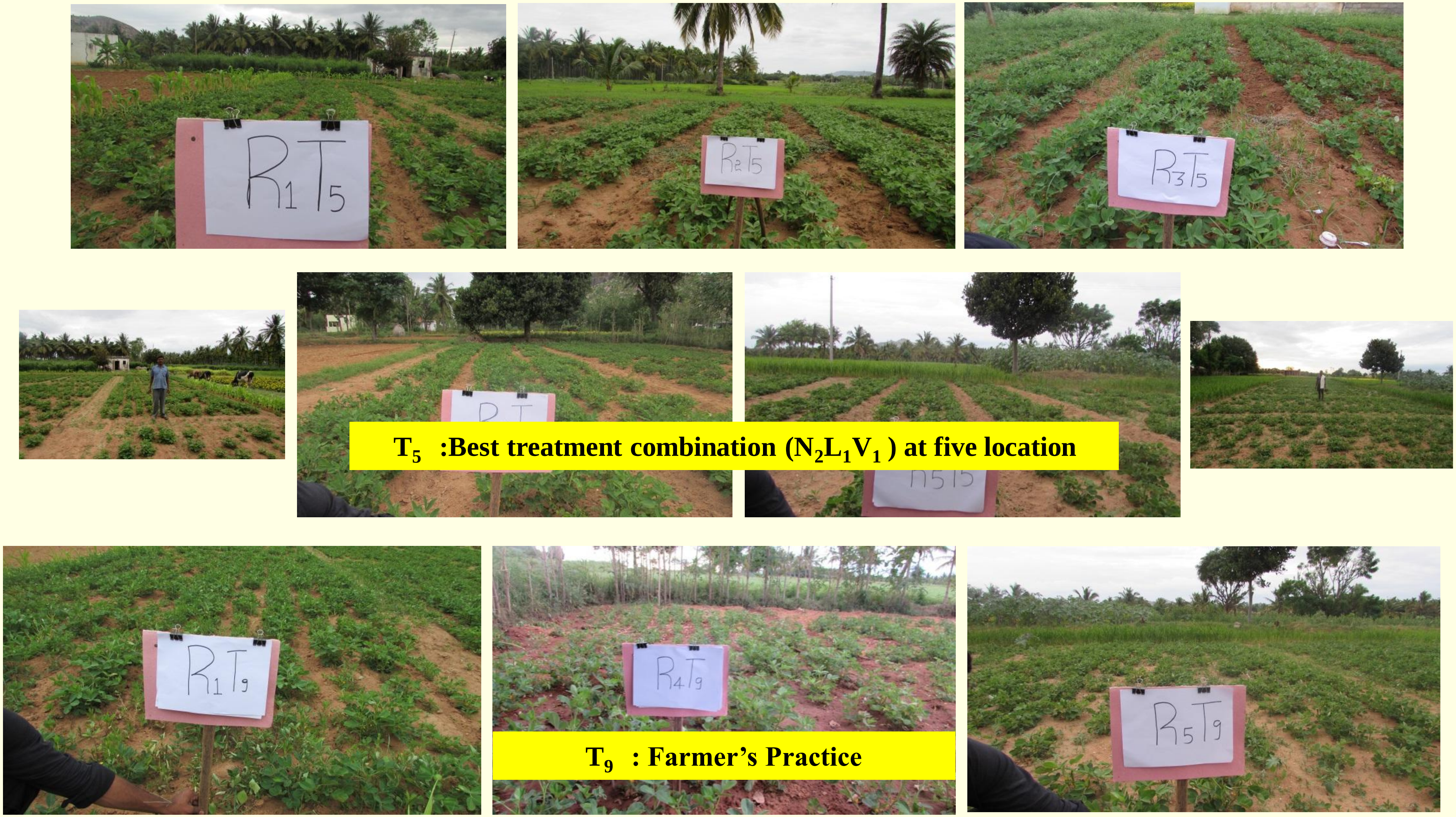


Plate: 2 Groundnut crop at 30 DAS

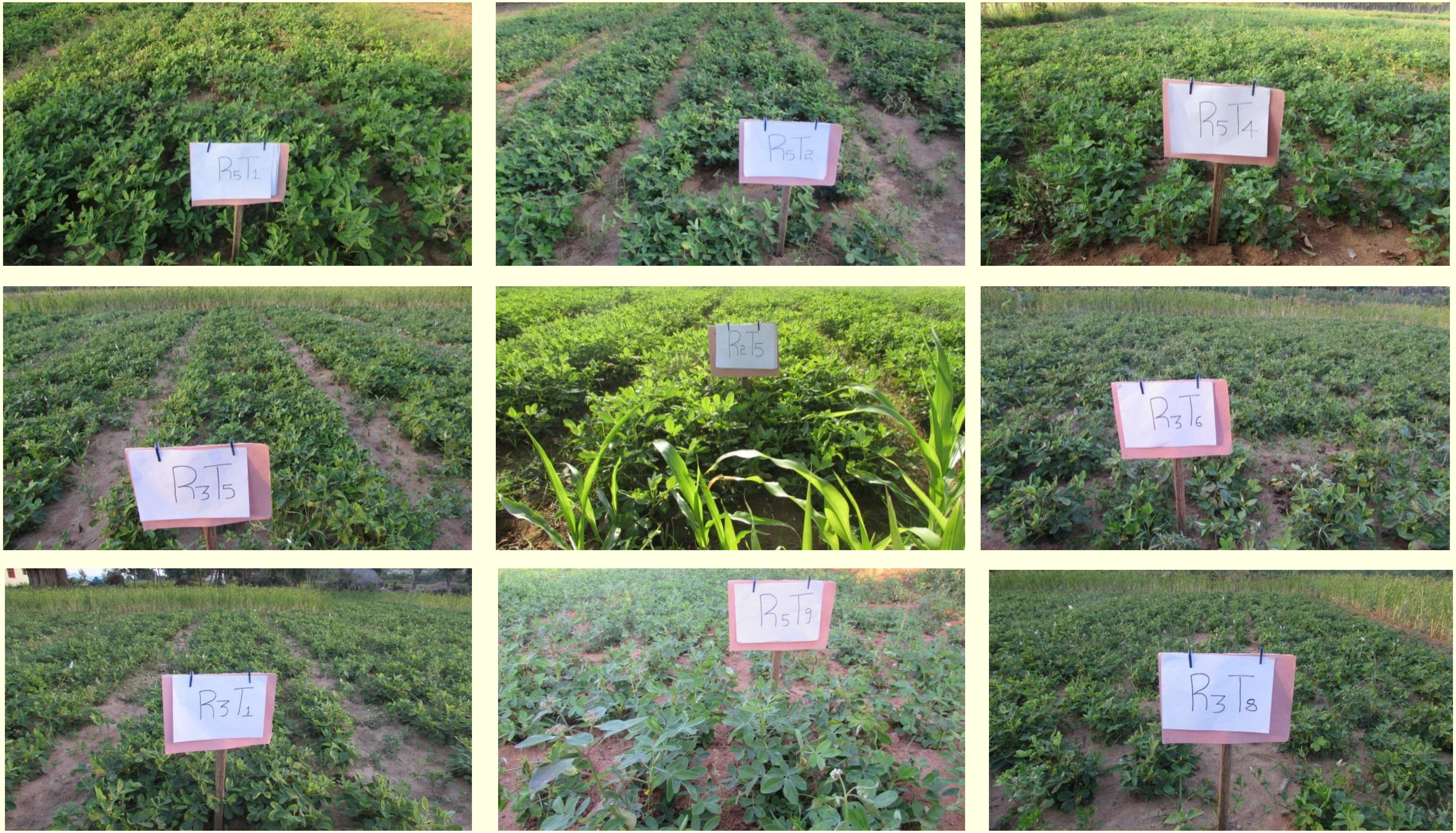


Plate: 3 Groundnut crop at 60 DAS

Plate: 4 Groundnut crop at 90 DAS

Table 3.2: Weakly Weather data during cropping year (2016), at Karnataka State Natural Disaster Monitoring Centre

Date	Temp.(^{o} C)		Rainfall(mm)	RH (%)	
	Min.	Max.		Min.	Max.
1Aug - 7Aug	20.1	28.1	5.16	58.1	95.4
8Aug - 14 Aug	20.8	30.0	9.92	53.7	99.0
15Aug - 21 Aug	20.8	29.7	1.42	53.3	94.9
22Aug - 28 Aug	22.4	30.2	7.13	50.6	94.7
29 Aug - 4 Sept	21.3	28.5	21.79	62.0	95.6
5 Sept - 11Sept	20.3	29.6	7.53	49.5	94.6
12 Sept - 18 Sept	21.7	30.0	7.14	49.7	93.7
19 Sept - 25 Sept	21.4	29.0	5.96	55.1	94.4
26 Sept - 2 Oct	21.7	29.7	2.88	54.9	95.5
3 Oct - 9 Oct	19.5	31.3	4.68	38.8	93.7
10 Oct - 16 Oct	20.7	31.2	71.84	44.1	91.9
17 Oct - 23 Oct	18.1	34.0	0.0	29.8	81.6
24 Oct - 30 Oct	18.7	31.6	0.0	30.4	76.7
31 Oct - 6 Nov	20.8	31.7	6.55	39.9	87.2
7 Nov - 13 Nov	17.2	30.8	0.0	27.9	81.6
14 Nov - 20 Nov	21.0	32.2	0.0	38.1	91.6
Total			**152**		

3.6 Calendar of cultural operations

The details of various cultural operations performed during the course of experimentation are given in the Table 3.5

3.6.1 Pre sowing operations

3.6.1.1 Land preparation

The experimental field was prepared by one ploughing followed by one harrowing with help of tractor drawn implements. The field was then demarcated as per the plan of layout.

3.6.1.1.1 Flat bed:

No tillage other than the one given before sowing of the crop.

3.6.1.1.2 Broad bed and furrow:

A bed of 150 cm width with furrow of 30 cm width and 15 cm depth was formed with the help of BBF former after the preparatory tillage and before sowing.

3.6.1.2 Fertilizer application

Fertilizer was applied basally as per the soil test based recommendation in the form of urea, di ammonium phosphate, murate of potash, zinc sulphate and boron at the time of sowing .While, sulphur in the form of gypsum was also applied at 30 days after sowing in furrow as per treatments.

Table 3.3 Soil physical properties of experimental site

Properties	Farmer: 1	Farmer:2	Farmer: 3	Farmer :4	Farmer :5	Method
1. Particle size analysis						
Sand (%)	91.23	68.50	86.22	74.85	89.98	International pipette method (Piper, 1966)
Silt (%)	6.27	15.12	10.02	15.09	6.26	International pipette method (Piper, 1966)
Clay (%)	2.51	16.38	3.76	10.06	3.76	International pipette method (Piper, 1966)
2. Textural class	Sandy	Sandy loam	Loamy Sand	Sandy loam	Sandy	
3. Moisture at field capacity ($g\ g^{-1}$)	0.044	0.141	0.059	0.106	0.057	Pressure Plate apparatus (Laryea, Pathak and Katyal,1997)
4. Moisture at permanent wilting point ($g\ g^{-1}$)	0.028	0.103	0.036	0.079	0.040	Pressure Plate apparatus (Laryea, Pathak and Katyal,1997)

Table 3.4 Soil chemical properties of experimental site

Properties	Farmer: 1	Farmer:2	Farmer: 3	Farmer :4	Farmer :5	Method
1. Soil pH	5.70	5.47	7.16	7.58	6.77	pH meter (Thomas, 1996)
2. Electrical Conductivity ($d\ S\ m^{-1}$)	0.06	0.07	0.09	0.09	0.07	Conductivity meter (Rhoades, 1996)
3. Organic carbon (%)	0.23	0.46	0.21	0.62	0.20	Walkely and Black's wet oxidation method (Nelson and Sommers,1996)
4. Available nitrogen ($kg\ ha^{-1}$)	282.24	290.40	145.15	362.88	145.15	Alkaline permanganate method (Subbaiah and Asija, 1956)
5. Available phosphorus ($kg\ ha^{-1}$)	25.31	8.51	23.05	23.744	22.62	Olsen's method (Jackson, 1967)
6. Available potassium ($kg\ ha^{-1}$)	252	168	255.36	280	420	Flame Photometry method (Jackson,1967)
7. Available sulphur ($kg\ ha^{-1}$)	13.91	12.16	19.54	10.46	13.77	Turbid metric method (Shirisha, Sahrawat, Murthy, 2010)
8. Available zinc($mg\ kg^{-1}$)	1.21	0.68	1.16	2.11	1.31	AAS(Lindsay and Norvell, 1978)
9. Available boron ($mg\ kg^{-1}$)	0.16	0.19	0.61	0.72	0.15	Colorimetric method (Keren, 1996)

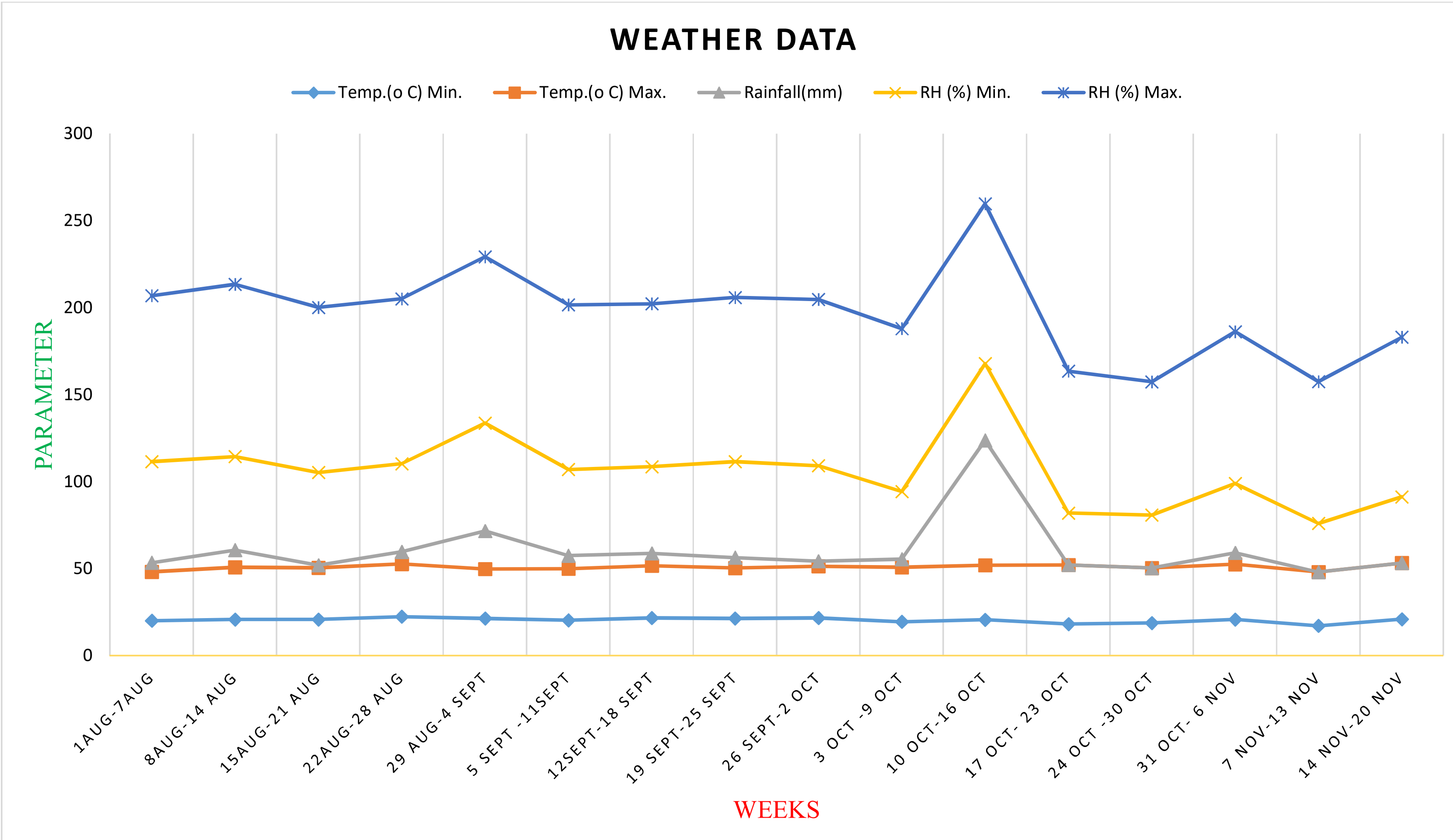


Fig 3.2: Weekly meteorological data prevailing during crop growth period (*Kharif*, 2016).

3.5 Calendar of cultural operations

Sl. No.	Field operation	Frequency	Date of operation
A.	**Pre-sowing**		
1.	Tractor ploughing	1	01/08/2016
2.	Harrowing with tractor	1	04/08/2016
3.	Broad bed and furrow making	1	04/08/2016
4.	Field layout	1	06/08/2016
5.	Fertilizer application	1	07/08/2016
6.	Sowing	1	07/08/2016
7.	Seed Treatment	1	07/08/2016
8.	Drenching	1	07/08/2016
B.	**Post sowing operations**		
1.	Weedicide spraying	1	08/08/2016
2.	Gap filling	1	18/08/2016
3.	Inter culturing	1	05/09/2016
4.	Hand weeding	1	06/09/2016
5.	Gypsum Application	1	07/09/2016
6.	Insecticide Spraying	1	09/10/2016
7.	Fungicide Spraying	1	09/10/2016
8.	Harvesting	1	18/11/2016
9.	Irrigation	3	08/09/2016, 23/09/2016, 08/10/2016

3.6.1.3 Seed and sowing

The graded and healthy seed of groundnut ICGV 91114 and K 6 were treated with *Rhizobium japonicum* and *Trichoderma viridae* @ 10 g per kg of seed before sowing. The treated seed was sown as per the treatments. On 7th August, 2016 with a recommended seed rate of 125 kg kernel ha^{-1}.

3.6.1.4 Drenching

Drenching of insecticide was done for the problem of ants. Insecticide used in drenching was Chlorphyryphos (SULBAN) 20 % E.C @ 10ml per tank.

3.6.2 Post Sowing Operations

3.6.2.1 Gap filling, inter culturing and hand weeding

Gap filling was done 11 days after sowing to facilitate optimum plant density by maintaining an intra row spacing of 10 cm. Inter culturing with blade harrow and hand weeding were carried out as mentioned in Table 3.2 to control weeds and proper aeration.

3.6.2.2 Plant protection measures

The experiment plots were kept free from weeds by application of Alachlor (LASSO) 30% E.C @ 2 litre ha^{-1} was sprayed to entire experiment plots with one hand weeding at 30 days after sowing.

In experimental plot the occurrence of plant defoliator *Spodoptera litura* was arrived while conducting the experiment it was managed by Lambda–cyhalothrin (KARATE) 05% E.C @ 0.5 ml per liter of water at 60 days after sowing. For control of leaf spot disease the crop was sprayed with mancozeb (DAITHANE M-45) @ 2 g per liter of water 60 at days after sowing.

3.6.3 Harvesting and striping

The groundnut crop was harvested at its full maturity by uprooting the plants by hands on 18th November. Five plants were harvested in each treatment separately for recording post-harvest observations and the pod and haulm yields were added to the final treatment yields. The pods were stripped off manually. The produce was allowed to sundry in the respective plots and the dry weights of the pods and haulms were recorded separately for each treatment.

3.7 Collection of Experimental data

The crop response to different treatments application under the present investigation was evaluated on the basis of growth studies, yield attributes, yield, quality parameters and physico-chemical studies which are given in Table 3.6.

3.7.1 Pre-Harvest Observation

Plant height was measured from ground level to the top of main shoot of randomly selected five observational plants in each treatment at 30, 60, 90 DAS and harvest. Average value for each treatment at each stage was computed and recorded. The average value was then computed.

3.7.1.2 Number of branches per plant

The number of branches was counted in five randomly selected observational plants in each treatment at 30, 60, 90 DAS and harvest. The average value was then computed.

3.7.1.3 Leaf area

The leaf was measured by leaf area meter. Three plants were sampled from second row of each treatment randomly selected plants in each treatment at 30, 60 and 90 DAS. The average value was then computed and the value is expressed in cm^2.

3.7.1.4 Total dry matter production

Three plants were sampled from second row of each treatment at 30, 60 and 90 DAS and at harvest. The plants (excluding roots) were then dried in the oven at $65 \pm 5\ ^0C$ till the constant weight. The average value of dry matter per plant was recorded.

3.7.1.5 Leaf area index

The leaf area per plant at 30, 60 and 90 DAS was worked out by leaf area meter from three plants selected at random in each plot and expressed as leaf area per plant. Later leaf area index was calculated by using the following formula (Sestak *et al.,* 1971)

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

3.7.1.6 Crop growth rate

The values for CGR were calculated for the stage between 0-30, 30-60 and 60-90 DAS with the help of the following formula (Cheema *et al.,* 1991).

$$\text{CGR (g day}^{-1}\text{ plant}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where;

W_1 and W_2 = Weight of dry matter of plant (g plant^{-1}) at first and second stages

t_1 and t_2 = Time in days of first and second stages

3.7.1.7 Relative growth rate (RGR)

The values of RGR were calculated for the stage between 0-30, 30-60 and 60-90 DAS with the help of the following formula (Cheema *et al.,* 1991).

$$\text{RGR (g g}^{-1}\text{ plant}^{-1}\text{day}^{-1}\text{)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where;

Log_e = Natural logarithm (base e)

W_1 and W_2 = Weight of dry matter of plant (g) at first and second stage

t_1 and t_2 = Time in days of first and second stages

3.7.2 Post-harvest parameters of groundnut

The yield parameters studies were carried out after harvest of crop on the selected five observation plants. Yield and yield contributing characters were estimated as per details entitled below.

3.7.2.1 Number of pods plant^{-1}

Total number of matured pods from the five randomly selected observational plants counted from each plot and their average values were computed and recorded.

3.7.2.2 Pod weight (g plant^{-1})

Five observational plants randomly selected from net plot were harvested and allowed to sundry for six days. All the matured pods were stripped, weighed and average weight of pods per plant was recorded for each plot.

3.7.2.3 100 seed weight (g)

A representative pod sample was drawn randomly from the produce of each plot and shelled out manually. Hundred kernels were counted from the sample and this weight in grams was recorded as test weight of each treatment.

3.7.2.4 Pod yield (kg ha^{-1})

The produce of each treatment was collected separately including the yield of five observational plants. The pod yield was dried in sun for 6 days. The dried pod yield was recorded. The pod yield per treatment was then converted into kilogram per hectare.

3.7.2.5 Haulm yield (kg ha^{-1})

The plants after stripped off pods from each treatment including five observational plants kept for sun drying in the same plot. After complete drying, haulm was weighed and subsequently the values were converted into kilograms on hectare basis.

3.7.2.6 Shelling %

For each of the treatment 100 gram of dry pods were weighed, shelled and shelling percentage was worked out by using following formula.

$$\text{Shelling (\%)} = \frac{\text{Weight of kernels (g)}}{\text{Dry weight of pods(g)}} \times 100$$

3.7.2.7 Harvest index

The harvest index was calculated by using the following formula.

$$HI = \frac{\text{Pod yield (kg ha}^{-1}\text{)}}{\text{Pod yield (kg ha}^{-1}\text{)+Haulm Yield(kg ha}^{-1}\text{)}}$$

3.7.3 Microbial activity observation

3.7.3.1 Nodulation

The number of root nodules was recorded at 45 DAS in randomly selected three plants. The plants were carefully removed from the soil without damaging the roots and were dipped gently in a bucket containing water to remove the soil and then nodules were counted.

3.7.3.2 Mycorrhizae sampling (Root sampling)

The observation for VAM infection was recorded at 45 DAS and at pod formation stage. For each observation three randomly selected plants for each treatment.

Following procedure (McGonigle *et al.,* 1990) was done to get VAM infection observation:

3.7.3.2.1 Cleaning or washing*:*

Three random root samples were observed for each treatment. The root samples collected from the field are cut into half centimeter and are washed in tap water about 2-3 minute then they were transferred to mixture of alcohol and acetic acid, mixture is in the ratio of 1:1 about few minutes.

3.7.3.2.2 Fixing:

Then the samples were transferred to 10% w/v KOH solution. Again the samples were rinsed by tap water,

3.7.3.2.3 Staining:

Then the samples were shifted to trypan blue stain (0.01%) kept samples about 24 hours at room temperature.

3.7.3.2.4 Examination or observation:

After 24 hour among the sample about 10 cut pieces are selected randomly and are put on parallel to the long axis of the slide cover them with a cover slip, bubbles trapped during cover slipping then the root samples were examined in the compound microscope .The infected root samples shows the vesicles, arbuscules and hyphae. Based on the observation the percent colonization is calculated.

3.7.4 Quality Parameters

3.7.4.1 Oil content (%)

Representative samples of seed were taken at the maturity from each plot and oven dried for 16 hours at 105 °C. About 10-15 g seed were taken for the analysis of oil content. The oil content of seed sample was determined by non-destructive method using Nuclear Magnetic Resonance Spectrophotometer as suggested by Jambunathan *et al.* (1985).

3.7.4.2 Oil yield (kg ha^{-1})

Oil yield per hectare was worked out by using the following formula.

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%) x Shelling (\%) x Pod yield (kg ha}^{-1}\text{)}}{10000}$$

3.7.4.3 Protein content (%)

Nitrogen in seed was estimated on per cent dry weight basis as per modified Kjeldahl's method as described by Jackson (1967). The protein content of seeds was worked out by multiplying nitrogen content in seeds with the factor of 6.25 as per reported by Angelo and Mann (1973).

3.7.5 Physico- chemical analysis of soil

3.7.5.1 Soil pH

Soil pH was determined by digital automatic pH meter in soil water suspension 1:2 (Thomas, 1996).

3.7.5.2 Organic carbon

Organic carbon was estimated by Walkley and Black rapid titration method (Nelson and Sommers, 1996).

3.7.5.3 Electrical conductivity

Electrical conductivity was estimated by E c meter in soil water suspension 1:2 (Rhoades, 1996).

3.7.5.4 Moisture at field capacity (g $g^{-1)}$

Moisture at field capacity was estimated by pressure plate apparatus at 0.33 bar (Laryea *et al*., 1997)

3.7.5.5 Moisture at permanent wilting point (g $g^{-1)}$

Moisture at field capacity was estimated by pressure plate apparatus at 15 bar (Laryea *et al*., 1997).

3.7.5.6 Available nitrogen (kg ha^{-1})

Available nitrogen content in soil after harvest of crop was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

3.7.5.7 Available phosphorous (kg ha^{-1})

Available phosphorus content in soil after harvest of crop was analyzed by the method as suggested by Olsen (1954).

3.7.5.8 Available potassium (kg ha^{-1})

Available potassium content in soil after harvest of crop was analyzed by the flame photometer after 5 minute shaking with 25 ml of 1 N ammonium acetate (Jackson 1967).

3.7.5.9 Available sulphur (kg ha^{-1})

The available (heat soluble) S was determined as per the method adopted by Williams and Steinbergs (1959).

3.7.5.10 Available boron (mg kg^{-1})

The extracted B in the filtered extract is determined by the azo methane -H colorimetric method. (Keren. R, 1996)

3.7.5.11 Available zinc (mg kg^{-1})

Atomic absorption spectroscopy and inductively coupled plasma emission spectroscopy both can be successfully applied for the estimation of available zinc. (Lindsay and Norvell, 1978)

3.7.6 Plant analysis

3.7.6.1 Total nitrogen

The automated procedure for the determination of total nitrogen is based on the modified Berthelot reaction: ammonia is buffered and chlorinated to on chloramine, which reacts with salicylate to 5- amino salicylate. After oxidation and oxidative coupling a green colored complex is formed. The absorption of the formed complex is measured at 660 nm. (Millsand Jones 1996). Observation was taken at 45 days after sowing and at harvest.

$$\text{N uptake by haulm (kg ha}^{-1}\text{)} = \frac{\text{N content in haulm (\%)} \times \text{Haulm yield (kg ha}^{-1}\text{)}}{100}$$

3.7.6.2 Total phosphorus

The automated procedure for the determination of total phosphate is based on the following reaction; ammonium heptamolybdate and potassium antimony (III) oxide tartrate react in an acidic medium with diluted solutions of phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by L (+) ascorbic acid. The complex is measured at 880 nm. (Millsand Jones 1996). Observation was taken at 45 days after sowing and at harvest.

$$\text{P uptake by haulm (kg ha}^{-1}\text{)} = \frac{\text{P content in haulm (\%)} \times \text{Haulm yield (kg ha}^{-1}\text{)}}{100}$$

3.7.6.3 Total potassium

Digested samples with nitric acid in the presence of an oxidizing agent such as Hydrogen Peroxide. The above digest can be used for the estimation of total nutrients by inductively coupled plasma optical emission spectrometry (ICP-OES). (Matthew *et al.*) Observation was taken at 45 days after sowing and at harvest.

$$\text{K uptake by haulm (kg ha}^{-1}\text{)} = \frac{\text{K content in haulm (\%)} \times \text{Haulm Yield (kg ha}^{-1}\text{)}}{100}$$

3.7.6.4 Total sulphur

Digested samples with nitric acid in the presence of an oxidizing agent such as Hydrogen Peroxide. The above digest can be used for the estimation of total nutrients by inductively coupled plasma optical emission spectrometry (ICP-OES). (Matthew *et al.*) Observation was taken at 45 days after sowing and at harvest.

$$\text{S uptake by haulm (kg ha}^{-1}\text{)} = \frac{\text{S content in haulm (ppm)} \times \text{Haulm Yield (kg ha}^{-1}\text{)}}{100}$$

3.7.6.5 Total zinc

Digested samples with nitric acid in the presence of an oxidizing agent such as Hydrogen Peroxide. The above digest can be used for the estimation of total nutrients by inductively coupled plasma optical emission spectrometry (ICP-OES). (Matthew *et al.*) Observation was taken at 45 days after sowing and at harvest.

$$\text{Zn uptake by haulm (g ha}^{-1}\text{)} = \frac{\text{Zn content in haulm (ppm)} \times \text{Haulm Yield (kg ha}^{-1}\text{)} \times 10^{3}}{100}$$

3.7.6.6 Total boron

Digested samples with Nitric acid in the presence of an oxidizing agent such as Hydrogen Peroxide. The above digest can be used for the estimation of total nutrients by inductively coupled plasma optical emission spectrometry (ICP-OES). (Matthew *et al.*) Observation was taken at 45 days after sowing and at harvest.

$$\text{B uptake by haulm (g ha}^{-1}) = \frac{\text{B content in haulm (ppm)} \times \text{Haulm Yield (kg ha}^{-1}) \times 10^{3}}{100}$$

3.8 Economic analysis

3.8.1 Cost of cultivation (₹ ha^{-1})

The expense incurred for all the cultivation operations from preparatory tillage to harvesting including threshing, cleaning as well as the cost of inputs *viz.,* seeds, fertilizers, pesticides, *etc.* applied to each treatment were calculated on the basis of prevailing local charges.

3.8.2 Gross income (₹ ha^{-1})

The gross realization in terms of rupees per hectare was worked out taking into consideration the pod and haulm yields from each treatment and local market prices.

3.8.2 Net income (₹ ha^{-1})

Net returns of each treatment were calculated by deducting the total cost of cultivation from the gross returns.

3.8.2 Benefit: Cost ratio (%)

The B:C ratio worked out by the following formula.

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

3.9 Statistical analysis

Data collected in respect of various parameters were analyzed statistically as described by Sundarajan *et al*. (1972). The factorial randomized completely block design was adopted in the experiment. The percentage values were transformed into respective angular values before analysis. The data was subjected to the test of significance (‘F’ test) by analysis of variance method. In the tables, critical difference values are for the observation significant at five percent level and for non-significant (NS) values the S.Em ± values are given.

CHAPTER - IV
RESULTS AND DISCUSSION

The results of the field experiment entitled "Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation", conducted during *kharif*, 2016 was at farmer's field *i.e.* in five location of the same village Hiregundgal, District: Tumkur (Karnataka) under the project of Bhoo-Samruddhi collaboration between KSDA (Karnataka State Department of Agriculture) and ICRISAT (International Crop Research Institute for Semi-Arid Tropics Agriculture), Hyderabad. This chapter deals with the observations recorded on different growth parameters, yield attributes, quality parameters, various soil physico-chemical properties, microbial observation, grain yield and haulm yield of groundnut under different nutrients, land configurations and varieties. The observation was statistically analyzed and the interpretations of the results are presented tables and as well as in figures.

4.1 Pre-harvest observations

4.1.1 Plant height (cm)

The mean plant height of groundnut in different interval of time as influenced by different nutrients, land configuration and varieties are presented in Table 4.1a & 4.1b and also graphically represented in fig 4.1.

The plant height was increased with advancement in crop growth period and reached maximum at the stage of harvesting. The rate of increase in plant height was higher up to 90 DAS and thereafter, it was declined up to the stage of harvesting. The highest general mean of plant height was recorded 27.68 cm at the stage of harvesting.

4.1.1.1 Nutrients

The plant height was significantly influenced due to nutrients at all days of observations except 30 DAS observation. It was significantly higher in the recommended dose of fertilizer along with micro nutrient treatment at 60 DAS (18.81 cm), 90 DAS (27.66 cm) and at harvest (28.25 cm). Whereas, lowest plant height was recorded in only recommended dose of fertilizer treatment at all growth stages except 30 DAS. The plant height higher in the case of the recommended dose of fertilizer along with micro nutrient treatment might be due to micro nutrient like zinc which will enhances the growth hormone.

4.1.1.2 Land configuration

The plant height was significantly influenced due to land configuration at all days of observations except early stage of observation *i.e.* 30 DAS. It was significantly higher in the broad bed and furrow treatment at 60 DAS (19.04 cm), 90 DAS (27.93 cm) and at harvest (28.73 cm). Whereas lowest plant height was recorded in flat bed treatment at all growth stages except early stage of observation *i.e.* 30 DAS. The plant height was higher in the broad bed and furrow method it might be due to loose porous supporting soil at base, favorable physical environment in the root zone resulting in absorption of more water and nutrients. In fact plant height is due to continues cell division and enlargement. The favorable physical environment in the root zone for cell division and enlargement with broad bed furrow resulted taller plants. The same result was reported by Vaghasia *et al*. (2007).

4.1.1.3 Varieties

The plant height was significantly influenced due to varieties at all days of observations. It was significantly higher in the cultivated variety ICGV 91114 at 30 DAS (8.91 cm), 60 DAS (18.97 cm), 90 DAS (27.75 cm) and harvest (28.45 cm). Whereas, lowest plant height was recorded in cultivated variety K 6 at all growth stages. The reason for the maximum plant height in cultivated variety ICGV 91114 it may be due to its varietal superiority over cultivated variety K 6.

4.1.1.4 Interaction effect

The interaction effects were non-significant among the various treatments with respect to the plant height at all growth stages.

Table 4.1a: Plant height (cm) influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

Treatments			Plant height (cm)			
			30 DAS	60 DAS	90 DAS	Harvest
Nutrient	**N_1**	RDF	8.52	18.05	26.26	27.11
	N_2	RDF+MN	8.49	18.81	27.66	28.25
		S.Em ±	**0.22**	**0.25**	**0.31**	**0.32**
		CD (P=0.05)	**NS**	**0.74**	**0.91**	**0.92**
Land	**L_1**	BBF	8.51	19.04	27.93	28.73
configuration	**L_2**	FB	8.50	17.82	25.98	26.62
		S.Em ±	**0.22**	**0.25**	**0.31**	**0.32**
		CD (P=0.05)	**NS**	**0.74**	**0.91**	**0.92**
Variety	**V_1**	ICGV 91114	8.91	18.97	27.75	28.45
	V_2	K 6	8.10	17.88	26.17	26.90
		S.Em ±	**0.22**	**0.25**	**0.31**	**0.32**
		CD (P=0.05)	**0.64**	**0.74**	**0.91**	**0.92**
Interaction						
NXL			NS	NS	NS	NS
LXV			NS	NS	NS	NS
NXV			NS	NS	NS	NS
NXLXV			NS	NS	NS	NS
General mean			**8.50**	**18.43**	**26.96**	**27.68**
Farmer's practice			8.42	15.80	21.73	22.23
S.Em ±			**0.43**	**0.55**	**0.64**	**0.63**
CD (P=0.05)			**NS**	**1.57**	**1.83**	**1.81**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.1 b: Treatment combination of plant height (cm) influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	Harvest
$N_1L_1V_1$	8.7	18.72	27.61	28.18
$N_1L_1V_2$	8.06	18.12	26.73	26.98
$N_1L_2V_1$	8.67	18.21	26.27	27.64
$N_1L_2V_2$	8.63	17.13	25.2	25.58
$N_2L_1V_1$	9.14	20.42	29.7	30.44
$N_2L_1V_2$	8.13	18.88	27.55	28.47
$N_2L_2V_1$	9.13	18.54	27.38	27.72
$N_2L_2V_2$	7.57	17.38	25.63	26.16
S.Em ±	**0.44**	**0.51**	**0.47**	**0.45**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**

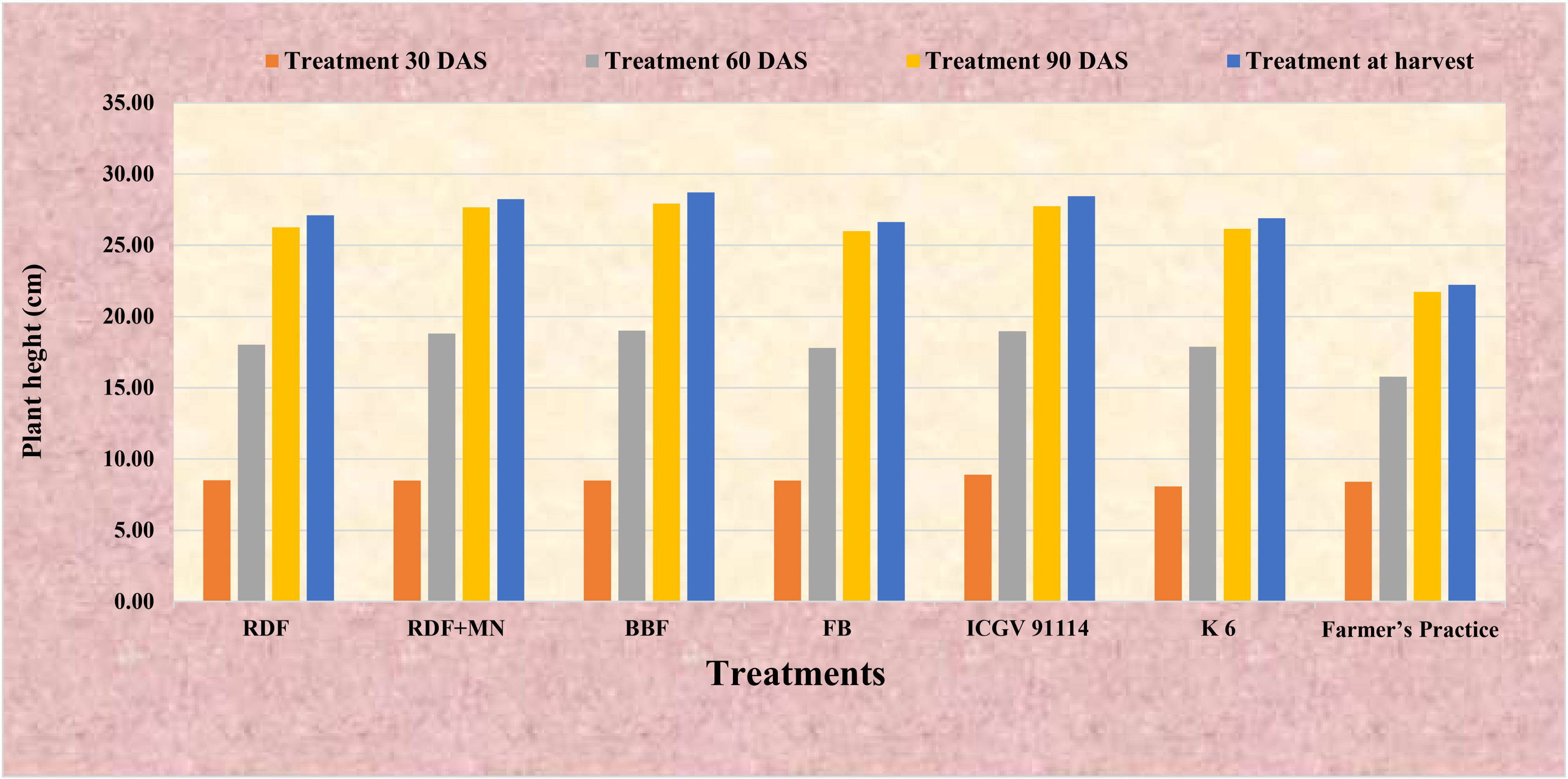


Fig 4.1 Plant height (cm) influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

4.1.1.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lower plant height at 60 DAS (15.80 cm), 90 DAS (21.73 cm) and harvest (22.23 cm) against other treatment throughout the entire growth period except 30 DAS. There was lower plant height it may be due to lack of micro nutrient and variety K 6 was used in this treatment.

4.1.2 Number of branches plant^{-1}

The perusal data shows that the mean number of branches per plant during experiment is presented in the Table 4.2a & 4.2b and also graphically represented in fig 4.2. The number of branches per plant was progressively increased with advancement in growth period of crop.

It was almost steady from 90 DAS to the stage of harvesting. The maximum mean of number of branches per plant was 27.62 recorded at harvest.

4.1.2.1 Nutrients

Number of branches per plant were non-significantly influenced due to both nutrient management practices throughout growth period.

4.1.2.2 Land configuration

Number of branches per plant were non-significantly influenced due to land configuration throughout growth period.

4.1.2.3 Varieties

The number of branches per plant were non-significantly influenced due to varieties at all days of observations. They were significantly higher in the cultivated variety ICGV 91114 at 30 DAS (5.97), 60 DAS (8.43), 90 DAS (28.02) and harvest (28.62). Whereas the lower number of branches per plant were recorded in cultivated variety K 6 at all growth stages.

4.1.2.4 Interaction effect

The interaction effects were non-significant among the various treatments with respect to the number of branches per plant at all growth stages.

Table 4.2a: Number of branches plant^{-1} influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

Treatment			**Number of branches plant^{-1}**			
			30 DAS	**60 DAS**	**90 DAS**	**harvest**
Nutrient	**N_1**	RDF	5.69	8.03	27.30	27.73
	N_2	RDF+MN	5.85	8.20	27.81	28.24
		S.Em ±	**0.10**	**0.10**	**0.31**	**0.32**
		CD (P=0.05)	**NS**	**NS**	**NS**	**NS**
Land configuration	**L_1**	BBF	5.86	8.24	27.80	28.34
	L_2	FB	5.68	7.99	27.31	27.62
		S.Em ±	**0.10**	**0.10**	**0.31**	**0.32**
		CD (P=0.05)	**NS**	**NS**	**NS**	**NS**
Variety	**V_1**	ICGV 91114	5.97	8.43	28.02	28.62
	V_2	K 6	5.57	7.80	27.10	27.34
		S.Em ±	**0.10**	**0.10**	**0.31**	**0.32**
		CD (P=0.05)	**0.29**	**0.30**	**0.90**	**0.92**
Interaction						
NXL			NS	NS	NS	NS
LXV			NS	NS	NS	NS
NXV			NS	NS	NS	NS
NXLXV			NS	NS	NS	NS
General mean			**5.77**	**8.11**	**27.56**	**27.98**
Farmer's practice			5.14	6.92	20.76	21.64
S.Em ±			**0.20**	**0.21**	**0.73**	**0.70**
CD (P=0.05)			**0.57**	**0.59**	**2.10**	**2.02**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.2b: Treatment combination of number of branches plant^{-1} influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

Treatment	**Number of branches plant^{-1}**			
	30 DAS	**60 DAS**	**90 DAS**	**harvest**
$N_1L_1V_1$	8.7	18.72	27.61	28.18
$N_1L_1V_2$	8.06	18.12	26.73	26.98
$N_1L_2V_1$	8.67	18.21	26.27	27.64
$N_1L_2V_2$	8.63	17.13	25.2	25.58
$N_2L_1V_1$	9.14	20.42	29.7	30.44
$N_2L_1V_2$	8.13	18.88	27.55	28.47
$N_2L_2V_1$	9.13	18.54	27.38	27.72
$N_2L_2V_2$	7.57	17.38	25.63	26.16
S.Em ±	**0.44**	**0.51**	**0.47**	**0.45**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**

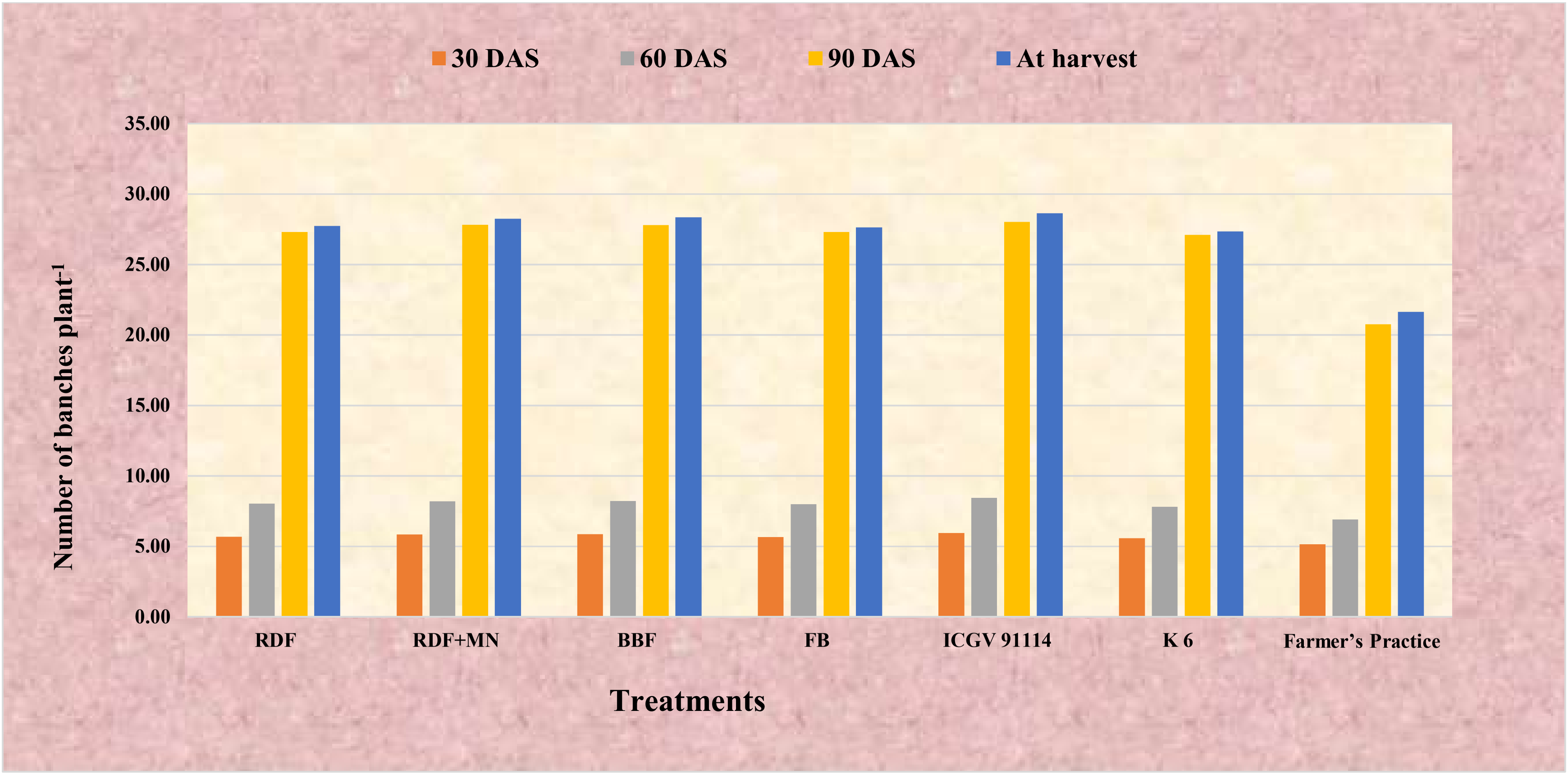


Fig 4.2 Number of branches plant^{-1} influenced by nutrients, land configuration and varieties at 30, 60, 90 DAS and harvest

4.1.2.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lower number of branches per plant at 30 DAS (5.14), 60 DAS (6.92), 90 DAS (20.76) and harvest (21.64) against other treatment throughout the growth period of groundnut.

4.1.3 Leaf area plant^{-1} (cm^2)

The data pertaining to the mean leaf area per plant during experiment is presented in the Table 4.3a, 4.3b, 4.3c and 4.3d. The leaf area per plant was progressively increased with advancement in growth period of crop. The leaf area per plant was varied significantly due to different treatments under experimental programme at 60 DAS and 90 DAS. The maximum general mean of leaf area per plant was 2377.04 cm^2 recorded at 90 DAS.

4.1.3.1 Nutrients

The leaf area per plant was significantly influenced due to nutrients at 90 DAS and harvest. It was significantly higher in the recommended dose of fertilizer along with micro nutrient treatment at 60 DAS (1160.67 cm^2) and 90 DAS (2432.63 cm^2). Whereas, the lowest leaf area per plant was recorded in recommended dose of fertilizer treatment at 60 DAS and 90 DAS. The higher leaf area per plant in the recommended dose of fertilizer along with micro nutrient treatment is might be due to involvement of zinc in various enzyme systems, adequate supply of zinc might have promoted cell division and enlargement, which ultimately resulted in higher leaf area.

4.1.3.2 Land configuration

The leaf area per plant was significantly influenced due to land configuration at 60 DAS and 90 DAS data. They were significantly higher in the broad bed and furrow at 60 DAS (1175.03 cm^2) and 90 DAS (2455.70 cm^2). Whereas, the lowest leaf area per plant was recorded in flat bed at 60 DAS and 90 DAS data. Kadam *et al*. (2000) reported broad bed and furrow recorded the highest leaf area per plant over border method and ridges and furrows methods in groundnut crop.

Table 4.3a: Leaf area plant^{-1} (cm^2) at influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment			Leaf area plant^{-1} (cm^2)		
			30 DAS	**60 DAS**	**90 DAS**
Nutrient	**N_1**	RDF	332.77	1033.91	2321.45
	N_2	RDF+MN	340.25	1160.67	2432.63
		S.Em ±	**6.80**	**20.87**	**29.16**
		CD (P=0.05)	**NS**	**60.46**	**84.46**
Land configuration	**L_1**	BBF	344.56	1175.03	2455.70
	L_2	FB	328.45	1019.54	2298.38
		S.Em ±	**6.80**	**20.87**	**29.16**
		CD (P=0.05)	**NS**	**60.46**	**84.46**
Variety	**V_1**	ICGV 91114	344.07	1162.35	2425.42
	V_2	K 6	328.95	1032.23	2328.66
		S.Em ±	**6.80**	**20.87**	**29.16**
		CD (P=0.05)	**NS**	**60.46**	**84.46**
Interaction					
NXL			NS	S	S
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**336.51**	**1097.29**	**2377.04**
Farmer's practice			245.37	910.98	1846.79
S.Em ±			**13.35**	**41.61**	**60.09**
CD(P=0.05)			**38.45**	**119.86**	**173.10**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.3b: Treatment combination of leaf area plant^{-1} (cm^2) influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment	Leaf area plant^{-1} (cm^2)		
	30 DAS	**60 DAS**	**90 DAS**
$N_1L_1V_1$	343.23	1151.23	2428.31
$N_1L_1V_2$	322.71	976.42	2271.80
$N_1L_2V_1$	332.77	1031.57	2348.89
$N_1L_2V_2$	332.35	976.42	2236.81
$N_2L_1V_1$	365.81	1372.19	2568.53
$N_2L_1V_2$	346.49	1200.30	2554.16
$N_2L_2V_1$	334.46	1094.40	2355.94
$N_2L_2V_2$	314.23	975.78	2251.87
S.Em ±	**13.60**	**41.74**	**58.31**
CD (P=0.05)	**NS**	**NS**	**NS**

4.1.3.3 Varieties

The leaf area per plant was significantly influenced due to varieties at all days of observations. They were significantly higher in the cultivated variety ICGV 91114 at 30 DAS (344.07 cm^2), 60 DAS (1162.35 cm^2) and 90 DAS (2425.42 cm^2). Whereas, lowest leaf area per plant was recorded in cultivated variety K 6 at all growth stages.

4.1.3.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration at 60 DAS and 90 DAS observation which are represented in Table 4.3c and 4.3d. The leaf area per plant was significantly higher *i.e.* 1286.25 and 2561.35 cm^2 at 60 DAS and 90 DAS in the combination of recommended dose of fertilizer along with micro nutrient and broad bed and furrow treatment. Whereas, other treatment combination registered lower leaf area per plant at 60 DAS and 90 DAS.

Table 4.3 c: Interaction effect of nutrient and land configuration on leaf area plant^{-1} (cm^2) at 60 DAS

	Leaf area plant^{-1} (cm^2) at 60 DAS	
	L_1:BBF	**L_2:FB**
N_1:RDF	1063.82	1003.99
N_2 :RDF + MN	1286.25	1035.09
S.Em ±	**29.52**	
CD (P=0.05)	**85.5**	

Table 4.3 d: Interaction effect of nutrient and land configuration on leaf area plant^{-1} (cm^2) at 90 DAS

	Leaf area plant^{-1} (cm^2) at 90 DAS	
	L_1:BBF	**L_2:FB**
N_1:RDF	2350.05	2292.85
N_2 :RDF + MN	2561.35	2303.91
S.Em ±	**41.23**	
CD (P=0.05)	**119.45**	

4.1.3.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lowest leaf area per plant at 30 DAS (245.37 cm^2), 60 DAS (910.98 cm^2) and 90 DAS (1846.79 cm^2) against other treatment throughout the entire growth period of groundnut.

4.1.4 Total dry matter (g $plant^{-1}$)

The mean total dry matter per plant of groundnut in different interval of time as influenced by different treatment combination of nutrients, land configuration and varieties are presented in Table 4.4a, 4.4b, 4.4c & 4.4d and also graphically represented in fig 4.3.

The total dry matter per plant was increased with advancement in crop growth. The highest general mean of total dry matter was observed 36.05 g $plant^{-1}$ at 90 DAS.

4.1.4.1 Nutrients

The total dry matter per plant was not significantly influenced due to nutrients at 30 DAS but significantly differed at 60 and 90 DAS observation of experiment. It was significantly higher in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) treatment at 60 DAS (12.32 g $plant^{-1}$) and 90 DAS (36.70 g $plant^{-1}$). Whereas, the lowest total dry matter per plant was recorded in only recommended dose of fertilizer treatment at both 60 and 90 DAS except 30 DAS. The recommended dose of fertilizer along with micro nutrient treatment found higher values because groundnut respond very well to zinc, which will enhance the nitrogen assimilation and carbohydrate metabolism .

4.1.4.2 Land configuration

The total dry matter per plant was significantly influenced due to land configuration at 30, 60 and 90 DAS. It was significantly higher in the broad bed and furrow treatment at 30 DAS (3.61 g $plant^{-1}$), 60 DAS (12.40 g $plant^{-1}$) and 90 DAS (37.11 g $plant^{-1}$).

Table 4.4a: Total dry matter (g plant^{-1}) influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment			**Total dry matter (g plant^{-1})**		
			30 DAS	**60 DAS**	**90 DAS**
Nutrient	**N$_1$**	RDF	3.32	11.06	35.40
	N$_2$	RDF+MN	3.54	12.32	36.70
		S.Em ±	**0.09**	**0.19**	**0.41**
		CD (P=0.05)	**NS**	**0.56**	**1.18**
Land configuration	**L$_1$**	BBF	3.61	12.40	37.11
	L$_2$	FB	3.24	10.99	35.00
		S.Em ±	**0.09**	**0.19**	**0.41**
		CD (P=0.05)	**0.25**	**0.56**	**1.18**
Variety	**V$_1$**	ICGV 91114	3.60	12.50	36.67
	V$_2$	K 6	3.26	10.89	35.44
		S.Em ±	**0.09**	**0.19**	**0.41**
		CD (P=0.05)	**0.25**	**0.56**	**1.18**
Interaction					
NXL			NS	S	S
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			3.43	11.69	36.05
Farmer's practice			2.46	9.49	27.11
S.Em ±			**0.17**	**0.37**	**0.81**
CD (P=0.05)			**0.49**	**1.07**	**2.32**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.4b: Treatment combination of total dry matter (g) influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment	**Total dry matter (g plant^{-1})**		
	30 DAS	**60 DAS**	**90 DAS**
$N_1L_1V_1$	3.70	11.96	36.18
$N_1L_1V_2$	3.20	10.61	35.49
$N_1L_2V_1$	3.25	11.83	35.54
$N_1L_2V_2$	3.15	9.85	34.40
$N_2L_1V_1$	4.10	14.36	39.23
$N_2L_1V_2$	3.45	12.66	37.53
$N_2L_2V_1$	3.35	11.85	35.72
$N_2L_2V_2$	3.24	10.43	34.33
S.Em ±	**0.17**	**0.38**	**0.82**
CD (P=0.05)	**NS**	**NS**	**NS**

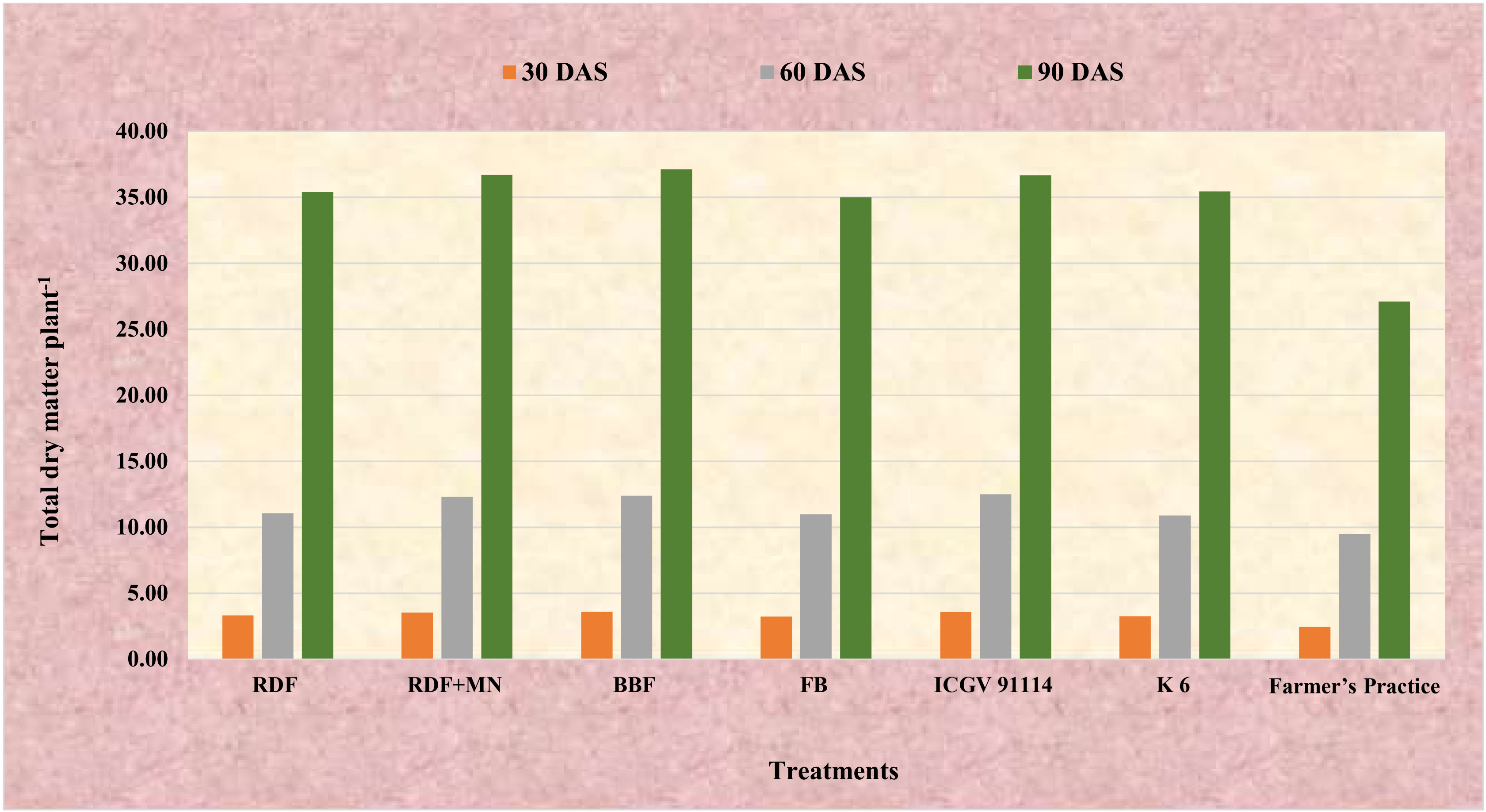


Fig 4.3 Total dry matter (g plant^{-1}) influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Whereas, the lowest total dry matter was recorded in flat bed treatment at all growth stages. The same result was reported by Kadam *et al.* (2000), Vaghasia *et al*. (2007) and Patil *et al.* (2007) with respect to broad bed and furrow.

4.1.4.3 Varieties

The total dry matter per plant was significantly influenced due to varieties in all three observations. It was significantly higher in the cultivated variety ICGV 91114 at 30 DAS (3.60 g plant^{-1}), 60 DAS (12.50 g plant^{-1}) and 90 DAS (36.67 g plant^{-1}). Whereas, the lowest total dry matter was recorded in cultivated variety K 6 at all observation.

4.1.4.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration at 60 DAS and 90 DAS observation which are represented in Table 4.4c and 4.4d. The total dry matter per plant was significantly higher *i.e.* 13.51 g plant^{-1} and 38.38 g plant^{-1} at 60 DAS and 90 DAS respectively in the combination of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1} & Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lowest total dry matter at 60 DAS and 90 DAS.

4.1.4.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lowest total dry matter per plant at 30 DAS (2.46 g plant^{-1}), 60 DAS (9.49 g plant^{-1}) and 90 DAS (27.11 g plant^{-1}) against other treatment in all observation.

Table 4.4 c: Interaction effect of nutrient and land configuration on total dry matter (g plant^{-1}) at 60 DAS

	Total dry matter (g plant^{-1}) at 60 DAS	
	L_1:BBF	**L_2:FB**
N_1:RDF	11.29	10.84
N_2 :RDF + MN	13.51	11.14
S.Em ±	**0.27**	
CD (P=0.05)	**0.79**	

Table 4.4 d: Interaction effect of nutrient and land configuration on total dry matter (g plant^{-1}) at 90 DAS

Total dry matter (g plant^{-1}) at 90 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	35.84	34.97
N_2 :RDF + MN	38.38	35.03
S.Em ±	**0.58**	
CD (P=0.05)	**1.68**	

4.1.5 Leaf area index

The observation on leaf area index of groundnut at 30, 60, and 90 DAS are presented in Table 4.5a, 4.5b, 4.5c & 4.5d and Fig 4.4. At 30 DAS, leaf area index did not differ significantly among the eight treatment treatments but against farmer's practice it was significantly differed in all observation of the experiment.

It is a resultant of leaf area from which the leaf area index was formed by certain formula.

4.1.5.1 Nutrients

There was no significant difference observed at 30 DAS but at 60 and 90 DAS significant difference was observed in leaf area index of groundnut. It was significantly higher in the recommended dose of fertilizer along with micro nutrient treatment at 60 DAS (3.87) and 90 DAS (8.11). Whereas, the lowest leaf area index was recorded in only recommended dose of fertilizer treatment at both 60 and 90 DAS except 30 DAS.

4.1.5.2 Land configuration

There was a significant difference among the treatment 60 and 90 DAS but not at 30 DAS in the leaf area index of groundnut. It was significantly superior value found in the broad bed and furrow treatment at 60 DAS (3.92) and 90 DAS (8.19). Whereas, the inferior value of leaf area index of groundnut was recorded in flat bed treatment at all growth stages excluding the 30 DAS observation.

4.1.5.3 Varieties

The leaf area index was significantly influenced due to varieties in 60 and 90 DAS observations.

Table 4.5a: Leaf area index land configuration and varieties influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment			Leaf area index		
			30 DAS	60 DAS	90 DAS
Nutrient	**N_1**	RDF	1.11	3.45	7.74
	N_2	RDF+MN	1.13	3.87	8.11
		S.Em ±	**0.02**	**0.07**	**0.10**
		CD (P=0.05)	**NS**	**0.20**	**0.28**
Land configuration	**L_1**	BBF	1.15	3.92	8.19
	L_2	FB	1.09	3.40	7.66
		S.Em ±	**0.02**	**0.07**	**0.10**
		CD (P=0.05)	**NS**	**0.20**	**0.28**
Variety	**V_1**	ICGV 91114	1.15	3.87	8.08
	V_2	K 6	1.10	3.44	7.76
		S.Em ±	**0.02**	**0.07**	**0.10**
		CD (P=0.05)	**NS**	**0.20**	**0.28**
Interaction					
NXL			NS	S	S
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**1.12**	**3.66**	**7.92**
Farmer's practice			0.82	3.04	6.16
S.Em ±			**0.05**	**0.14**	**0.20**
CD (P=0.05)			**0.13**	**0.40**	**0.58**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.5b: Treatment combination of leaf area index influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

Treatment	Leaf area index		
	30 DAS	60 DAS	90 DAS
$N_1L_1V_1$	1.14	3.84	8.09
$N_1L_1V_2$	1.08	3.25	7.57
$N_1L_2V_1$	1.11	3.44	7.83
$N_1L_2V_2$	1.11	3.25	7.46
$N_2L_1V_1$	1.22	4.57	8.56
$N_2L_1V_2$	1.15	4.00	8.51
$N_2L_2V_1$	1.11	3.65	7.85
$N_2L_2V_2$	1.05	3.25	7.51
S.Em ±	**0.05**	**0.14**	**0.19**
CD (P=0.05)	**NS**	**NS**	**NS**

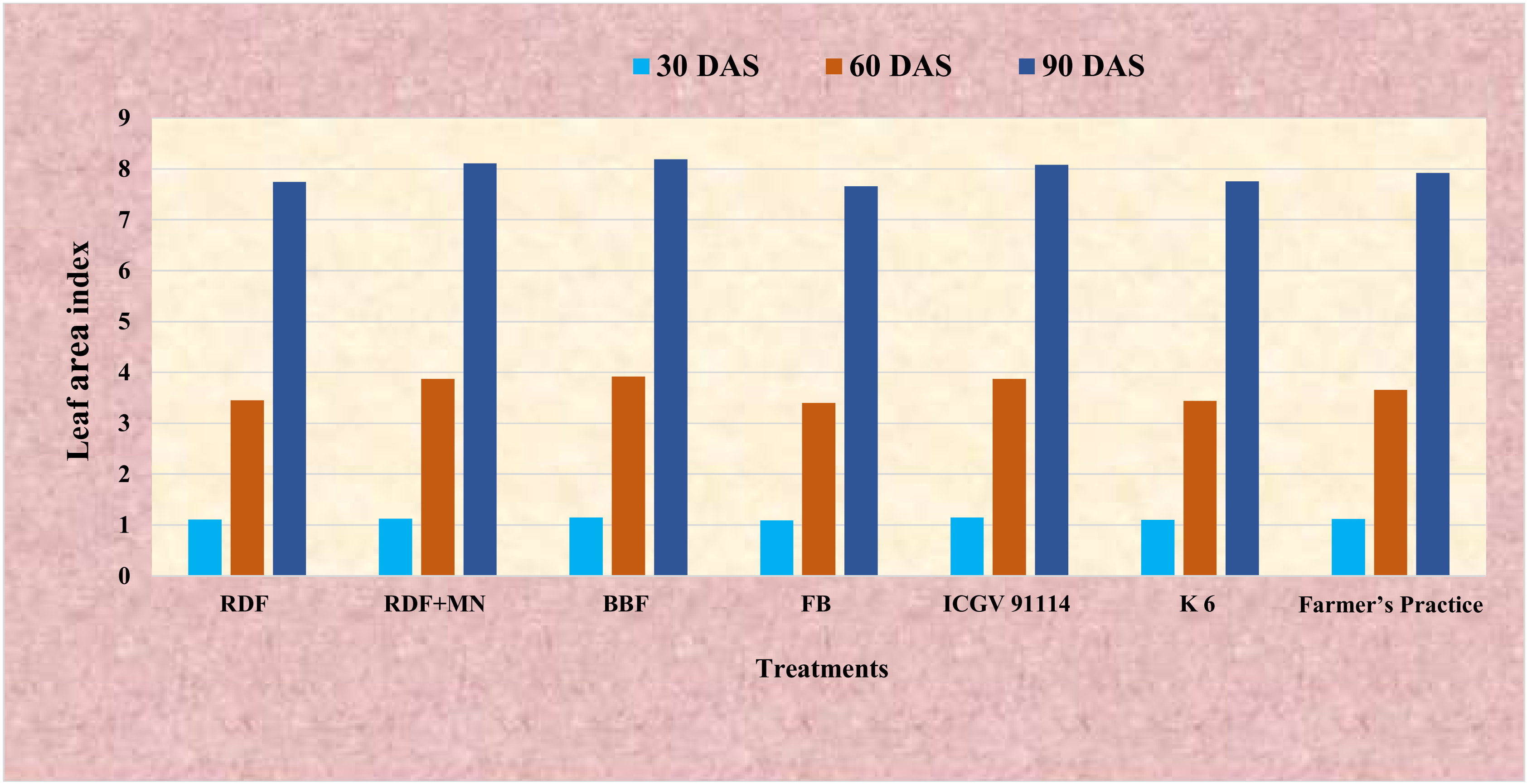


Fig 4.4 Leaf area index influenced by nutrients, land configuration and varieties at 30, 60 and 90 DAS

It was significantly higher in the cultivated variety ICGV 91114 at 60 DAS (3.87) and 90 DAS (8.08). Whereas, lowest leaf area index was recorded in cultivated variety K 6 at all observation.

4.1.5.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration at 60 DAS and 90 DAS observation which are represented in table 4.5c and 4.5d.

The leaf area index was significantly higher *i.e.* 4.29 and 8.54 at 60 DAS and 90 DAS respectively in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lowest leaf area index at 60 DAS and 90 DAS.

Table 4.5 c: Interaction effect of nutrient and land configuration on leaf area index at 60 DAS

Leaf area index at 60 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	3.55	3.35
N_2 :RDF + MN	4.29	3.45
S.Em ±	**0.1**	
CD (P=0.05)	**0.29**	

Table 4.5 d: Interaction effect of nutrient and land configuration on leaf area index at 90 DAS

Leaf area index at 90 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	7.83	7.64
N_2 :RDF + MN	8.54	7.68
S.Em ±	**0.14**	
CD (P=0.05)	**0.40**	

4.1.5.5 Farmer’s practice vs other treatments

The farmer’s practice registered significantly lowest leaf area index at 30 DAS (0.82), 60 DAS (3.04) and 90 DAS (6.16) against other treatment in all observation.

4.1.6 Crop growth rate (g day^{-1} plant^{-1})

The observation on crop growth rate of groundnut at 0-30, 30-60 and 60-90 DAS are presented in Table 4.6a, 4.6b & 4.6c and Fig.4.5

4.1.6.1 Nutrients

There was no significant difference observed at 0-30 and 60-90 DAS but at 30-60 DAS significant difference was observed in crop growth rate of groundnut. It was significantly higher in the recommended dose of fertilizer along with micro nutrient treatment at 30-60 DAS (0.293 g day^{-1} plant^{-1}). Whereas, the lowest crop growth rate (0.258 g day^{-1} plant^{-1}) was recorded in only recommended dose of fertilizer treatment at both 30-60 DAS. Increased dry matter production under recommended dose of fertilizer along with micro nutrient treatment evidently resulted in higher crop growth rate.

4.1.6.2 Land configuration

There was a significant difference among the treatment 0-30 and 30-60 DAS but not at 60-90 DAS in the crop growth rate of groundnut. It was significantly superior value found in the broad bed and furrow treatment at 0-30 DAS (0.120 g day^{-1} plant^{-1}) and 30-60 DAS (0.293 g day^{-1} plant^{-1}). Whereas, the inferior value of crop growth rate of groundnut was recorded in flat bed treatment at all growth stages excluding the 60-90 DAS observation. Increased dry matter production under broad bed and furrow treatment directly propositional to crop growth.

4.1.6.3 Varieties

The crop growth rate was significantly influenced due to varieties in 0-30 and 30-60 DAS observations. It was significantly higher in the cultivated variety ICGV 91114 at 0-30 DAS (0.120 g day^{-1} plant^{-1}) and 30-60 DAS (0.297 g day^{-1} plant^{-1}). Whereas, the lowest crop growth rate was recorded in cultivated variety K 6 at all observation. The dry matter production was higher in the cultivated variety ICGV 91114 which leads to resultant higher crop growth rate.

4.1.6.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration at 30-60 DAS observation which is represented in table 4.6c.

Table 4.6a: Crop growth rate (g day^{-1} plant^{-1}) influenced by nutrients, land configuration and varieties at 0-30, 30-60 and 60-90 DAS

Treatment			**Crop growth rate (g day^{-1} plant^{-1})**		
			0-30 DAS	**30-60 DAS**	**60-90 DAS**
Nutrient	**N_1**	RDF	0.111	0.258	0.811
	N_2	RDF+MN	0.118	0.293	0.813
		S.Em ±	**0.003**	**0.006**	**0.017**
		CD (P=0.05)	**NS**	**0.018**	**NS**
Land configuration	**L_1**	BBF	0.120	0.293	0.824
	L_2	FB	0.108	0.258	0.800
		S.Em ±	**0.003**	**0.006**	**0.017**
		CD (P=0.05)	**0.008**	**0.018**	**NS**
Variety	**V_1**	ICGV 91114	0.120	0.297	0.806
	V_2	K 6	0.109	0.254	0.818
		S.Em ±	**0.003**	**0.006**	**0.017**
		CD (P=0.05)	**0.008**	**0.018**	**NS**
Interaction					
NXL			NS	S	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**0.114**	**0.275**	**0.812**
Farmer's practice			0.082	0.234	0.587
S.Em ±			**0.006**	**0.012**	**0.032**
CD (P=0.05)			**0.016**	**0.036**	**0.093**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.6b: Treatment combination of crop growth rate (g day^{-1} plant^{-1}) influenced by nutrients, land configuration and varieties at 0-30, 30-60 and 60-90 DAS

Treatment	**Crop growth rate (g day^{-1} plant^{-1})**		
	0-30 DAS	**30-60 DAS**	**60-90 DAS**
$N_1L_1V_1$	0.123	0.275	0.807
$N_1L_1V_2$	0.107	0.247	0.829
$N_1L_2V_1$	0.108	0.286	0.790
$N_1L_2V_2$	0.105	0.223	0.818
$N_2L_1V_1$	0.137	0.342	0.829
$N_2L_1V_2$	0.115	0.307	0.829
$N_2L_2V_1$	0.112	0.283	0.796
$N_2L_2V_2$	0.108	0.240	0.797
S.Em ±	**0.006**	**0.013**	**0.033**
CD(P=0.05)	**NS**	**NS**	**NS**

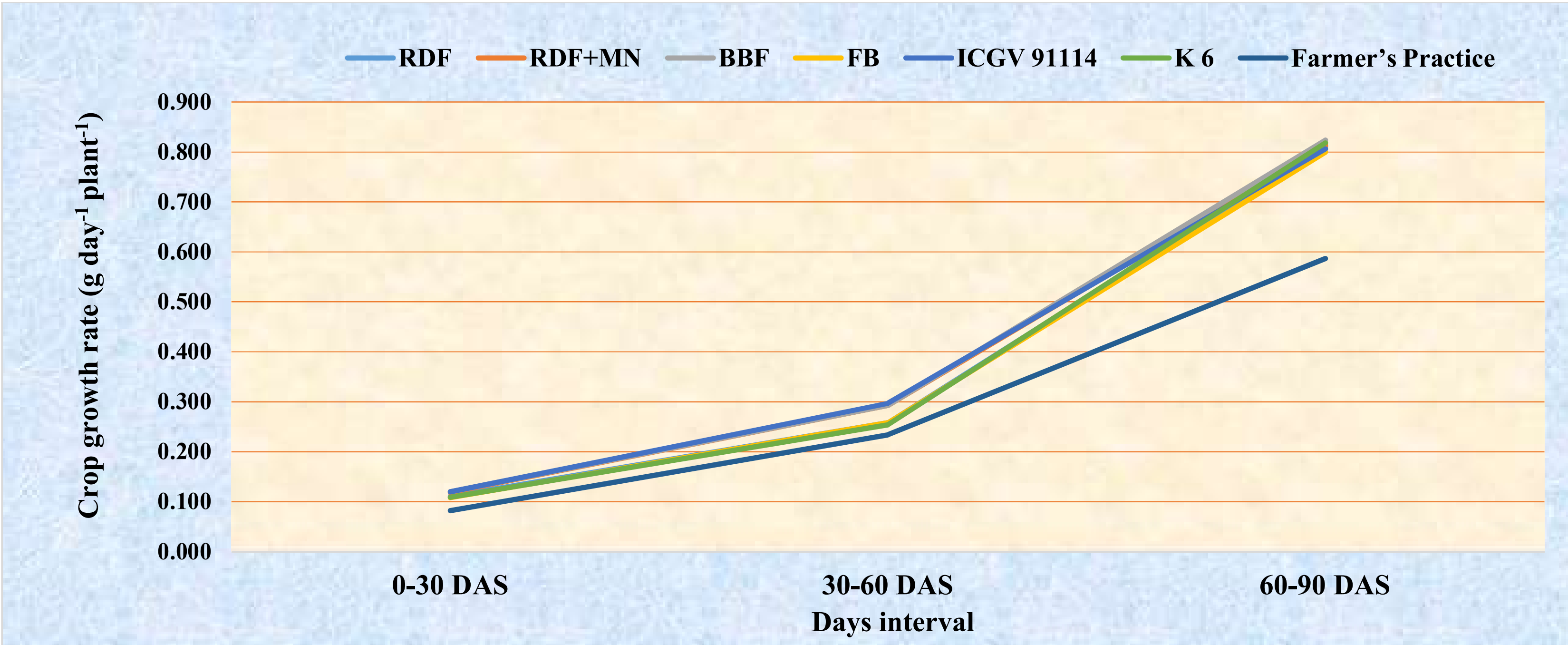


Fig 4.5 Crop growth rate (g day^{-1} $plant^{-1}$) influenced by nutrients, land configuration and varieties at 0-30, 30-60 and 60-90 DAS

The crop growth rate was significantly higher *i.e.* 0.324 g day^{-1} plant^{-1} at 30-60 DAS in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment. Whereas, other treatment combination registered lowest crop growth rate at 30-60 DAS.

Table 4.6 c: Interaction effect of nutrient and land configuration on crop growth rate (g day^{-1} plant^{-1}) at 30-60 DAS

Crop growth rate (g day^{-1} plant^{-1}) at 30-60 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	0.261	0.255
N_2 :RDF + MN	0.324	0.262
S.Em ±	**0.009**	
CD (P=0.05)	**0.026**	

4.1.6.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lowest crop growth rate at 0-30 DAS (0.082 g day^{-1} plant^{-1}), 30-60 DAS (0.234 g day^{-1} plant^{-1}) and 60-90 DAS (0.587 g day^{-1} plant^{-1}) against other treatment in all observation.

4.1.7 Relative growth rate (g g^{-1} day^{-1})

The observation on relative growth rate of groundnut at 0-30, 30-60 and 60-90 DAS are presented in Table 4.7a, 4.7b & 4.7c and Fig 4.6.

There was a significant difference was observed in 0-30 and 30-60 DAS observation but not at 60-90 DAS observation.

4.1.7.1 Nutrients

There was significant difference observed in relative growth rate of groundnut at 30-60 DAS but not at 0-30 and 60-90 DAS. It was significantly higher in the micro nutrient treatment at 30-60 DAS was (0.0313 g g^{-1} day^{-1} plant^{-1}). Whereas, the lowest relative growth rate at 30-60 DAS (0.0295 g g^{-1} day^{-1} plant^{-1}) was recorded in only recommended dose of fertilizer treatment.

4.1.7.2 Land configuration

There was significant difference observed in relative growth rate of groundnut at 0-30 and 30-60 DAS but not at 60-90 DAS.

4.7a: Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$) influenced by nutrients, land configuration and varieties at 0-30, 30-60 and 60-90 DAS

Treatment			Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$)		
			0-30 DAS	**30-60 DAS**	**60-90 DAS**
Nutrient	**N_1**	RDF	0.0173	0.0295	0.0459
	N_2	RDF+MN	0.0181	0.0313	0.0458
		S.Em±	**0.0004**	**0.0003**	**0.0003**
		CD (P=0.05)	**NS**	**0.0010**	**NS**
Land configuration	**L_1**	BBF	0.0185	0.0313	0.0461
	L_2	FB	0.0169	0.0294	0.0457
		S.Em±	**0.0004**	**0.0003**	**0.0003**
		CD (P=0.05)	**0.0011**	**0.0010**	**NS**
Variety	**V_1**	ICGV 91114	0.0184	0.0315	0.0458
	V_2	K 6	0.0170	0.0292	0.0460
		S.Em±	**0.0004**	**0.0003**	**0.0003**
		CD (P=0.05)	**0.0011**	**0.0010**	**NS**
Interaction					
NXL			NS	S	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**0.0177**	**0.0304**	**0.0459**
Farmer's practice			0.0129	0.0280	0.0413
S.Em ±			**0.0008**	**0.0007**	**0.0006**
CD (P=0.05)			**0.0022**	**0.0020**	**0.0017**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

4.7b: Treatment combination of relative growth rate (g g^{-1} day^{-1} $plant^{-1}$) influenced by nutrients, land configuration and varieties at 0-30, 30 –60 and 60-90 DAS

Treatment	Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$)		
	0 -30 DAS	**30-60 DAS**	**60-90 DAS**
$N_1L_1V_1$	0.0188	0.0304	0.0458
$N_1L_1V_2$	0.0167	0.0289	0.0462
$N_1L_2V_1$	0.0170	0.0274	0.0456
$N_1L_2V_2$	0.0165	0.0310	0.0461
$N_2L_1V_1$	0.0203	0.0336	0.0462
$N_2L_1V_2$	0.0179	0.0321	0.0461
$N_2L_2V_1$	0.0174	0.0309	0.0455
$N_2L_2V_2$	0.0168	0.0285	0.045
S.Em ±	**0.0007**	**0.0007**	**0.0006**
CD (P=0.05)	**NS**	**NS**	**NS**

Fig 4.5 Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$) influenced by nutrients, land configuration and varieties at 0-30, 30-60 and 60-90 DAS

It was significantly higher in the only broad bed and furrow treatment at 0-30 DAS (0.0185 g g^{-1} day^{-1} $plant^{-1}$) and 30-60 DAS was (0.0313 g g^{-1} day^{-1} $plant^{-1}$). Whereas, the lowest relative growth rate at 0-30 DAS (0.0169 g g^{-1} day^{-1} $plant^{-1}$) and 30-60 DAS (0.0294 g g^{-1} day^{-1} $plant^{-1}$) was recorded in flat bed treatment.

4.1.7.3 Varieties

There was significant difference observed in relative growth rate of groundnut at 0-30 and 30-60 DAS but not at 60-90 DAS. It was significantly higher in the only cultivated variety ICGV 91114 treatment at 0-30 DAS (0.0184 g g^{-1} day^{-1} $plant^{-1}$) and 30-60 DAS was (0.0315 g g^{-1} day^{-1} $plant^{-1}$). Whereas, the lowest relative growth rate at 0-30 DAS (0.0170 g g^{-1} day^{-1} $plant^{-1}$) 30-60 DAS (0.0292 g g^{-1} day^{-1} $plant^{-1}$) was recorded in cultivated variety K 6.

4.1.7.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration at 30-60 DAS observation which is represented in Table 4.6c. The relative growth rate was significantly higher *i.e.* 0.0328 g g^{-1} day^{-1} $plant^{-1}$ at 30-60 DAS in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment. Whereas, other treatment combination registered lowest relative growth rate at 30-60 DAS.

Table 4.7 c: Interaction effect of nutrient and land configuration on relative growth rate (g day^{-1} $day^{-1}plant^{-1}$) at 30-60 DAS

	Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$) at 30-60 DAS	
	L_1:BBF	**L_2:FB**
N_1:RDF	0.0297	0.0292
N_2 :RDF + MN	0.0328	0.0297
S.Em ±	**0.0005**	
CD (P=0.05)	**0.0014**	

4.1.7.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lowest relative growth rate at 30-60 DAS (0.0349 g g^{-1} day^{-1} $plant^{-1}$) against other treatment in all observation.

4.2 Yield and yield components of groundnut

4.2.1 Number of pods plant^{-1}

The data is concerned to number of pods per plant presented in the Table 4.8a, 4.8b and 4.8c. There was a significant difference found in number of pods per plant due to varied treatments. The mean number of pods per plant were 35.39.

4.2.1.1 Nutrients

There were significantly maximal number of pods per plant in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) treatment (37.02). Though, the minimal number of pods per plant were recorded in only recommended dose of fertilizer treatment (33.76).

4.2.1.2 Land configuration

There were significantly superior number of pods per plant found in the broad bed and furrow treatment (38.26). While, the inferior number of pods per plant of groundnut was recorded in flat bed treatment (32.52). It might be because of higher moisture retaining capacity and absorption capacity of broad bed and furrow treatment. Kantwa *et al*. (2005) reported higher number of pods per plant in pigeon pea under broad bed and furrow treatment.

4.2.1.3 Varieties

There were significantly higher number of pods per plant observed in the cultivated variety ICGV 91114 (37.59). Whereas, the lower number of pods per plant were recorded in cultivated variety K 6 (33.19).

4.2.1.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration observation. Those are represented in table 4.8c. The number of pods per plant were significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment (41.06). Whereas, other treatment combination registered lower number of pods per plant.

Table 4.8a: Number of pods plant^{-1} and weight of pods plant^{-1} influenced by nutrients, land configuration and varieties

Treatment			Number of pods plant^{-1}	Weight of pod plant^{-1} (g)
Nutrient	**N_1**	RDF	33.76	28.37
	N_2	RDF+MN	37.02	32.70
		S.Em ±	**0.80**	**0.94**
		CD (P=0.05)	**2.31**	**2.71**
Land configuration	**L_1**	BBF	38.26	33.21
	L_2	FB	32.52	27.86
		S.Em ±	**0.80**	**0.94**
		CD (P=0.05)	**2.31**	**2.71**
Variety	**V_1**	ICGV 91114	37.59	32.57
	V_2	K 6	33.19	28.49
		S.Em ±	**0.80**	**0.94**
		CD (P=0.05)	**2.31**	**2.71**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**35.39**	**30.53**
Farmer's practice			23.80	23.80
S.Em ±			**1.59**	**1.59**
CD (P=0.05)			**4.57**	**4.57**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.8b: Treatment combination of number of pods plant^{-1} and weight of pods plant^{-1} influenced by nutrients, land configuration and varieties

Treatment	Number of pods plant^{-1}	Weight of pods plant^{-1} (g)
$N_1L_1V_1$	38.32	32.10
$N_1L_1V_2$	32.60	26.87
$N_1L_2V_1$	34.52	28.67
$N_1L_2V_2$	29.60	25.84
$N_2L_1V_1$	41.81	38.99
$N_2L_1V_2$	40.31	34.88
$N_2L_2V_1$	35.72	30.54
$N_2L_2V_2$	30.24	26.38
S.Em ±	**1.60**	**1.87**
CD (P=0.05)	**NS**	**NS**

Fig 4.7 Weight of pods plant^{-1} influenced by nutrients, land configuration and varieties

Table 4.8 c: Effect of nutrient and land configuration on of number of pods plant^{-1}

Number of pods plant^{-1}		
	L_1:BBF	**L_2:FB**
N_1:RDF	35.46	32.06
N_2 :RDF + MN	41.06	32.98
S.Em ±	**1.13**	
CD (P=0.05)	**3.27**	

4.2.1.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lower number of pods per plant (23.80) against other treatments.

4.2.2 Weight of pods plant^{-1} (g)

The data is concerned to weight of pods per plant presented in the Table 4.8a, 4.8b. & 4.8c. And graphically represented in fig. 4.7. There was a significant difference found in number of pods per plant due to varied treatments. The mean weight of pods per plant was 30.53 gram.

4.2.2.1 Nutrients

There was significantly supreme weight of pods per plant in the recommended dose of fertilizer along with micro nutrient treatment (32.70 g). Though, the minimal weight of pods per plant was recorded in only recommended dose of fertilizer treatment (28.37 g).

4.2.2.2 Land configuration

There was significantly superior weight of pods per plant found in the broad bed and furrow treatment (33.21 g). While, the inferior weight of pods per plant of groundnut was recorded in flat bed treatment (27.86 g). Broad bed and furrow having higher value this might be due to higher trend in growth attributes finally resulted into higher pod per plant. Patil *et al.* (2007) found the same results in broad bed and furrow method of planting in groundnut crop.

4.2.2.3 Varieties

There was significantly highest weight of pods per plant observed in the cultivated variety ICGV 91114 (32.57 g). Whereas, the lowest weight of pods per plant was recorded in cultivated variety K 6 (28.49 g).

4.2.2.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration observation. Those are represented in table 4.8d. The number of pods per plant were significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment (41.06). Whereas, other treatment combination registered lower weight of pods per plant.

Table 4.8 d: Effect of nutrient and land configuration on weight of pods plant^{-1} (g)

Weight of pods plant^{-1} (g)

	L_1:BBF	**L_2:FB**
N_1:RDF	29.48	27.25
RDF + MN : N_2	36.93	28.46
S.Em ±	**1.32**	
CD (P=0.05)	**3.84**	

4.2.2.5 Farmer's practice vs other treatments

The farmer's practice registered significantly lower number of pods per plant (23.80) against other treatments.

4.2.3 Pod yield (kg ha^{-1})

The data is related to pod yield presented in the Table 4.9a, 4.9b and 4.9c, graphically represented in Fig. 4.8. It is clear from the data a significant difference found in pod yield (kg ha^{-1}) due to various treatments. The mean pod yield was 1514.00 kg ha^{-1}.

4.2.3.1 Nutrients

There was significantly greater pod yield in the recommended dose of fertilizer along with micro nutrient treatment (1633.95 kg ha^{-1}). Though, the lowest pod yield was recorded in only recommended dose of fertilizer treatment (1394.04 kg ha^{-1}).

Table 4.9 a: Pod, haulm yield (kg ha^{-1}) and harvest index influenced by nutrients, land configuration and varieties

Treatment			Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	H.I
Nutrient	**N_1**	RDF	1394.04	1766.73	0.440
	N_2	RDF+MN	1633.95	2059.89	0.442
		S.Em ±	**34.39**	**52.28**	**0.005**
		CD (P=0.05)	**99.63**	**151.45**	**NS**
Land configuration	**L_1**	BBF	1697.69	2143.89	0.441
	L_2	FB	1330.30	1682.73	0.441
		S.Em ±	**34.39**	**52.28**	**0.005**
		CD (P=0.05)	**99.63**	**151.45**	**NS**
Variety	**V_1**	ICGV 91114	1616.91	1913.31	0.458
	V_2	K 6	1411.08	1913.31	0.424
		S.Em ±	**34.39**	**52.28**	**0.005**
		CD (P=0.05)	**99.63**	**NS**	**0.014**
Interaction					
NXL			S	S	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**1514.00**	**1913.31**	**0.441**
Farmer's practice			1072.80	1453.04	0.424
S.Em ±			**66.01**	**101.16**	**0.009**
CD (P=0.05)			**190.16**	**291.41**	**0.027**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.9 b: Treatment combination of pod, haulm yield (kg ha^{-1}) and harvest index influenced by nutrients, land configuration and varieties

Treatment	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	H.I
$N_1L_1V_1$	1560.33	1907.18	0.450
$N_1L_1V_2$	1395.70	1925.05	0.422
$N_1L_2V_1$	1429.03	1611.23	0.468
$N_1L_2V_2$	1191.11	1623.45	0.420
$N_2L_1V_1$	2025.80	2391.86	0.458
$N_2L_1V_2$	1808.94	2351.46	0.435
$N_2L_2V_1$	1452.49	1742.98	0.455
$N_2L_2V_2$	1248.57	1753.25	0.420
S.Em ±	**68.78**	**104.56**	**0.010**
CD (P=0.05)	**NS**	**NS**	**0.028**

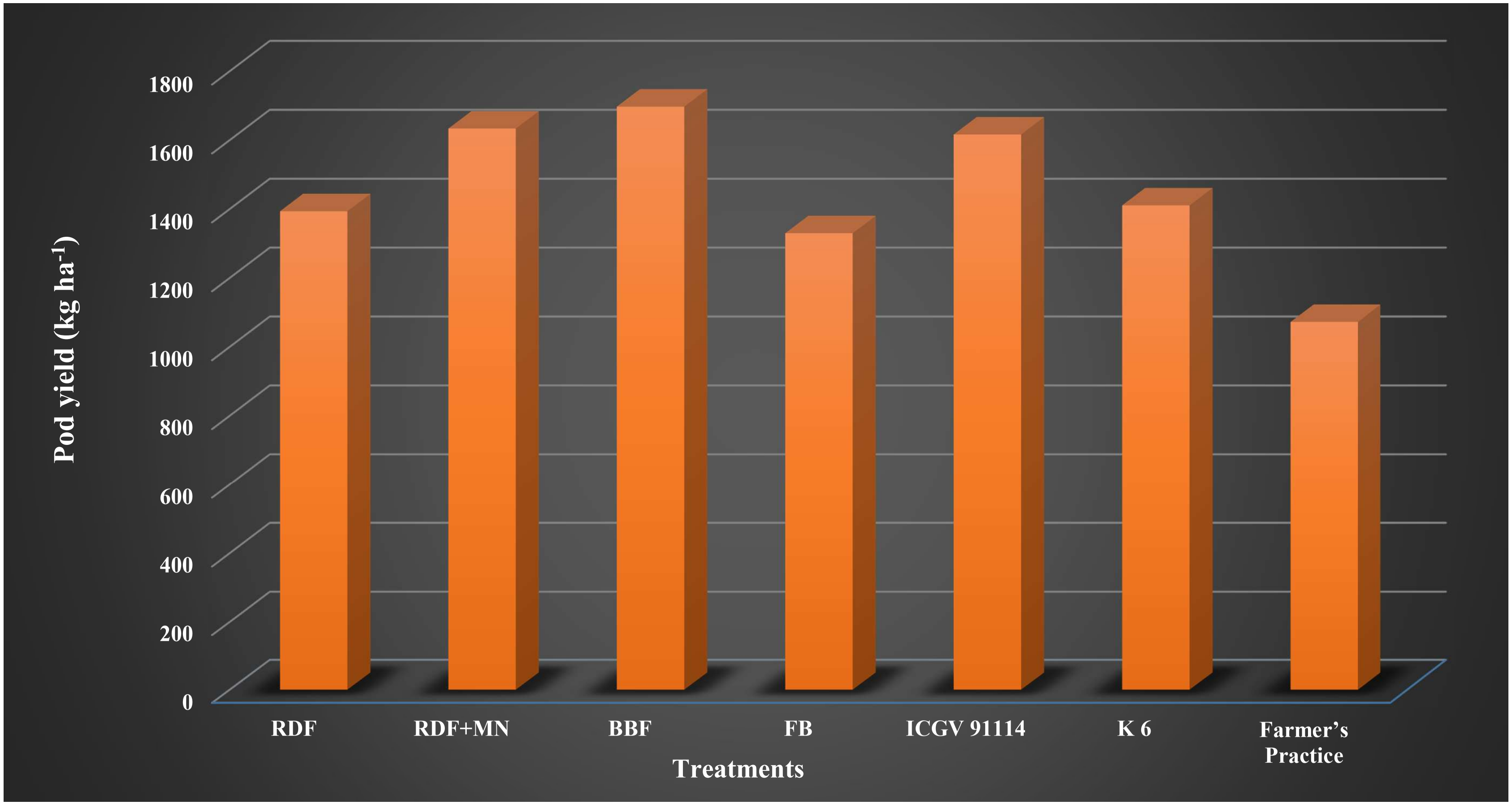


Fig 4.8 Pod yield (kg ha^{-1}) and harvest index influenced by nutrients, land configuration and varieties

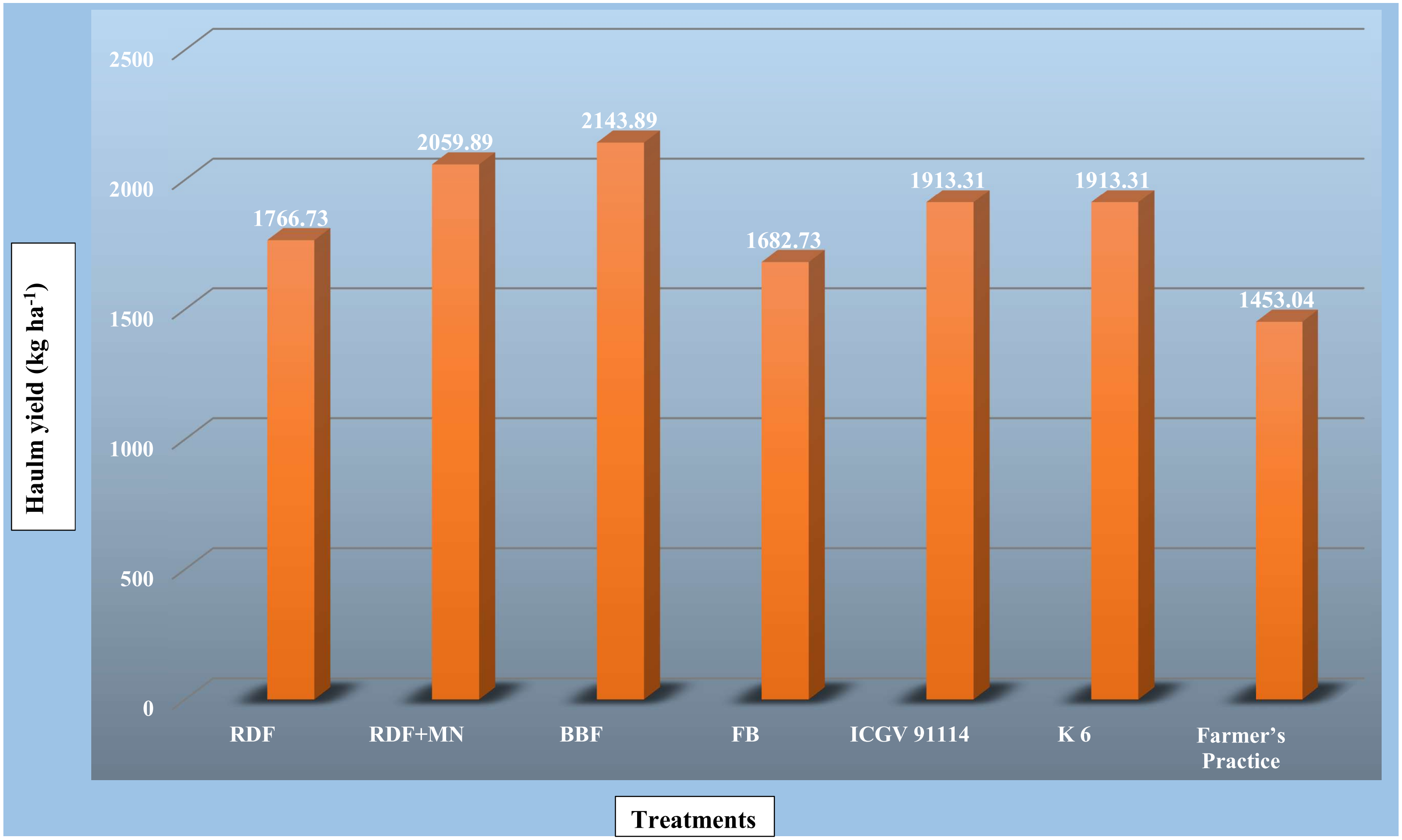


Fig 4.9 Haulm yield (kg ha^{-1}) and harvest index influenced by nutrients, land configuration and varieties

There was about 14.68% superior pod yield (1633.95 kg ha^{-1}) was observed in recommended dose of fertilizer along with micro nutrient treatment ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) over only recommended dose of fertilizer treatment. Growth and yield attributes regarding recommended dose of fertilizer along with micro nutrient treatment were superior so the pod yield was higher than the recommended dose of fertilizer. Ganesh *et al.* (2015) reported pod yield maximum under the combined application of RDF + Mo + Zn + Rhizobium + PSB. According to Narh and Naab (2015) the P K + gypsum +Zn treatment had the highest pod yield. Sharma *et al.* (2011) revealed that application of 100% N P K S Zn significantly enhanced the pod and haulm yields of groundnut by 25.9 and 22.4 per cent over 100% N P K, respectively.

4.2.3.2 Land configuration

There was significantly highest pod yield found in the broad bed and furrow treatment (1697.69 kg ha^{-1}). While, the minimal pod yield of groundnut was recorded in flat bed treatment (1330.30 kg ha^{-1}). About 21.64% superior yield is observed in broad bed and furrow treatment over flat bed treatment. As mentioned above the growth and yield attributes are more at broad bed and furrow than flat bed treatment. So the broad bed and furrow treatment resulted higher yield. Same results observed by Vekariya *et al*. (2015), Shrinivasraju (2012) and Kathmale *et al*. (2009) in broad bed and furrow.

4.2.3.3 Varieties

There was significantly maximum pod yield observed in the cultivated variety ICGV 91114 (1616.91 kg ha^{-1}). Whereas, the minimum pod yield was recorded in cultivated variety K 6 (1411.08 kg ha^{-1}). There was about 12.72% superior yield is observed in ICGV 91114 variety over K 6 variety. Cultivated variety ICGV 91114 showed the supreme growth and yield attributes resulted superior yield as compared to cultivated variety K 6.

4.2.3.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration observation. Those are represented in table 4.9c. Pod yield was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment (1917.37kg ha^{-1}). Whereas, other treatment combination registered lower pod yield.

Table 4.9 c: Interaction effect of nutrient and land configuration on pod yield (kg ha^{-1})

Pod yield (kg ha^{-1})		
	L_1:BBF	**L_2:FB**
N_1:RDF	1478.01	1310.07
N_2 :RDF + MN	1917.37	1350.53
S.Em ±	**48.64**	
CD (P=0.05)	**140.89**	

4.2.3.5 Farmer's practice vs other treatments

There was significantly lowest pod yield (1072.80 kg ha^{-1}) recorded in the farmer's practice as compared to all other treatments. There was about 29.14% inferior pod yield was observed in farmer's practice.

4.2.4 Haulm yield (kg ha^{-1})

The data of haulm yield presented in the Table 4.9a, 4.9b and 4.9 d and graphically represented in fig. 4.9. It is evident from data a significant difference found in haulm yield due to various treatments. But there was no significance difference found between variety treatments. The mean haulm yield was 1913.31 kg ha^{-1}.

4.2.4.1 Nutrients

There was significantly greater haulm yield (2059.89 kg ha^{-1}) was recorded in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}). However, the comparatively less haulm yield was recorded in only recommended dose of fertilizer treatment (1766.73 kg ha^{-1}). There was about 14.23% superior haulm yield was observed in recommended dose of fertilizer along with micro nutrient treatment over only recommended dose of fertilizer treatment. Ganesh *et al.* (2015) found maximum haulm yield (kg ha^{-1}) under the combined application of RDF +Mo +Zn +Rhizobium +PSB.

4.2.4.2 Land configuration

There was significantly highest haulm yield found in the broad bed and furrow treatment (2143.89 kg ha^{-1}). While, the minimal haulm yield of groundnut was recorded in flat bed treatment (1682.73 kg ha^{-1}). There was about 21.51% superior haulm yield is observed in broad bed and furrow treatment over flat bed treatment. Kathmale *et al*. (2009), Dhadage *et al*. (2008) noticed the higher haulm yield in the broad bed and furrow method.

4.2.4.3 Varieties

There was no significant difference in haulm yield was observed in both the varieties.

4.2.4.4 Interaction effect

There was a significant results were observed in between nutrient and land configuration observation. Those are represented in table 4.9d. Haulm yield was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment (2371.66 kg ha^{-1}). Though, the other treatment combination registered lower haulm yield.

Table 4.9 d: Interaction effect of nutrient and land configuration on haulm yield (kg ha^{-1})

Haulm yield(kg ha^{-1})		
	L_1:BBF	**L_2:FB**
N_1:RDF	1916.12	1617.34
N_2 :RDF + MN	2371.66	1748.12
S.Em ±	**73.93**	
CD (P=0.05)	**214.18**	

4.2.4.5 Farmer's practice vs other treatments

There was significantly lowest haulm yield (1453.04 kg ha^{-1}) recorded in the farmer's practice as compared to all other treatments. There was about 24.05% inferior yield was observed in farmer's practice.

4.2.5 Harvest index

The data of harvest index presented in the Table 4.9a and 4.9b. It is depend on both pod and haulm yield. The mean harvest index was 0.441.

4.2.5.1 Nutrients

There was no significant difference was recorded in case of harvest index among the both nutrient treatments. But higher harvest index was observed in the recommended dose of fertilizer along with micro nutrient treatment (0.442) than recommended dose of fertilizer treatment (0.440).

4.2.5.2 Land configuration

There was no significant difference was recorded in case of harvest index among the both land configuration treatments.

4.2.5.3 Varieties

There was significantly maximum harvest index observed in the cultivated variety ICGV 91114 (0.458). Whereas, the minimum harvest index was recorded in cultivated variety K 6 (0.424).

4.2.5.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the harvest index of groundnut.

4.2.5.5 Farmer’s practice vs other treatments

There was significantly lowest harvest index (0.424) recorded in the farmer’s practice as compared to all other treatments.

4.3 Quality parameter

4.3.1 100 seed weight (g)

The data is related to 100 seed weight presented in the Table 4.10a and 4.10b. The mean 100 seed weight was 40.36 g.

4.3.1.1 Nutrients

There was no significant difference between both the treatments. But higher 100 seed weight was observed in the recommended dose of fertilizer along with micro nutrient treatment (40.78 g) than recommended dose of fertilizer treatment (39.94 g).

4.3.1.2 Land configuration

There was no significant difference between both the treatments. But higher 100 seed weight was observed in the broad bed and furrow treatment (40.47 g) than flat bed treatment (40.25 g).

4.3.1.3 Varieties

There was significantly maximum 100 seed weight found in the cultivated variety ICGV 91114 (42.53 g). Whereas, the minimum 100 seed weight was recorded in cultivated variety K 6 (38.19 g). It is because of cultivated variety ICGV 91114 having bold seeds than cultivated variety K 6.

4.3.1.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the 100 seed weight of groundnut.

4.3.1.5 Farmer's practice vs other treatments

There was significantly lowest 100 seed weight (36.22 g) recorded in the farmer's practice as compared to all other treatments.

4.3.2 Shelling per cent

The data is related to shelling per cent presented in the Table 4.10a 4.10b and 4.10c. There was a significant difference found in shelling per cent due to various treatments. The mean shelling per cent was 72.19%.

4.3.2.1 Nutrients

There was significantly greater shelling per cent in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) treatment (72.54%).

Table 4.10 a: 100 seed weight (g) and shelling % influenced by nutrients, land configuration and varieties

Treatment			100 seed weight (g)	Shelling %
Nutrient	**N_1**	RDF	39.94	71.84
	N_2	RDF+MN	40.78	72.54
		S.Em ±	**0.36**	**0.22**
		CD (P=0.05)	**NS**	**0.63**
Land configuration	**L_1**	BBF	40.47	72.59
	L_2	FB	40.25	71.79
		S.Em ±	**0.36**	**0.22**
		CD (P=0.05)	**NS**	**0.63**
Variety	**V_1**	ICGV 91114	42.53	73.12
	V_2	K 6	38.19	71.26
		S.Em ±	**0.36**	**0.22**
		CD (P=0.05)	**1.04**	**0.63**
Interaction				
NXL			NS	NS
LXV			NS	S
NXV			NS	NS
NXLXV			NS	NS
General mean			**40.36**	**72.19**
Farmer's practice			36.22	70.99
S.Em ±			**0.74**	**0.41**
CD (P=0.05)			**2.14**	**1.19**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.10 b: Treatment combination of 100 seed weight (g), shelling % and harvest index influenced by nutrients, land configuration and varieties

Treatment	100 seed weight (g)	Shelling %
$N_1L_1V_1$	42.38	73.67
$N_1L_1V_2$	37.42	70.50
$N_1L_2V_1$	42.12	71.78
$N_1L_2V_2$	37.82	71.42
$N_2L_1V_1$	42.98	75.03
$N_2L_1V_2$	39.08	71.17
$N_2L_2V_1$	42.64	72.01
$N_2L_2V_2$	38.42	71.95
S.Em ±	**0.72**	**0.44**
CD (P=0.05)	**NS**	**NS**

Though, the lowest shelling per cent was recorded in only recommended dose of fertilizer treatment (71.84%). Ganesh *et al.* (2015) found maximum shelling per cent under the combined application of RDF+ Mo+ Zn+ Rhizobium+ PSB.

4.3.2.2 Land configuration

There was significantly highest shelling per cent found in the broad bed and furrow treatment (72.59%). While, the minimal shelling per cent of groundnut was recorded in flat bed treatment (71.79%). Same result was founded by Patil *et al.* (2007) shelling per centage was maximum in case of broad bed and furrow treatment.

4.3.2.3 Varieties

There was significantly maximum shelling per cent observed in the cultivated variety ICGV 91114 (73.12%). Whereas, the minimum shelling per cent was recorded in cultivated variety K 6 (71.26%).

4.3.2.4 Interaction effect

There was a significant results were observed in between land configuration and variety observation. Those are represented in table 4.10c. Shelling per cent was significantly higher in the association of broad bed & furrow and cultivated variety ICGV 91114 treatments (74.35%). Though, the other treatment combination registered lower shelling per cent.

4.3.2.5 Farmer's practice vs other treatments

There was significantly lowest shelling per cent (70.99%) recorded in the farmer's practice as compared to all other treatments.

4.3.3 Oil per cent

The data is related to oil per cent presented in the Table 4.11a and 4.11b. There was significant difference observed in all treatment combination. The mean oil per cent was 47.51.

Table 4.10 c: Interaction effect of land configuration and variety on shelling %

	Shelling %	
	V_1: ICGV 91114	**V_2: K 6**
L_1:BBF	74.35	70.84
L_2:FB	71.90	71.69
S.Em ±	**0.31**	
CD (P=0.05)	**0.89**	

4.3.3.1 Nutrients

Significant difference between both the treatments. Higher oil per cent was observed in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) treatment (48.11%) than recommended dose of fertilizer treatment (46.92%).

4.3.3.2 Land configuration

Significant difference between both the treatments. Higher oil per cent was observed in the broad bed and furrow treatment (48.26%) than flat bed treatment (46.76%).

4.3.3.3 Varieties

There was significantly higher oil per cent observed in the cultivated variety ICGV 91114 (48.22%). Whereas, cultivated variety K 6 oil per cent was (46.80%).

4.3.3.4 Interaction effect

Non-significant results were observed in between all interactions.

4.3.3.5 Farmer's practice vs other treatments

There was significantly lowest oil per cent recorded in the farmer's practice as compared to all other treatments.

4.3.4 Oil yield (kg ha^{-1})

The data is regarding to oil yield exhibited in the Table 4.11a, 4.11b and 4.11c. There was a significant difference found in oil yield (kg ha^{-1}) due to various treatments. However, the mean oil yield (kg ha^{-1}) was 519.07 kg ha^{-1}.

4.3.2.1 Nutrients

There was significantly greater oil yield in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) treatment (575.78 kg ha^{-1}). Though, the lowest shelling per cent was recorded in only recommended dose of fertilizer treatment (472.56 kg ha^{-1}).

Table 4.11 a: Oil per cent, yield (kg ha^{-1}) and protein per cent in seeds of groundnut influenced by nutrients, land configuration and varieties

Treatment			Oil %	Oil yield (kg ha^{-1})	Protein %
Nutrient	**N$_1$**	RDF	46.92	472.56	20.00
	N$_2$	RDF+MN	48.11	575.78	20.30
		S.Em ±	**0.38**	**13.30**	**0.44**
		CD (P=0.05)	**1.11**	**38.527**	**NS**
Land configuration	**L$_1$**	BBF	48.26	599.32	19.95
	L$_2$	FB	46.76	449.01	20.35
		S.Em ±	**0.38**	**13.30**	**0.44**
		CD (P=0.05)	**1.11**	**38.527**	**NS**
Variety	**V$_1$**	ICGV 91114	48.22	574.34	20.71
	V$_2$	K 6	46.80	473.99	19.59
		S.Em ±	**0.38**	**13.30**	**0.44**
		CD (P=0.05)	**1.11**	**38.527**	**NS**
Interaction					
NXL			NS	S	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**47.51**	**524.17**	**20.15**
Farmer's practice			45.48	346.92	17.68
S.Em ±			**0.74**	**25.68**	**0.85**
CD (P=0.05)			**2.14**	**73.98**	**NS**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.11 b: Treatment combination of oil per cent, yield (kg ha^{-1}) and protein in seeds of groundnut per cent influenced by nutrients, land configuration and varieties

Treatment	Oil %	Oil Yield (kg ha^{-1})	Protein %
N$_1$L$_1$V$_1$	46.22	531.89	20.12
N$_1$L$_1$V$_2$	47.52	468.56	20.06
N$_1$L$_2$V$_1$	45.48	466.47	20.94
N$_1$L$_2$V$_2$	49.84	421.80	18.75
N$_2$L$_1$V$_1$	47.40	725.30	19.69
N$_2$L$_1$V$_2$	48.12	617.76	19.71
N$_2$L$_2$V$_1$	45.90	478.89	21.85
N$_2$L$_2$V$_2$	48.84	441.92	19.28
S.Em ±	**0.71**	**22.04**	**0.87**
CD (P=0.05)	**NS**	**NS**	**NS**

4.3.2.2 Land configuration

There was significantly highest oil yield found in the broad bed and furrow treatment (599.32 kg ha^{-1}). While, the minimal oil yield of groundnut was recorded in flat bed treatment (449.01 kg ha^{-1}). Kathmale *et al*. (2009) and Patil *et al.* (2007) found same results.

4.3.2.3 Varieties

There was significantly maximum oil yield observed in the cultivated variety ICGV 91114 (574.34 kg ha^{-1}). Whereas, the minimum oil yield was recorded in cultivated variety K 6 (473.99 kg ha^{-1}).

4.3.2.4 Interaction effect

There was a significant oil yield results was observed in between nutrient and land configuration observation. That is represented in Table 4.11c.the oil yield was significantly highest in association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment (671.53 kg ha^{-1}). Whereas, other treatment combination registered lower oil yield.

4.3.2.5 Farmer's practice vs other treatments

There was significantly lowest oil yield (352.94 kg ha^{-1}) recorded in the farmer's practice as compared to all other treatments

Table 4.11 c: Interaction effect of land configuration and variety on oil yield (kg ha^{-1})

	Oil yield (kg ha^{-1})	
	V_1: ICGV 91114	**V_2: K 6**
L_1:BBF	504.84	440.28
L_2:FB	693.81	457.74
S.Em ±	**18.81**	
CD (P=0.05)	**54.49**	

4.3.4 Protein per cent

The data is related to protein per cent presented in the Table 4.11a and 4.11b. There was no significant difference found in protein per cent due to various treatments. The mean protein per cent was 20.15.

4.3.4.1 Nutrients

There was no significant difference was recorded in case of protein per cent among the both nutrient treatments. But higher protein per cent was observed in the recommended dose of fertilizer along with micro nutrient treatment (20.30%) than recommended dose of fertilizer treatment (20.00%).

4.3.4.2 Land configuration

There was no significant difference was recorded in case of protein per cent among the both land configuration treatments. But higher protein per cent was observed in the flat bed treatment (20.21%) than broad bed and furrow treatment (19.97%).

4.3.4.3 Varieties

There was no significant difference was observed in protein per cent in both the variety. But the cultivated variety ICGV 91114 (20.71%) showed maximum protein per cent. Whereas, the minimum protein per cent was recorded in cultivated variety K 6 (19.59%).

4.3.4.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the protein per cent of groundnut.

4.3.4.5 Farmer's practice vs other treatments

Farmer's practice non-significantly differed with other treatments. The protein per cent (17.68%) recorded in the farmer's practice.

4.4 Microbial observation

4.4.1 Number of nodules plant^{-1}

The data is related to number of nodules per plant presented in the Table 4.12a and 4.12b. The mean number of nodules plant^{-1} was 81.37.

4.4.1.1 Nutrients

There was no significant difference was recorded in case of number of nodules per plant among the both nutrient treatments. But higher number of nodules per plant was observed in the recommended dose of fertilizer along with micro nutrient treatment (85.23) than recommended dose of fertilizer treatment (77.50).

4.4.1.2 Land configuration

There was no significant difference was recorded in case of number of nodules per plant among the both land configuration treatments. But higher number of nodules per plant was observed in the broad bed and furrow treatment (83.97) than flat bed treatment (78.77).

4.4.1.3 Varieties

There was significantly maximum number of nodules per plant were observed in the cultivated variety ICGV 91114 (90.20). Whereas, the minimum number of nodules per plant were recorded in cultivated variety K 6 (72.53). It might be due to cultivated variety ICGV 91114 having the capacity to produce more number of nodules.

4.4.1.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the number of nodules per plant of groundnut.

4.4.1.5 Farmer's practice vs other treatments

There was significantly lower number of nodules per plant (47.80) recorded in the farmer's practice as compared to all other treatments.

4.4.2 Mycorrhizae infection per cent

The data is related to mycorrhizae infection per cent presented in the Table 4.12a and 4.12b. There was no significance difference observed in the case of mycorrhizae infection per cent at the both the observation. The higher mean mycorrhizae infection per cent (43.08%) was found at 45 DAS.

4.4.2.1 Nutrients

There was no significant difference was recorded in case of mycorrhizae infection per cent among the both nutrient treatments at the both the observation.

Table 4.12a: Number of nodules plant^{-1}, mycorrhizae infection influenced by nutrients, land configuration and varieties.

Treatment			Nodules plant^{-1}	Mycorrhizae infection %	
				45 DAS	60 DAS
Nutrient	**N_1**	RDF	77.50	41.67	42.17
	N_2	RDF+MN	85.23	44.50	40.67
		S.Em ±	**2.92**	**1.65**	**1.24**
		CD (P=0.05)	**NS**	**NS**	**NS**
Land configuration	**L_1**	BBF	83.97	43.67	42.83
	L_2	FB	78.77	42.50	40.00
		S.Em ±	**2.92**	**1.65**	**1.24**
		CD (P=0.05)	**NS**	**NS**	**NS**
Variety	**V_1**	ICGV 91114	90.20	43.50	41.83
	V_2	K 6	72.53	42.67	41.00
		S.Em ±	**2.92**	**1.65**	**1.24**
		CD (P=0.05)	**8.46**	**NS**	**NS**
Interaction					
NXL			NS	NS	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**81.37**	**43.08**	**41.42**
Farmer's practice			47.80	31.07	33.33
S.Em ±			**5.60**	**3.18**	**2.38**
CD (P=0.05)			**16.14**	**NS**	**NS**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.12b: Treatment combination of number of nodules plant^{-1}, mycorrhizae infection (%) at influenced by nutrients, land configuration and varieties.

Treatment	Nodules number plant^{-1}	Mycorrhizae infection %	
		45 DAS	60 DAS
$N_1L_1V_1$	84.40	44.67	43.33
$N_1L_1V_2$	77.07	42.00	42.67
$N_1L_2V_1$	80.80	39.33	42.67
$N_1L_2V_2$	67.73	40.67	40.00
$N_2L_1V_1$	102.87	45.33	42.67
$N_2L_1V_2$	71.53	42.67	42.67
$N_2L_2V_1$	92.73	44.67	38.67
$N_2L_2V_2$	73.80	45.33	38.67
S.Em ±	**5.84**	**3.31**	**2.47**
CD (P=0.05)	**NS**	**NS**	**NS**

But comparatively higher mycorrhizae infection per cent was observed in the recommended dose of fertilizer along with micro nutrient treatment (44.50%) than recommended dose of fertilizer treatment (41.67%).

4.4.2.2 Land configuration

There was no significant difference was recorded in case of mycorrhizae infection per cent among the both land configuration treatments at the both the observation. But higher mycorrhizae infection per cent was observed in the broad bed and furrow treatment (43.67%) than flat bed treatment (42.50%).

4.4.2.3 Varieties

There was no significant difference was recorded in case of mycorrhizae infection per cent among the both varieties treatments at the both the observation. But maximum mycorrhizae infection per cent were observed in the cultivated variety ICGV 91114 (43.50%). Whereas, the minimum mycorrhizae infection per cent was recorded in cultivated variety K 6 (42.67%).

4.4.2.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the mycorrhizae infection per cent of groundnut.

4.4.2.5 Farmer's practice vs other treatments

There was no significant difference was found between farmer's practice as compared to all other treatments in case of mycorrhizae infection per cent (33.33%).

4.5 Soil physico – chemical properties

4.5.1 Soil pH

The data is related to soil pH at the time of harvest presented in the Table 4.13a and 4.13b. There was no significance difference observed in the case of soil pH. The mean soil pH was 6.39.

4.5.1.1 Nutrients

There was no significant difference was recorded in case of soil pH among the both nutrient treatments. But higher soil pH was observed in the recommended dose of fertilizer along with micro nutrient treatment (6.43) than recommended dose of fertilizer treatment (6.36).

4.5.1.2 Land configuration

There was no significant difference was recorded in case of soil pH among the both land configuration treatments. But lower soil pH was observed in the broad bed and furrow treatment (6.36) than flat bed treatment (6.43).

4.5.1.3 Varieties

There was no significant difference was recorded in case of soil pH among the both varieties treatments observation.

4.5.1.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil pH of groundnut crop treatments.

4.5.1.5 Farmer's practice vs other treatments

There was no significant difference was found between farmer's practice and all other treatments in case of soil pH (6.55).

4.5.2 Soil electrical conductivity (d S m^{-1})

The data is related to soil electrical conductivity presented in the Table 4.13a and 4.13b. There was no significance difference observed in the case of soil electrical conductivity. The mean soil electrical conductivity was 0.131 d S m^{-1}.

4.5.2.1 Nutrients

There was no significant difference was recorded in case of soil electrical conductivity among the both nutrient treatments. But higher soil electrical conductivity was observed in the recommended dose of fertilizer along with micro nutrient treatment (0.137 d S m^{-1}) than recommended dose of fertilizer treatment (0.124 d S m^{-1}).

4.5.2.2 Land configuration

Land configuration does not show any significant difference in respect to soil electrical conductivity.

Table 4.13 a: Soil pH, E c (d S m^{-1}) and O.C (%) influenced by nutrients, land configuration and varieties at harvest

Treatment			Soil pH	Soil E c (d S m^{-1})	Soil O.C. (%)
Nutrient	**N_1**	RDF	6.36	0.124	0.379
	N_2	RDF+MN	6.43	0.137	0.404
		S.Em ±	**0.05**	**0.005**	**0.009**
		CD (P=0.05)	**NS**	**NS**	**NS**
Land configuration	**L_1**	BBF	6.36	0.132	0.400
	L_2	FB	6.43	0.130	0.383
		S.Em ±	**0.05**	**0.005**	**0.009**
		CD (P=0.05)	**NS**	**NS**	**NS**
Variety	**V_1**	ICGV 91114	6.47	0.129	0.393
	V_2	K 6	6.32	0.132	0.390
		S.Em ±	**0.05**	**0.005**	**0.009**
		CD (P=0.05)	**NS**	**NS**	**NS**
Interaction					
NXL			NS	NS	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**6.39**	**0.131**	**0.391**
Farmer's practice			6.55	0.106	0.371
S.Em ±			**0.12**	**0.010**	**0.019**
CD (P=0.05)			**NS**	**NS**	**NS**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.13 b: Treatment combination of pH, E c (d S m^{-1}) and organic carbon (%) influenced by nutrients, land configuration and varieties at harvest

Treatment	Soil pH	Soil E c (d S m^{-1})	Soil O.C (%)
$N_1L_1V_1$	6.26	0.125	0.37
$N_1L_1V_2$	6.27	0.126	0.40
$N_1L_2V_1$	6.60	0.115	0.39
$N_1L_2V_2$	6.30	0.129	0.36
$N_2L_1V_1$	6.52	0.142	0.42
$N_2L_1V_2$	6.38	0.134	0.40
$N_2L_2V_1$	6.48	0.134	0.40
$N_2L_2V_2$	6.32	0.140	0.39
S.Em ±	**0.11**	**0.010**	**0.02**
CD (P=0.05)	**NS**	**NS**	**NS**

4.5.2.3 Varieties

There was no significant difference was recorded in case of soil electrical conductivity among the both varieties treatments. But comparatively les soil electrical conductivity was observed in the cultivated variety ICGV 91114 (0.129 d S m^{-1}) treatment as compared to cultivated variety K 6 treatment.

4.5.2.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil electrical conductivity of groundnut crop treatments.

4.5.2.5 Farmer's practice vs other treatments

There was non-significant difference was found between farmer's practice and all other treatments in case of soil electrical conductivity.

4.5.3 Soil organic carbon per cent

Data related to soil organic carbon per cent presented in the Table 4.13a and 4.13b. Nutrient management, land configuration and variety treatments does not show any significant difference in soil organic per cent. The mean number of soil organic carbon per cent was 0.391%.

4.5.3.1 Nutrients

There was non-significant difference was recorded in case of soil organic carbon per cent among the both nutrient treatments. But comparatively higher soil organic carbon per cent was observed in the recommended dose of fertilizer along with micro nutrient treatment (0.404%) as compared to recommended dose of fertilizer treatment (0.379%).

4.5.3.2 Land configuration

There was no significant difference was recorded in case of soil organic carbon per cent among the both land configuration treatments. But higher soil organic carbon per cent was observed in the broad bed and furrow treatment (0.400%) than flat bed treatment (0.383%).

4.6.1.3 Varieties

Both the varieties recorded non-significant difference in soil organic carbon per cent. But slightly higher soil organic carbon per cent was recorded in the cultivated variety ICGV 91114 (0.393%).

4.5.3.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil organic carbon per cent of groundnut crop treatments.

4.5.3.5 Farmer's practice vs other treatments

There was no significant difference was found between farmer's practice and all other treatments in case of soil organic carbon (0.371%).

4.5.4: Soil moisture (g g^{-1}) at field capacity

The data is related to soil moisture at field capacity in the Table 4.14a and 4.14b. There was no significance difference observed in the case of soil moisture at field capacity. The mean soil moisture at field capacity was 0.089 g g^{-1}.

4.5.4.1 Nutrients

Nutrient management practices does not influence the soil moisture at field capacity. But, slightly lower soil moisture at field capacity was observed in the recommended dose of fertilizer along with micro nutrient treatment (0.089 g g^{-1}) than recommended dose of fertilizer treatment (0.090 g g^{-1}).

4.5.4.2 Land configuration

There was significant difference was recorded in case of soil moisture at field capacity among the both land configuration treatments. Higher soil moisture at field capacity was observed in the broad bed and furrow treatment (0.093 g g^{-1}) than flat bed treatment (0.085 g g^{-1}). The possible reason for lower soil moisture content in flat bed might have created due to a higher vapour pressure gradient between crop canopy and atmosphere causing a greater loss of water from soil. Further, compacted soil or presence of hard pan under flat bed might have lowered infiltration and increased runoff losses of rainwater. Similar results was also reported by Shrinivasraju (2012) and Vaghasia *et al.* (2007).

Table 4.14 a: Soil moisture (g g^{-1}) at field capacity and permanent wilting point influenced by nutrients, land configuration and varieties at harvest

Treatment			Soil moisture (g g^{-1})	
			Field capacity	**Permanent wilting point**
Nutrient	**N_1**	RDF	0.090	0.059
	N_2	RDF+MN	0.089	0.059
		S.Em ±	**0.001**	**0.001**
		CD (P=0.05)	**NS**	**NS**
Land configuration	**L_1**	BBF	0.093	0.063
	L_2	FB	0.085	0.055
		S.Em ±	**0.001**	**0.001**
		CD (P=0.05)	**0.002**	**0.003**
Variety	**V_1**	ICGV 91114	0.089	0.059
	V_2	K 6	0.090	0.059
		S.Em ±	**0.001**	**0.001**
		CD (P=0.05)	**NS**	**NS**
Interaction				
NXL			NS	NS
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**0.089**	**0.059**
Farmer's practice			0.077	0.049
S.Em ±			**0.002**	**0.002**
CD (P=0.05)			**0.005**	**0.006**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.14 b: Treatment combination of moisture (g g^{-1}) at field capacity and permanent wilting point influenced by nutrients, land configuration and varieties at harvest.

Treatment	Soil moisture(g g^{-1})	
	Field capacity	**Permanent wilting point**
$N_1L_1V_1$	0.094	0.063
$N_1L_1V_2$	0.094	0.062
$N_1L_2V_1$	0.085	0.056
$N_1L_2V_2$	0.086	0.056
$N_2L_1V_1$	0.093	0.063
$N_2L_1V_2$	0.093	0.062
$N_2L_2V_1$	0.084	0.054
$N_2L_2V_2$	0.085	0.055
S.Em ±	**0.001**	**0.002**
CD (P=0.05)	**NS**	**NS**

4.5.4.3 Varieties

There was no significant difference was recorded in case of soil moisture at field capacity among the both varieties treatments observation. But comparatively less soil moisture at field capacity was observed in the cultivated variety ICGV 91114 (0.089 g g^{-1}) treatment. Whereas, the minimum soil moisture at field capacity was recorded in cultivated variety K 6 (0.090 g g^{-1}) treatment.

4.5.4.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil moisture at field capacity of groundnut crop treatments.

4.5.4.5 Farmer's practice vs other treatments

There was significant difference was found between farmer's practice and all other treatments in case of soil moisture at field capacity (0.077 g g^{-1}).

4.5.5: Soil moisture (g g^{-1}) at permanent wilting point

Data related to soil moisture at permanent wilting point presented in the Table 4.14a and 4.14b. Non-significance difference was observed in the case of soil moisture at permanent wilting point in respect to nutrient and variety. Whereas, it was significant in land configuration. The mean soil moisture at permanent wilting point was 0.059 g g^{-1}.

4.5.5.1 Nutrients

There was no significant difference was recorded in case of soil moisture at permanent wilting point among the both nutrient treatments. Similar soil moisture at permanent wilting point was observed in the recommended dose of fertilizer along with micro nutrient treatment and recommended dose of fertilizer treatment.

4.5.5.2 Land configuration

Significant difference was recorded in case of soil moisture at permanent wilting point in both the land configuration. Higher soil moisture at permanent wilting point was observed in the broad bed and furrow treatment (0.063 g g^{-1}) than flat bed treatment (0.055 g g^{-1}). The higher moisture found in broad bed and furrow treatment because it is having the more porous nature and having the capacity to hold more water as compared to flat bed treatment.

4.5.5.3 Varieties

There was no significant difference was recorded in case of soil moisture at permanent wilting point among the both varieties treatments observation. Similar soil moisture at permanent wilting point was observed in the cultivated variety ICGV 91114 treatment and in cultivated variety K 6 (0.059 g g^{-1}) treatment.

4.5.5.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil moisture at permanent wilting point of groundnut crop.

4.5.5.5 Farmer's practice vs other treatments

There was significant difference was found between farmer's practice and all other treatments in case of soil moisture at permanent wilting point (0.049 g g^{-1}).

4.5.6: Soil available nitrogen (kg ha^{-1})

Data is related to soil available nitrogen presented in the Table 4.15a and 4.15b. There was no significance difference observed in the case of soil available nitrogen in any nutrient, land configuration and variety. The mean soil available nitrogen was 247.12 kg ha^{-1}.

4.5.6.1 Nutrients

Non-significant difference was recorded in case of soil available nitrogen among the both nutrient management. However, lower soil available nitrogen was recorded in recommended dose of fertilizer along with micro nutrient treatment (245.86 kg ha^{-1}) and slightly higher value (248.37 kg ha^{-1}) was recorded in recommended dose of fertilizer.

4.5.6.2 Land configuration

There was no significant difference was recorded in case of soil available nitrogen at the both land configuration treatments both land configurations registered same value of soil available nitrogen (247.12 kg ha^{-1}) at harvest.

Table 4.15 a: Soil available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}) and potassium (kg ha^{-1}) influenced by nutrients, land configuration and varieties at harvest

Treatment			N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Nutrient	**N_1**	RDF	248.37	21.69	269.98
	N_2	RDF+MN	245.86	21.01	273.76
		S.Em ±	**1.35**	**1.05**	**1.63**
		CD (P=0.05)	**NS**	**NS**	**NS**
Land configuration	**L_1**	BBF	247.12	21.39	273.85
	L_2	FB	247.12	21.31	269.90
		S.Em ±	**1.35**	**1.05**	**1.63**
		CD (P=0.05)	**NS**	**NS**	**NS**
Variety	**V_1**	ICGV 91114	247.74	20.77	271.54
	V_2	K 6	246.49	21.93	272.21
		S.Em ±	**1.35**	**1.05**	**1.63**
		CD (P=0.05)	**NS**	**NS**	**NS**
Interaction					
NXL			NS	NS	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**247.12**	**21.35**	**271.87**
Farmer's practice			245.47	23.15	263.16
S.Em ±			**2.95**	**2.02**	**3.25**
CD (P=0.05)			**NS**	**NS**	**NS**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.15 b: Treatment combination of soil available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}) and potassium (kg ha^{-1}) at harvest

Treatment	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
$N_1L_1V_1$	248.37	22.69	272.08
$N_1L_1V_2$	248.37	22.45	272.64
$N_1L_2V_1$	248.37	20.04	268.92
$N_1L_2V_2$	248.37	21.59	266.30
$N_2L_1V_1$	248.37	22.86	274.34
$N_2L_1V_2$	243.35	22.16	276.33
$N_2L_2V_1$	245.86	22.06	270.80
$N_2L_2V_2$	245.86	21.54	273.58
S.Em ±	**2.69**	**2.11**	**3.26**
CD(P=0.05)	**NS**	**NS**	**NS**

4.5.6.3 Varieties

There was no significant difference was recorded in case of soil available nitrogen among the both varieties. But marginal higher value of soil available nitrogen (247.74 kg ha^{-1}) was observed in the cultivated variety ICGV 91114 as compared to variety K 6 (246.49 kg ha^{-1}).

4.5.6.4 Interaction effect

Interaction effects between nutrient management, land configuration and variety in respect to soil available nitrogen at harvest.

4.5.6.5 Farmer's practice vs other treatments

There was no significant difference was recorded between farmer's practice and all other management practices in the case of soil available nitrogen. Farmer's practice recorded 245.47 kg ha^{-1} soil available nitrogen at harvest.

4.5.7: Soil available phosphorus (kg ha^{-1})

Soil available phosphorus is presented in Table 4.15a and 4.15b. There was no significance difference observed in the case of soil available phosphorus among the different management practices. The mean soil available phosphorus was 21.35 kg ha^{-1}.

4.5.7.1 Nutrients

There was no significant difference was recorded in case of soil available phosphorus among nutrient management. But slightly higher value (21.69 kg ha^{-1}) was recorded in recommended dose of fertilizer as compared to recommended dose of fertilizer along with micro nutrient (21.01 kg ha^{-1}) and it was very marginal difference.

4.5.7.2 Land configuration

Soil available phosphorus show non-significant difference in respect to land configuration. However, slightly higher value (21.39 kg ha^{-1}) was recorded in broad bed and furrow as compared to flat bed but difference was very marginal and non-significant.

4.5.7.3 Varieties

Both the varieties show non-significant difference in available phosphorus at harvest. But slightly lower soil available phosphorus was observed in the variety ICGV 91114 (20.77 kg ha^{-1}) as compared to K 6 (21.93 kg ha^{-1}).

4.5.7.4 Interaction effect

Interaction effects was non-significant among the various treatments with respect to the soil available phosphorus of groundnut crop.

4.5.7.5 Farmer's practice vs other treatments

There was no significant difference was found between farmer's practice and all other treatments in case of soil available phosphorus.

4.5.8: Soil available potassium (kg ha^{-1})

Data related to soil available potassium was presented in the Table 4.15a and 4.15b. There was no significance difference observed among all the management practices. The mean soil available potassium was 271.87 kg ha^{-1}.

4.5.8.1 Nutrients

Non-significant difference was recorded in case of soil available potassium among the both nutrient treatments. But higher soil available potassium was observed in the recommended dose of fertilizer along with micro nutrient treatment (273.76 kg ha^{-1}) and lower value (269.98 kg ha^{-1}) was recorded in recommended dose of fertilizer.

4.5.8.2 Land configuration

Land configuration treatment recorded non-significant difference in soil available potassium at harvest. Relatively higher value broad bed and furrow recorded (273.85 kg ha^{-1}) in soil available potassium as camped to flat bed (269.90 kg ha^{-1}).

4.5.8.3 Varieties

There was no significant difference was recorded in case of soil available potassium among the both varieties. But lower soil available potassium was observed in the variety ICGV 91114 treatment (271.54 kg ha^{-1}) than cultivated variety K 6 treatment (272.21 kg ha^{-1}).

4.5.8.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil available potassium of groundnut crop treatments.

4.5.8.5 Farmer's practice vs other treatments

There was no significant difference was found between farmer's practice and all other treatments in case of soil available potassium. The soil available potassium was recorded in farmer's practice is 263.16 kg ha^{-1}.

4.5.9: Soil available sulphur (kg ha^{-1})

Data related to soil available sulphur presented in Table 4.16a and 4.16b. There was no significance difference observed in the case of soil available sulphur in regards to different marginal practices.

4.5.9.1 Nutrients

There was non-significant difference was recorded in case of soil available sulphur among the both nutrient treatments. But higher soil available sulphur was observed in the recommended dose of fertilizer along with micro nutrient treatment (11.52 kg ha^{-1}) and lower value was recorded in recommended dose of fertilizer treatment (10.99 kg ha^{-1}).

4.5.9.2 Land configuration

Non-significant difference was recorded in case of soil available sulphur in both the land configuration treatments. Slightly higher soil available sulphur was observed in the broad bed and furrow treatment (11.38 kg ha^{-1}) as compared to flat bed (11.13 kg ha^{-1}). Both the varieties recorded non-significant difference in soil available sulphur at harvest. But lower soil available sulphur was observed in the variety ICGV 91114 (10.98 kg ha^{-1}) as compared to variety K 6 (11.53 kg ha^{-1}).

4.5.9.3 Varieties

Non-significant difference was recorded in case of soil available sulphur in both verities treatment.

4.5.9.4 Interaction effect

The interaction effects was non-significant among the various treatments with respect to the soil available sulphur of groundnut crop treatments. It might be because of gypsum was applied at the same rate in all nutrient, land configuration and varietal treatment.

4.5.9.5 Farmer's practice vs other treatments

There was significant difference was found between farmer's practice and all other treatments in case of soil available sulphur. Under farmer's practice soil available sulphur was less as compared to other treatments due in farmer's practice no gypsum was applied. Farmers usually does not use gypsum for their field. Gypsum consisting of two secondary nutrients *viz.,* sulphur and calcium. Calcium avoid pop pod disorder in groundnut and sulphur enhance the oil content in oil seed crops. Gypsum was applied at 30 DAS, it is easily and chiefly available fertilizer for source of sulphur and calcium.

4.5.10: Soil available zinc (mg kg^{-1})

Data is related to soil available zinc presented in Table 4.16a and 4.16b. There was no significance difference observed in the case of soil available zinc except nutrient treatments. The mean soil available zinc was 2.93 mg kg^{-1}. Zinc activates enzymes that are responsible for the synthesis of certain proteins. It is used in the formation of chlorophyll and some carbohydrates, conversion of starches to sugars and its presence in plant tissue helps the plant to withstand cold temperatures. Zinc is essential in the formation of auxins, which help with growth regulation and stem elongation. It was applied in the form of zinc sulphate during the sowing of crop. Zinc is a deficient nutrient in Indian soils.

4.5.10.1 Nutrients

Significant difference was recorded in case of soil available zinc among the both nutrient treatments. Higher soil available zinc was observed in the recommended dose of fertilizer along with micro nutrient (3.32 mg kg^{-1}) and lower value was recorded in recommended dose of fertilizer (2.54 mg kg^{-1}). The higher value in the recommended dose of fertilizer along with micro nutrient treatment. It is because the treatment was under gone with zinc sulphate application whereas the other treatment was not applied.

4.5.10.2 Land configuration

There was non-significant difference was recorded in case of soil available zinc in the both land configuration treatments. However marginally lower soil available zinc was available in the broad bed and furrow treatment as compared to flat bed.

Table 4.16 a: Soil available sulphur (kg ha^{-1}), zinc (mg kg^{-1}) and boron (mg kg^{-1}) influenced by nutrients, land configuration and varieties at harvest.

Treatment			Sulphur (kg ha^{-1})	Zinc (mg kg^{-1})	Boron (mg kg^{-1})
Nutrient	**N_1**	RDF	10.99	2.54	0.28
	N_2	RDF+MN	11.52	3.32	0.38
		S.Em ±	**0.20**	**0.16**	**0.02**
		CD (P=0.05)	**NS**	**0.46**	**0.06**
Land configuration	**L_1**	BBF	11.38	3.00	0.32
	L_2	FB	11.13	2.86	0.33
		S.Em ±	**0.20**	**0.16**	**0.02**
		CD (P=0.05)	**NS**	**NS**	**NS**
Variety	**V_1**	ICGV 91114	10.98	2.79	0.33
	V_2	K 6	11.53	3.07	0.32
		S.Em ±	**0.20**	**0.16**	**0.02**
		CD (P=0.05)	**NS**	**NS**	**NS**
Interaction					
NXL			NS	NS	NS
LXV			NS	NS	NS
NXV			NS	NS	NS
NXLXV			NS	NS	NS
General mean			**11.26**	**2.93**	**0.33**
Farmer's practice			9.88	2.27	0.21
S.Em ±			**0.43**	**0.16**	**0.04**
CD (P=0.05)			**1.23**	**0.46**	**0.13**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.16 b: Treatment combination of soil available sulphur (kg ha^{-1}), zinc (mg kg^{-1}) and boron (mg kg^{-1}) influenced by nutrients, land configuration and varieties at harvest.

Treatment	Sulphur (kg ha^{-1})	Zinc (mg kg^{-1})	Boron (mg kg^{-1})
$N_1L_1V_1$	10.89	2.31	0.26
$N_1L_1V_2$	11.02	2.89	0.27
$N_1L_2V_1$	10.56	2.73	0.30
$N_1L_2V_2$	11.49	2.23	0.28
$N_2L_1V_1$	11.55	3.00	0.43
$N_2L_1V_2$	12.05	3.80	0.33
$N_2L_2V_1$	10.94	3.12	0.35
$N_2L_2V_2$	11.56	3.35	0.41
S.Em ±	**0.41**	**0.32**	**0.04**
CD (P=0.05)	**NS**	**NS**	**NS**

4.5.10.3 Varieties

Verities do not show any significant difference in soil available zinc. Difference between both the varieties in respect to available zinc was very marginal as non-significant.

4.5.10.4 Interaction effect

The interaction effect was non-significant among the various treatments with respect to the soil available zinc of groundnut crop treatments.

4.5.10.5 Farmer's practice vs other treatments

Significant difference was recorded between farmer's practice and all other treatments in case of soil available zinc. Farmer's practice recorded lower soil available zinc (2.27 mg kg^{-1}) due to under this treatment no zinc was applied.

4.5.11: Soil available boron (mg kg^{-1})

Data is related to soil available boron presented in Table 4.16a and 4.16b. There was no significance difference observed in the case of soil available boron in all management practices. The mean soil available boron was 0.33 mg kg^{-1}.

4.5.11.1 Nutrients

There was significant difference was recorded in case of soil available boron (mg kg^{-1}) among the both nutrient treatments. Higher soil available boron (mg kg^{-1}) was observed in the recommended dose of fertilizer along with micro nutrient treatment (0.38 mg kg^{-1}) and lower value was found in recommended dose of fertilizer (0.28 mg kg^{-1}). Higher value in the recommended dose of fertilizer along with micro nutrient treatment. It is because the treatment was undergone with borax application whereas, the other treatment was not applied.

4.5.11.2 Land configuration

There was no significant difference was recorded in case of soil available boron under both the land configuration treatments. But lower soil available boron was observed in the broad bed and furrow treatment (2.97 mg kg^{-1}) than flat bed treatment (3.36 mg kg^{-1}).

4.5.11.3 Varieties

Both the varieties does not affect the soil available boron at harvest. Whereas, lower soil available boron was recorded in the variety ICGV 91114 (2.79 mg kg^{-1}) as compared to K 6 (3.54 mg kg^{-1}).

4.5.11.4 Interaction effect

The interaction effect was non-significant among the various treatments with respect to the soil available boron of groundnut crop.

4.5.11.5 Farmer's practice vs other treatments

There was significant difference was found between farmer's practice and all other treatments in case of soil available boron. The soil available boron was recorded in farmer's practice was 2.27 mg kg^{-1}. Because under farmer's practice borax was not applied.

4.6 Nutrients uptake (kg ha^{-1}) of haulm

The data pertaining to uptake of nutrients *viz.,* N, P, K S, Zn and B by the crop as influenced by nutrient, land configuration and varieties are presented below.

4.6.1 Nitrogen uptake (kg ha^{-1}) of haulm at 45 DAS

An appraisal of data presented in Table 4.17a, 4.17b and 4.17c shows that nitrogen uptake of haulm at 45 DAS. Which was recorded significance difference between the treatments.

4.6.1.1 Nutrients

There was significantly greater nitrogen uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (19.09 kg ha^{-1}). Though, the lowest nitrogen uptake of haulm was recorded in only recommended dose of fertilizer treatment (14.35 kg ha^{-1}).

4.6.1.2 Land configuration

There was significantly highest nitrogen uptake of haulm found in the broad bed and furrow treatment (19.57 kg ha^{-1}). While, the minimal nitrogen uptake of haulm in groundnut was recorded in flat bed treatment (13.87 kg ha^{-1}).

4.6.1.3 Varieties

Significantly maximum nitrogen uptake of haulm recorded in cultivated variety ICGV 91114 (17.98 kg ha^{-1}). Whereas, the minimum nitrogen uptake of haulm was recorded in cultivated variety K 6 (15.46 kg ha^{-1}). This is due to varietal difference, variety ICGV 91114 responds well as compared to local variety.

4.6.1.4 Interaction effect

There was a significant nitrogen uptake of haulm results was recorded in between nutrient and land configuration. That is represented in table 4.17c the nitrogen uptake of haulm was significantly highest in the combination of recommended dose of fertilizer along with micro nutrient and broad bed furrow (23.91 kg ha^{-1}). Whereas, other treatment combination registered lower nitrogen uptake of haulm.

4.6.1.5 Farmer's practice vs other treatments

There was significantly lowest nitrogen uptake of haulm (10.30 kg ha^{-1}) recorded in the farmer's practice as compared to all other treatments.

4.6.2 Nitrogen uptake (kg ha^{-1}) of haulm at harvest

An appraisal of data presented in Table 4.17a, 4.17b and 4.17d shows that nitrogen uptake of haulm at harvest. Which was recorded significance difference between the treatments of nutrient and land configuration but not in case of variety treatment.

4.6.2.1 Nutrients

There was significantly greater nitrogen uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (40.15 kg ha^{-1}). Though, the lowest nitrogen uptake of haulm was recorded in only recommended dose of fertilizer treatment (34.39 kg ha^{-1}). Sharma *et al.* (2011) found same results in RDF with application of S and Zn.

4.6.2.2 Land configuration

Significantly highest nitrogen uptake of haulm found in the broad bed and furrow treatment (41.77 kg ha^{-1}). While, the flat bed recorded minimum nitrogen uptake of haulm in groundnut (32.77 kg ha^{-1}).

Table 4.17a: Nitrogen uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Nitrogen uptake (kg ha^{-1})	
			45 DAS	**Harvest**
Nutrient	**N_1**	RDF	14.35	34.39
	N_2	RDF+MN	19.09	40.15
		S.Em ±	**0.83**	**0.89**
		CD (P=0.05)	**2.39**	**2.57**
Land configuration	**L_1**	BBF	19.57	41.77
	L_2	FB	13.87	32.77
		S.Em ±	**0.83**	**0.89**
		CD (P=0.05)	**2.39**	**2.57**
Variety	**V_1**	ICGV 91114	17.98	37.71
	V_2	K 6	15.46	36.82
		S.Em ±	**0.83**	**0.89**
		CD (P=0.05)	**2.39**	**NS**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**16.72**	**37.27**
Farmer's practice			10.30	25.53
S.Em ±			**1.60**	**1.77**
CD (P=0.05)			**4.60**	**5.10**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.17b: Treatment combination of nitrogen uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Nitrogen uptake (kg ha^{-1})	
	45 DAS	**Harvest**
$N_1L_1V_1$	16.90	32.10
$N_1L_1V_2$	13.57	26.87
$N_1L_2V_1$	14.81	28.67
$N_1L_2V_2$	12.11	25.84
$N_2L_1V_1$	24.82	38.99
$N_2L_1V_2$	23.01	34.88
$N_2L_2V_1$	15.40	30.54
$N_2L_2V_2$	13.14	26.38
S.Em ±	**1.65**	**1.87**
CD (P=0.05)	**NS**	**NS**

Table 4.17 c: Interaction effect of nutrient and land configuration on nitrogen uptake (kg ha^{-1}) of haulm at 45 DAS

Nitrogen uptake (kg ha^{-1}) at 45 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	15.24	13.46
N_2:RDF + MN	23.91	14.27
S.Em ±	**1.17**	
CD (P=0.05)	**3.38**	

Mathukia and Khanpara (2009) and Mane *et al*. (2010) observed same results in the broad bed and furrow land configuration.

4.6.2.3 Varieties

Both the varieties does not show any marginal difference in nitrogen uptake of haulm at harvest. However, cultivated variety ICGV 91114 marginally high nitrogen uptake of haulm as compared to cultivated variety K 6.

4.6.2.4 Interaction effect

There was a significant nitrogen uptake of haulm was recorded in between nutrient and land configuration. That is represented in table 4.17d the nitrogen uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (46.58 kg ha^{-1}). Whereas, other treatment combination registered lower nitrogen uptake of haulm.

Table 4.17 d: Interaction effect of nutrient and land configuration on nitrogen uptake (kg ha^{-1}) of haulm at harvest

Nitrogen uptake (kg ha^{-1}) at harvest		
	L_1:BBF	**L_2:FB**
N_1:RDF	36.96	31.82
N_2 :RDF + MN	46.58	33.72
S.Em ±	**1.25**	
CD (P=0.05)	**3.63**	

4.6.2.5 Farmer's practice vs other treatments

There was significantly lowest nitrogen uptake of haulm (25.53 kg ha^{-1}) recorded under farmer's practice as compared to all other treatments.

4.6.3 Phosphorus uptake (kg ha^{-1}) of haulm at 45 DAS

An appraisal of data in Table 4.18a, 4.18b and 4.18c shows that phosphorus uptake of haulm at 45 DAS. Which was recorded significance difference between all treatments.

4.6.3.1 Nutrients

There was significantly higher phosphorus uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (1.66 kg ha^{-1}) than the recommended dose of fertilizer treatment (1.25 kg ha^{-1}).

4.6.3.2 Land configuration

Significantly highest phosphorus uptake (1.74 kg ha^{-1}) of haulm found in the broad bed and furrow treatment. Whereas, lowest phosphorus uptake of haulm recorded in flat bed land configuration (1.16 kg ha^{-1}).

4.6.3.3 Varieties

There was significant difference found between both the treatments. But maximum phosphorus uptake of haulm observed in the cultivated variety ICGV 91114 (1.62 kg ha^{-1}). Whereas, the minimum phosphorus uptake of haulm was recorded in cultivated variety K 6 (1.28 kg ha^{-1}).

4.6.3.4 Interaction effect

Significant phosphorus uptake of haulm was observed in nutrient management and land configuration combination. That is represented in Table 4.18c the nitrogen uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (2.15 kg ha^{-1}). Whereas, other treatment combination registered lower phosphorus uptake of haulm.

4.6.3.5 Farmer's practice vs other treatments

There was significantly lowest phosphorus uptake (0.86 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments.

Table 4.18a: Phosphorus uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Phosphorus uptake (kg ha^{-1})	
			45 DAS	**harvest**
Nutrient	**N_1**	RDF	1.25	3.18
	N_2	RDF+MN	1.66	3.66
		S.Em ±	**0.09**	**0.11**
		CD (P=0.05)	**0.25**	**0.33**
Land configuration	**L_1**	BBF	1.74	3.86
	L_2	FB	1.16	2.99
		S.Em ±	**0.09**	**0.11**
		CD (P=0.05)	**0.25**	**0.33**
Variety	**V_1**	ICGV 91114	1.62	3.45
	V_2	K 6	1.28	3.39
		S.Em ±	**0.09**	**0.11**
		CD (P=0.05)	**0.25**	**NS**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**1.45**	**3.42**
Farmer's practice			0.86	2.33
S.Em ±			**0.17**	**0.23**
CD (P=0.05)			**0.48**	**0.65**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

Table 4.18b: Treatment combination of phosphorus uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Phosphorus uptake (kg ha^{-1})	
	45 DAS	**harvest**
$N_1L_1V_1$	1.51	3.44
$N_1L_1V_2$	1.16	3.43
$N_1L_2V_1$	1.17	2.93
$N_1L_2V_2$	1.16	2.93
$N_2L_1V_1$	2.47	4.37
$N_2L_1V_2$	1.84	4.19
$N_2L_2V_1$	1.34	3.07
$N_2L_2V_2$	0.98	3.01
S.Em ±	**0.17**	**0.23**
CD (P=0.05)	**NS**	**NS**

Table 4.18 c: Interaction effect of nutrient and land configuration on phosphorus uptake (kg ha^{-1}) of haulm at 45 DAS

Phosphorus uptake (kg ha^{-1}) at 45 DAS		
	L_1:BBF	**L_2:FB**
N_1:RDF	1.33	1.16
N_2 :RDF + MN	2.15	1.16
S.Em ±	**0.13**	
CD (P=0.05)	**0.38**	

4.6.4 Phosphorus uptake (kg ha^{-1}) of haulm at harvest

An appraisal of data in Table 4.18a, 4.18b and 4.18d shows that phosphorus uptake of haulm at harvest. Which was recorded significance difference between the nutrient and land configuration but not in variety treatments.

4.6.4.1 Nutrients

There was significantly greater phosphorus uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (3.66 kg ha^{-1}). Though, the lowest phosphorus uptake of haulm was recorded in only recommended dose of fertilizer treatment (3.18 kg ha^{-1}).

4.6.4.2 Land configuration

There was significantly highest phosphorus uptake of haulm found in the broad bed and furrow treatment (3.86 kg ha^{-1}). While, minimal phosphorus uptake of haulm in groundnut was recorded in flat bed treatment (2.99 kg ha^{-1}).

4.6.4.3 Varieties

There was no significant difference found between both the varieties. But maximum nitrogen uptake of haulm observed in the cultivated variety ICGV 91114 (3.45 kg ha^{-1}). Whereas, minimum phosphorus uptake of haulm was recorded in cultivated variety K 6 (3.39 kg ha^{-1}).

4.6.4.4 Interaction effect

There was a significant phosphorus uptake of haulm was observed in nutrient management and land configuration combination. That is represented in table 4.18 d the nitrogen uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (4.28 kg ha^{-1}). Whereas, other treatment combination registered lower phosphorus uptake of haulm.

Table 4.18 d: Interaction effect of nutrient and land configuration on phosphorus uptake (kg ha^{-1}) of haulm at harvest

Phosphorus uptake (kg ha^{-1}) at harvest		
	L_1:BBF	**L_2 :FB**
N_1:RDF	3.44	2.93
N_2 :RDF + MN	4.28	3.04
S.Em ±	**0.16**	
CD (P=0.05)	**0.47**	

4.6.4.5 Farmer's practice vs other treatments

There was significantly lowest phosphorus uptake (2.33 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments.

4.6.5 Potassium uptake (kg ha^{-1}) of haulm at 45 DAS

An appraisal of data in Table 4.19a, 4.19b and 4.19c shows that potassium uptake of haulm at 45 DAS. Which was recorded significance difference between the treatments.

4.6.5.1 Nutrients

There was significantly greater potassium uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (11.65 kg ha^{-1}). Though, the lowest potassium uptake of haulm was recorded in only recommended dose of fertilizer treatment (8.82 kg ha^{-1}).

4.6.5.2 Land configuration

There was significantly highest potassium uptake of haulm found in the broad bed and furrow treatment (12.19 kg ha^{-1}). While, less potassium uptake of haulm in groundnut was recorded in flat bed treatment (8.29 kg ha^{-1}).

4.6.5.3 Varieties

There was significantly maximum potassium uptake of haulm observed in the cultivated variety ICGV 91114 (11.20 kg ha^{-1}). Whereas, minimum potassium uptake of haulm was recorded in cultivated variety K 6 (9.28 kg ha^{-1}).

4.6.5.4 Interaction effect

Significant potassium uptake of haulm was observed in combination of nutrient and land configuration. That is represented in Table 4.19c the potassium uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment combination (15.11 kg ha^{-1}). Whereas, other treatment combination registered lower potassium uptake of haulm.

4.6.5.5 Farmer's practice vs other treatments

Significantly lowest potassium uptake (6.76 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments mean (10.24 kg ha^{-1}).

4.6.6 Potassium uptake (kg ha^{-1}) of haulm at harvest

An appraisal of data in Table 4.19a and 4.19b shows that potassium uptake of haulm at harvest. Which was recorded significance difference between the nutrient and land configuration but not in variety treatments.

4.6.6.1 Nutrients

Significantly greater potassium uptake of haulm was recorded in combination of recommended dose of fertilizer and micro nutrient (33.38 kg ha^{-1}). Though, the lowest potassium uptake of haulm was recorded in only recommended dose of fertilizer treatment (28.89 kg ha^{-1}).

4.6.6.2 Land configuration

There was significantly highest potassium uptake of haulm found in the broad bed and furrow treatment (34.79 kg ha^{-1}). While, less potassium uptake of haulm in groundnut was recorded in flat bed treatment (27.47 kg ha^{-1}).

Table 4.19a: Potassium uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Potassium uptake (kg ha^{-1})	
			45 DAS	**harvest**
Nutrient	**N_1**	RDF	8.82	28.89
	N_2	RDF+MN	11.65	33.38
		S.Em ±	**0.54**	**1.18**
		CD (P=0.05)	**1.55**	**3.42**
Land configuration	**L_1**	BBF	12.19	34.79
	L_2	FB	8.29	27.47
		S.Em ±	**0.54**	**1.18**
		CD (P=0.05)	**1.55**	**3.42**
Variety	**V_1**	ICGV 91114	11.20	30.91
	V_2	K 6	9.28	31.36
		S.Em ±	**0.54**	**1.18**
		CD (P=0.05)	**1.55**	**NS**
Interaction				
NXL			S	NS
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**10.24**	**31.13**
Farmer's practice			6.76	21.39
S.Em ±			**1.04**	**2.28**
CD (P=0.05)			**2.98**	**6.57**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K6

Table 4.19b: Treatment combination of potassium uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Potassium uptake (kg ha^{-1}) at	
	45 DAS	**harvest**
$N_1L_1V_1$	9.94	30.74
$N_1L_1V_2$	8.59	31.34
$N_1L_2V_1$	8.49	26.56
$N_1L_2V_2$	8.27	26.90
$N_2L_1V_1$	16.73	38.83
$N_2L_1V_2$	13.49	38.26
$N_2L_2V_1$	9.63	27.49
$N_2L_2V_2$	6.76	28.94
S.Em ±	**1.07**	**2.36**
CD(P=0.05)	**NS**	**NS**

Table 4.19 c: Interaction effect of nutrient and land configuration on potassium uptake (kg ha^{-1}) of haulm at 45 DAS

Potassium uptake (kg ha^{-1}) at 45 DAS

	L_1:BBF	**L_2 :FB**
N_1:RDF	9.27	8.38
N_2 :RDF + MN	15.11	8.19
S.Em ±	**0.76**	
CD (P=0.05)	**2.20**	

4.6.6.3 Varieties

Both the verities do not show any significant difference in potassium uptake of haulm. However minimum potassium uptake of haulm observed in the cultivated variety ICGV 91114 (30.91 kg ha^{-1}). Whereas, maximum potassium uptake of haulm was recorded in cultivated variety K 6 (31.36 kg ha^{-1}).

4.6.6.4 Interaction effect

There was no significant potassium uptake of haulm results was observed in interaction effect.

4.6.6.5 Farmer's practice vs other treatments

There was significantly lowest potassium uptake (21.39 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments mean (31.13 kg ha^{-1}).

4.6.7 Sulphur uptake (kg ha^{-1}) of haulm at 45 DAS

An appraisal of data in Table 4.20a, 4.20b and 4.20c .Shows sulphur uptake of haulm at 45 DAS. Which was recorded significance difference between the nutrient and variety treatments but not in the land configuration.

4.6.7.1 Nutrients

There was significantly greater sulphur uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (1.48 kg ha^{-1}). Though, the lowest sulphur uptake of haulm was recorded in only recommended dose of fertilizer treatment (1.14 kg ha^{-1}).

4.6.7.2 Land configuration

There was significant difference found between both land configurations. Broad bed and furrow land configuration show highest sulphur uptake of haulm (1.57 kg ha^{-1}) compared to flat bed (1.05 kg ha^{-1}).

4.6.7.3 Varieties

There was non-significant sulphur uptake of haulm observed. But maximum in the cultivated variety ICGV 91114 (1.38 kg ha^{-1}) whereas minimum sulphur uptake of haulm was recorded in cultivated variety K 6 (1.24 kg ha^{-1}).

4.6.7.4 Interaction effect

There was a significant sulphur uptake of haulm results was observed in between nutrient and land configuration observation. That is represented in table 4.19c the sulphur uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (1.92 kg ha^{-1}). Whereas, other treatment combination registered lower sulphur uptake of haulm.

4.6.7.5 Farmer's practice vs other treatments

There was significantly lowest sulphur uptake (0.89 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments mean (1.31 kg ha^{-1}).

4.6.8 Sulphur uptake (kg ha^{-1}) of haulm at harvest

Data presented in Table 4.17a, 4.17b and 4.17d shows sulphur uptake of haulm at harvest. Which was recorded significance difference between the nutrient and variety treatments but not in the land configuration.

4.6.8.1 Nutrients

There was significantly greater sulphur uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (4.61 kg ha^{-1}). Though, the lowest sulphur uptake of haulm was recorded in only recommended dose of fertilizer treatment (4.08 kg ha^{-1}). Chaplot (2004) reported in wheat crop the addition of S, Zn and S+ Zn with N P K significantly improved content and uptake of N, P, K, S and Zn nutrients over application of N P, N P K and no fertilizer.

Table 4.20a: Sulphur uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Sulphur uptake (kg ha^{-1}) at	
			45 DAS	**harvest**
Nutrient	**N_1**	RDF	1.14	4.08
	N_2	RDF+MN	1.48	4.61
		S.Em ±	**0.07**	**0.13**
		CD (P=0.05)	**0.21**	**0.37**
Land configuration	**L_1**	BBF	1.57	4.87
	L_2	FB	1.05	3.82
		S.Em ±	**0.07**	**0.13**
		CD (P=0.05)	**0.21**	**0.37**
Variety	**V_1**	ICGV 91114	1.38	4.40
	V_2	K 6	1.24	4.28
		S.Em ±	**0.07**	**0.13**
		CD (P=0.05)	**NS**	**NS**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**1.31**	**4.34**
Farmer's practice			0.89	3.11
S.Em ±			**0.14**	**0.25**
CD (P=0.05)			**0.40**	**0.73**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K6

Table 4.20b: Treatment combination of sulphur uptake (kg ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Sulphur uptake (kg ha^{-1}) at	
	45 DAS	**harvest**
$N_1L_1V_1$	1.32	4.44
$N_1L_1V_2$	1.11	4.36
$N_1L_2V_1$	1.08	3.85
$N_1L_2V_2$	1.05	3.66
$N_2L_1V_1$	1.93	5.41
$N_2L_1V_2$	1.90	5.26
$N_2L_2V_1$	1.19	3.90
$N_2L_2V_2$	0.89	3.86
S.Em ±	**0.15**	**0.26**
CD (P=0.05)	**NS**	**NS**

Table 4.20 c: Interaction effect of nutrient and land configuration on sulphur uptake (kg ha^{-1}) of haulm 45 DAS

Sulphur uptake (kg ha^{-1}) at 45 DAS

	L_1:BBF	**L_2 :FB**
N_1:RDF	1.21	1.06
N_2 :RDF + MN	1.92	1.04
S.Em ±	**0.10**	
CD (P=0.05)	**0.30**	

4.6.8.2 Land configuration

There was significant difference found between both land configurations. Broad bed and furrow land configuration show highest sulphur uptake of haulm (4.87 kg ha^{-1}) compared to flat bed (3.82 kg ha^{-1}).

4.6.8.3 Varieties

There was non-significant sulphur uptake of haulm observed. But maximum in the cultivated variety ICGV 91114 (4.40 kg ha^{-1}) whereas minimum sulphur uptake of haulm was recorded in cultivated variety K 6 (4.28 kg ha^{-1}).

4.6.8.4 Interaction effect

There was a significant sulphur uptake of haulm results was observed in between nutrient and land configuration observation. That is represented in Table 4.19c the sulphur uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (5.33kg ha^{-1}). Whereas, other treatment combination registered lower sulphur uptake of haulm.

Table 4.20 d: Interaction effect of nutrient and land configuration on sulphur uptake (kg ha^{-1}) of haulm at harvest

Sulphur uptake (kg ha^{-1}) at 45 DAS

	L_1:BBF	**L_2 :FB**
N_1:RDF	4.40	3.75
N_2 :RDF + MN	5.33	3.88
S.Em ±	**0.18**	
CD (P=0.05)	**0.52**	

4.6.8.5 Farmer's practice vs other treatments

There was significantly lowest sulphur uptake (3.11 kg ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments. Mean of all other treatments (4.34 kg ha^{-1}).

4.6.9 Zinc uptake (g ha^{-1}) of haulm at 45 DAS

An appraisal of data in Table 4.21a, 4.21b and 4.21c shows that zinc uptake of haulm at 45 DAS. Which was recorded significance difference between the nutrient and land configuration except variety treatments.

4.6.9.1 Nutrients

There was significantly greater zinc uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (15.93 g ha^{-1}). Though, lowest zinc uptake of haulm was recorded in only recommended dose of fertilizer treatment (12.19 g ha^{-1}).

4.6.9.2 Land configuration

There was significantly highest zinc uptake of haulm was recorded in broad bed and furrow treatment (16.42 g ha^{-1}). While, the minimal zinc uptake of haulm in groundnut was recorded in flat bed treatment (11.70 g ha^{-1}).

4.6.9.3 Varieties

There was no significant difference was found between both varieties. But maximum zinc uptake of haulm observed in the cultivated variety ICGV 91114 (14.48 g ha^{-1}) as compared to variety K 6 (13.64 g ha^{-1}).

4.6.9.4 Interaction effect

There was a significant zinc uptake of haulm results was observed in between nutrient and land configuration observation. That is represented in table 4.21c Zinc uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (19.59 g ha^{-1}). Whereas, other treatment combination registered lower zinc uptake of haulm.

Table 4.21a: Zinc uptake (g ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Zinc uptake (g ha^{-1}) at	
			45 DAS	**harvest**
Nutrient	**N_1**	RDF	12.19	39.21
	N_2	RDF+MN	15.93	43.00
		S.Em ±	**0.69**	**1.28**
		CD (P=0.05)	**2.00**	**3.70**
Land configuration	**L_1**	BBF	16.42	46.41
	L_2	FB	11.70	35.80
		S.Em ±	**0.69**	**1.28**
		CD (P=0.05)	**2.00**	**3.70**
Variety	**V_1**	ICGV 91114	14.48	41.04
	V_2	K 6	13.64	41.17
		S.Em ±	**0.69**	**1.28**
		CD (P=0.05)	**NS**	**NS**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**14.06**	**41.10**
Farmer's practice			8.26	28.52
S.Em ±			**1.34**	**2.48**
CD (P=0.05)			**3.85**	**7.15**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K6

Table 4.21b: Treatment combination of zinc uptake (g ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Zinc uptake (g ha^{-1}) at	
	45 DAS	**harvest**
$N_1L_1V_1$	14.03	40.03
$N_1L_1V_2$	12.47	44.86
$N_1L_2V_1$	11.37	36.36
$N_1L_2V_2$	10.88	35.58
$N_2L_1V_1$	19.79	52.50
$N_2L_1V_2$	19.39	48.25
$N_2L_2V_1$	12.74	35.27
$N_2L_2V_2$	11.81	35.97
S.Em ±	**1.38**	**2.55**
CD (P=0.05)	**NS**	**NS**

Table 4.21 c: Interaction effect of nutrient and land configuration on zinc uptake ($g\ ha^{-1}$) of haulm at 45 DAS

Zinc uptake ($g\ ha^{-1}$) at 45 DAS		
	L_1:BBF	**L_2 :FB**
N_1:RDF	13.25	11.12
N_2 :RDF + MN	19.59	12.27
S.Em ±	**0.98**	
CD (P=0.05)	**2.83**	

4.6.9.5 Farmer's practice vs other treatments

There was significantly lowest zinc uptake (8.26 g ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments.

4.6.10 Zinc uptake ($g\ ha^{-1}$) of haulm at harvest

An appraisal of data in Table 4.21a, 4.21b and 4.21 d shows that zinc uptake of haulm at harvest. Which was recorded significance difference between nutrient and land configuration except variety treatments.

4.6.10.1 Nutrients

There was significantly greater zinc uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (43.00 g ha^{-1}). Though, the lowest zinc uptake of haulm was recorded in recommended dose of fertilizer treatment (39.21g ha^{-1}). Chaplot (2004) found higher zinc uptake in wheat crop with N, P, K, S and Zn applied treatment.

4.6.10.2 Land configuration

There was significantly highest zinc uptake of haulm found in the broad bed and furrow treatment (46.41 g ha^{-1}) as compared to flat bed treatment (35.80 g ha^{-1}). Same result was reported by Mathukia and Khanpara (2009) in the broad bed and furrow treatment of castor crop stalk.

4.6.10.3 Varieties

There was no significant difference was found between both varieties. But minimum zinc uptake of haulm observed in the cultivated variety ICGV 91114 (41.04 g ha^{-1}). Whereas, the maximum zinc uptake of haulm was recorded in cultivated variety K 6 (41.17 g ha^{-1}).

4.6.10.4 Interaction effect

There was a significant zinc uptake of haulm results was observed in between nutrient and land configuration observation. That is represented in Table 4.21d the zinc uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (671.53 g ha^{-1}). Whereas, other treatment combination registered lower zinc uptake of haulm.

Table 4.21 d: Interaction effect of nutrient and land configuration on zinc uptake (g ha^{-1}) of haulm at harvest

Zinc uptake (g ha^{-1}) at harvest		
	L_1:BBF	**L_2 :FB**
N_1:RDF	42.45	35.97
N_2 :RDF + MN	50.38	35.62
S.Em ±	**1.81**	
CD(P=0.05)	**5.23**	

4.6.10.5 Farmer's practice vs other treatments

There was significantly lowest zinc uptake (28.52 g ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments.

4.6.11 Boron uptake (kg ha^{-1}) of haulm at 45 DAS

Data presented in Table 4.22a, 4.22b and 4.22c shows that boron uptake of haulm at 45 DAS. Which was recorded significance difference between the treatments.

4.6.11.1 Nutrients

There was significantly greater boron uptake of haulm in the recommended dose of fertilizer along with micro nutrient treatment (21.51 g ha^{-1}). Though, the lowest boron uptake of haulm was recorded in application recommended dose of fertilizer only (16.94 g ha^{-1}).

4.6.11.2 Land configuration

There was significantly highest boron uptake of haulm found in the broad bed and furrow treatment (22.18 g ha^{-1}). As compared to flat bed treatment (16.27 g ha^{-1}).

Table 4.22a: Boron uptake (g ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment			Boron uptake (g ha^{-1}) at	
			45 DAS	**harvest**
Nutrient	**N_1**	RDF	16.94	65.39
	N_2	RDF+MN	21.51	73.52
		S.Em ±	**0.89**	**2.21**
		CD (P=0.05)	**2.59**	**6.40**
Land configuration	**L_1**	BBF	22.18	75.68
	L_2	FB	16.27	63.23
		S.Em ±	**0.89**	**2.21**
		CD (P=0.05)	**2.59**	**6.40**
Variety	**V_1**	ICGV 91114	21.07	69.77
	V_2	K 6	17.38	69.14
		S.Em ±	**0.89**	**2.21**
		CD (P=0.05)	**2.59**	**NS**
Interaction				
NXL			S	S
LXV			NS	NS
NXV			NS	NS
NXLXV			NS	NS
General mean			**19.23**	**69.46**
Farmer's practice			11.02	28.52
S.Em ±			**1.71**	**2.48**
CD (P=0.05)			**4.93**	**7.15**

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K6

Table 4.22b: Treatment combination of boron uptake (g ha^{-1}) of haulm influenced by nutrients, land configuration and varieties at 45 DAS and harvest

Treatment	Boron uptake (g ha^{-1}) at	
	45 DAS	**harvest**
$N_1L_1V_1$	20.49	66.43
$N_1L_1V_2$	15.35	67.90
$N_1L_2V_1$	16.43	66.04
$N_1L_2V_2$	15.50	61.21
$N_2L_1V_1$	28.54	84.68
$N_2L_1V_2$	24.34	83.73
$N_2L_2V_1$	18.82	61.93
$N_2L_2V_2$	14.34	63.74
S.Em ±	**1.78**	**4.42**
CD (P=0.05)	**NS**	**NS**

4.6.11.3 Varieties

Significantly higher boron uptake of haulm observed in the cultivated variety ICGV 91114 (21.07 g ha^{-1}). Whereas, the minimum boron uptake of haulm was recorded in cultivated variety K 6 (17.38 g ha^{-1}).

4.6.11.4 Interaction effect

Interaction of nutrient and land configuration was found significant in regard to boron uptake of haulm presented in table 4.22c. Combination of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment (26.44 g ha^{-1}) shows highest value of boron uptake of haulm as compared to other treatment combination.

Table 4.22 c: Interaction effect of nutrient and land configuration on boron uptake (g ha^{-1}) of haulm at 45 DAS

Boron uptake (g ha^{-1}) at 45 DAS		
	L_1:BBF	**L_2 :FB**
N_1:RDF	17.92	15.96
N_2 :RDF + MN	26.44	16.58
S.Em ±	**1.26**	
CD (P=0.05)	**3.66**	

4.6.11.5 Farmer's practice vs other treatments

There was significantly lowest boron uptake (11.02 g ha^{-1}) of haulm recorded in the farmer's practice as compared to all other treatments. Mean of all other treatments boron uptake (19.23 g ha^{-1}).

4.6.12 Boron uptake (kg ha^{-1}) of haulm at harvest

An appraisal of data in Table 4.22a, 4.22b and 4.22d shows that boron uptake of haulm at harvest. Which was recorded significance difference between the nutrient and land configuration except variety treatments. General mean of all treatment was (69.46 g ha^{-1}).

4.6.12.1 Nutrients

There was significantly greater boron uptake of haulm in recommended dose of fertilizer along with micro nutrient treatment (73.52 g ha^{-1}) due to application of borax @ 10 kg ha^{-1} at sowing. Though, the lowest boron uptake of haulm was recorded in only recommended dose of fertilizer treatment (65.39 g ha^{-1}).

4.6.12.2 Land configuration

There was significantly highest boron uptake of haulm found in the broad bed and furrow treatment (75.68 g ha^{-1}). While, the minimal boron uptake of haulm in groundnut was recorded in flat bed treatment (63.23 g ha^{-1}).

4.6.12.3 Varieties

There was no significant difference was found between both varieties. But maximum boron uptake of haulm observed in the cultivated variety ICGV 91114 (69.77 g ha^{-1}). Whereas, minimum boron uptake of haulm was recorded in cultivated variety K 6 (69.14 g ha^{-1}).

4.6.12.4 Interaction effect

There was a significant boron uptake of haulm results was observed in combination nutrient and land configuration. That is represented in Table 4.22d the boron uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed and furrow treatment (84.20 g ha^{-1}). Whereas, other treatment combination registered lower boron uptake of haulm.

4.6.12.5 Farmer's practice vs other treatments

There was significantly lowest boron uptake of haulm (28.52 g ha^{-1}) recorded in the farmer's practice as compared to all other treatments. Mean of all other treatments boron uptake (69.46 g ha^{-1})

Table 4.22 d: Interaction effect of nutrient and land configuration on boron uptake (g ha^{-1}) of haulm at harvest

Boron uptake (g ha^{-1}) at haulm at harvest		
	L_1:BBF	**L_2 :FB**
N_1:RDF	67.16	63.62
N_2 :RDF + MN	84.20	62.83
S.Em ±	**3.12**	
CD (P=0.05)	**9.05**	

4.7 Economics

Data with respect to cost of cultivation, gross return and benefit cost ratio are presented in Table 4.23a. The details about cost of cultivation of groundnut and treatment cost are presented in appendix III.

4.7.1 Cost of cultivation (₹ ha^{-1})

Cost of cultivation of five different locations according to actual cost was calculated and presented in appendix III. For the calculation actual cost of cultivation of different inputs like field preparation, sowing, seed cost and other cost considered. Treatment cost of cultivation calculated according to treatment variation. Cost of cultivation of recommended dose of fertilizer along with or without micro nutrient was ₹ 34343 and ₹ 32463 respectively difference between both the treatments was ₹ 1897 due to application of micronutrients. Application of micronutrients contributes 240 kg ha^{-1} pod yield advantage over without micronutrients treatment which is equivalent to ₹ 9120. Cost of cultivation for broad bed and furrow treatment was ₹ 34903 and for flatbed treatment ₹ 31903. For cultivated variety ICGV 91114 was ₹ 33529.00 and K 6 was ₹ 33279.00 respectively. Cost of cultivation according to farmer's practice was calculated according to practices adopted by the groundnut farmers and it was ₹ 29880.00 on basis of five locations mean.

4.7.2 Gross returns (₹ ha^{-1})

4.7.2.1 Nutrients

For the calculation of gross return market rate of groundnut pod was considered ₹ 38 kg^{-1} according to local market of the location. The gross return was maximum in the case of recommended dose of fertilizer treatment along with micro nutrient ₹ 67662 and minimum in the case of recommended dose of fertilizer treatment ₹ 57110.

4.7.2.2 Land configuration

The gross returns was maximum in the case of broad bed and furrow treatment ₹ 70243 than flat bed treatment ₹ 54529. Dhadage *et al.* (2008) found same results in broad bed and furrow treatment.

Table 4.23a: Cost of cultivation, gross, net returns (₹ ha^{-1}) and B:C ratio influenced by nutrients, land configuration and varieties

Treatment			Cost of Cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C Ratio
Nutrient	**N_1**	RDF	32464	57111	24647	1.77
	N_2	RDF+MN	34344	67662	33318	1.97
Land	**L_1**	BBF	34904	70243	35339	2.02
configuration	**L_2**	FB	31904	54529	22626	1.72
Variety	**V_1**	ICGV 91114	33529	63811	30283	1.91
	V_2	K 6	33279	60961	27682	1.83
General mean			**33404**	**62386**	**28982**	**1.87**
Farmer's practice			29880	44042	13789	1.45

RDF=Recommended Dose of Fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1}) MN=Micronutrients ($ZnSO_4$@ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) BBF=Broad Bed &Furrow, FB=Flat Bed, Farmer's practice =NPK (18:46:30) fertilizer+ Flat bed+ K 6

4.7.2.3 Varieties

The gross returns (₹ 63811) was higher in the case of cultivated variety ICGV 91114 than cultivated variety K 6 (₹ 60961).

4.7.2.4 Farmer's practice

A lowest gross return was observed in the case of farmer's practice compared to all other treatments about ₹ 44041.

4.7.3 Net returns (₹ ha^{-1})

4.7.3.1 Nutrients

The net returns (₹ 33318) was maximum in the case of recommended dose of fertilizer treatment along with micro nutrient and minimum in the case of recommended dose of fertilizer treatment (₹ 24646). Application of micronutrients provide monitory advantage of (₹ 8672) over the application of recommended dose of fertilizer only which is equivalent to 228 kg ha^{-1} pod yield advantage.

4.7.3.2 Land configuration

The net return was maximum in the case of broad bed and furrow treatment ₹ 35339 than flat bed treatment ₹ 22625. Broad bed and furrow system gives ₹ 12714 advantage over flat bed in respect to monitory gross return so that by minor change in land configuration gives great advantage in groundnut crop. Vekariya *et al*. (2015) reported the same result in groundnut crop broad bed (90 cm width) and furrow (45 cm) with 3 with highest net returns of ₹ 23,662 ha^{-1}.

4.7.3.3 Varieties

The net return was higher in the case of cultivated variety ICGV 91114 ₹ 30283 than cultivated variety K 6 ₹ 27682. Improved variety ICGV 91114 performed well as compared to local variety K 6.

4.7.2.4 Farmer's practice

Lowest net returns was observed in the case of farmer's practice compared to all other treatments about ₹ 13788 only which is very less monitory return in groundnut crop.

4.7.3 B:C ratio

4.7.3.1 Nutrients

The B:C ratio was maximum in the case of recommended dose of fertilizer treatment along with micro nutrient (1.97) and minimum in the case of recommended dose of fertilizer treatment (1.77). Application of micro nutrient contributes 0.2 addition advantage over without recommended dose of fertilizer per rupee invested. Wani *et al*. (2015) found same results in case of balanced fertilization.

4.7.3.2 Land configuration

The B: C ratio was maximum in the case of broad bed and furrow treatment (2.02) than flat bed treatment (1.72). Difference between both the land configurations was very vast in respect to benefit cost ratio so by modifying the land preparation in case of groundnut farmer can take advantage over existing system of land preparation. Baskaran *et al*. (2003) Dhadage *et al*. (2008) reported same results with broad bed and furrow treatment.

4.7.3.3 Varieties

The B: C ratio was higher in the case of cultivated variety ICGV 91114 (1.91) than cultivated variety K 6 (1.83).

4.7.2.4 Farmer's practice

Lowest B:C ratio was observed in the case of farmer's practice compared to all other treatments about 1.45 which is very less in respect to groundnut cultivation.

CHAPTER - V
SUMMARY AND CONCLUSIONS

Groundnut (*Arachis hypogaea* L.) is an annual legume native to South America. It is one of the principal oilseed crop of tropical and sub-tropical regions of the world belongs to the family Leguminoceae. It is commonly called as poor man's almond, wonder nutand is also called as king of oilseeds. It is the world's fourth most important source of edible oil and third most important source of vegetable protein.

Broad Bed and Furrow (BBF) System having the advantage is crop in raised bed showed excellent root growth and nodulation, vigorous plant growth and greener foliage than the flat bed. Raising of groundnut on broad beds reduces weed problem. Crops on BBF are more amenable for manual harvesting with fewer pods left in ground while pulling out.This system is recommended for all soils particularly for clayey soils in high rainfall areas.

Balanced nutrient application having advantages in declining factor productivity is largely due to imbalanced fertilizer use. Fertilizers application is highly skewed in favour of N, with relatively small use of K and P application, and rare use of secondary and micronutrients. Current generalized fertilizer recommendations are also sub-optimal and need upward refinement. So this concept of soil test based balanced nutrient application helps in getting good crop yields. Factor of productivity like balanced nutrients on the basis of soil test, land configuration and varieties of groundnut are key factor to obtain good yield, quality of kernel and haulm. Keeping the above factors in view the present experiment **"Effect of improved management practices on factor of productivity on Groundnut (*Arachis hypogaea* L.) cultivation"** was conducted at farmer's field *i.e.* in five location of the same village Hiregundgal, District: Tumkur (Karnataka) under the project of Bhoo Samruddhi collaboration between KSDA (Karnataka State Department of Agriculture) and ICRISAT (International Crop Research Institute for Semi-Arid Tropics Agriculture), Hyderabad. The experiment consisted of three factors *viz.* nutrient management, land configuration and variety along with farmer's practice as check treatment. In each factor two levels were used. First factor was nutrient management recommended dose of fertilizer with and without micro nutrient. Second factor was land configurations broad bed & furrow and flat bed and lastly two varieties ICGV 91114 and K 6 and farmer's practice as control treatment. Following are the treatment combination:

$N_1L_1V_1$: Recommended dose of fertilizer (25:50:25 NPK + Gypsum @ 500 kg ha^{-1} at 30 DAS) + BBF (Broad bed and furrow) + ICGV 91114, **$N_1L_1V_2$:** Recommended dose of fertilizer (25:50:25 NPK + Gypsum @ 500 kg ha^{-1} at 30 DAS) + BBF (Broad bed and furrow) + K 6, **$N_1L_2V_1$:** Recommended dose of fertilizer (25:50:25 NPK + Gypsum @ 500kg ha^{-1} at 30 DAS) + FB (Flat bed) + ICGV 91114, **$N_1L_2V_2$:** Recommended dose of fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1} at 30 DAS) + FB (Flat bed) + K 6, **$N_2L_1V_1$:** Recommended dose of fertilizer (25:50:25 NPK+ Gypsum @ 500 kg ha^{-1} at 30 DAS) + Micro nutrients ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1} at basal application) + BBF (Broad bed and furrow) + ICGV 91114, **N_2 L_1V_2:** Recommended dose of fertilizer (25:50:25 NPK + Gypsum @ 500kg ha^{-1} at 30 DAS) + Micro nutrients ($ZnSO_4$ @25 kg ha^{-1}& Borax @ 10 kg ha^{-1} at basal application) + BBF (Broad bed and furrow) + K 6, **$N_2L_2V_1$:** Recommended dose of fertilizer (25:50:25 NPK + Gypsum @500 kg ha^{-1} at 30 DAS) + Micro nutrients ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @10 kg ha^{-1} at basal application) + FB (Flat bed) + ICGV 91114, **$N_2L_2V_2$:** Recommended dose of fertilizer (25:50:25 NPK + Gypsum @ 500kg ha^{-1} at 30 DAS) + Micro nutrients ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1} at basal application) + FB (Flat bed) + K 6.

The results of the investigation are summarized as below

Plant height of groundnut recorded higher in the recommended dose of fertilizer along with micro nutrient treatment and broad bed and furrow at 60, 90 DAS and at harvest. The lowest plant height was found under recommended dose of fertilizer and flat bed at 60, 90 DAS and at harvest. Cultivated variety ICGV 91114 recorded higher plant height throughout the growth period than cultivated variety K 6. Framer's practice recorded significantly lowest plant height at 60, 90 DAS and at harvest compared to all treatments. The interaction effect due to nutrient management, land configuration and variety not found any significant difference at all growth stages in groundnut.

Number of branches per plant were recorded non-significant at all growth stages in nutrient and land configuration but in case of variety significantly highest number of branches per plant were recorded in cultivated variety ICGV 91114. Whereas lowest number of branches per plant were recorded in cultivated variety K 6 at all growth stages. Framer's practice recorded significantly lower number of branches per plant during all the growth period. The interaction effect due to nutrient management, land configuration and variety not found any significant difference at all growth stages in groundnut.

Leaf area per plant significantly higher in recommended dose of fertilizer along with micro nutrient, broad bed and furrow and variety ICGV 91114 treatments than recommended dose of fertilizer, flat bed and variety K 6 treatments at 60 and 90 DAS observation and non-significant at 30 DAS observation. Framer's practice recorded significantly lower leaf area per plant at all the observation. The interaction effect between nutrient and land configuration was recorded significant difference at 60 DAS and 90 DAS observation, where leaf area plant was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment.

Total dry matter per plant was significant at 60 DAS and 90 DAS for nutrient management where recommended dose of fertilizer along with micro nutrient recorded higher total dry matter per plant was recorded than recommended dose of fertilizer at 60 DAS and 90 DAS. Broad bed & furrow and variety ICGV 91114 treatments found significantly maximum total dry matter per plant at all three observation whereas minimum value recorded in flat bed and variety K 6 treatments. Framer's practice recorded significantly lowest total dry matter per plant as compared to other treatment combination. The interaction effect between nutrient and land configuration was recorded significant difference at 60 DAS and 90 DAS observation, where total dry matter per plant was significantly higher in the combination of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lowest total dry matter.

Leaf area index is based on leaf area per plant, so the same trends were observed in leaf area index also. leaf area index significantly higher in recommended dose of fertilizer along with micro nutrient, broad bed and furrow and variety ICGV

91114 treatments than recommended dose of fertilizer, flat bed and variety K 6 treatments at 60 and 90 DAS observation non-significant at 30 DAS observation in all treatments. Framer's practice recorded significantly lowest leaf area index in all record of observation compared to all treatments. The interaction effect between nutrient and land configuration was recorded significant difference at 60 DAS and 90 DAS observation, where leaf area index was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Other than this interaction none of the interactions were not shown significant difference.

Crop growth rate was significantly higher in in recommended dose of fertilizer along with micro nutrient at 60 DAS than recommended dose of fertilizer. Broad bed and furrow significantly recorded maximal value of crop growth rate at 30 and 60 DAS. Whereas, minimal values recorded in flat bed treatment. Variety ICGV 91114 recorded maximum value for the crop growth rate at 30 and 60 DAS. However, variety K 6 showed minimum value. Framer's practice recorded significantly lower crop growth rate in all record of observation than all treatments. There was a significant interaction results were observed in between nutrient and land configuration at 30-60 DAS observation. The crop growth rate was significantly higher at 30-60 DAS in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment. Whereas, other treatment combination registered lowest crop growth rate at 30-60 DAS. Other than this interaction none of the interactions were not shown significant difference.

Relative growth rate was also recorded same trends like crop growth rate. Significantly higher relative growth rate was recorded in recommended dose of fertilizer along with micro nutrient at 60 DAS than recommended dose of fertilizer. Broad bed and furrow significantly recorded maximal value of relative growth rate at 30 and 60 DAS. Whereas minimal values recorded in flat bed treatment. Variety ICGV 91114 recorded maximum value for the relative growth rate at 30 and 60 DAS. However, variety K 6 showed minimum value. Framer's practice recorded significantly lower relative growth rate in all record of observation than all treatments. There was a significant interaction results were observed in between nutrient and land configuration at 30-60 DAS observation. The relative growth rate was significantly higher at 30-60

DAS in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment. Whereas, other treatment combination registered lowest crop growth rate at 30-60 DAS. Other than this interaction none of the interactions were not shown significant difference.

There were significantly higher number of pods per plant in the recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}), Broad bed and furrow and cultivated variety ICGV 91114 treatment. Though, the less number of pods per plant were recorded in only recommended dose of fertilizer, flat bed and cultivated variety K 6 treatment. Framer's practice recorded significantly lower number of pods per plant than all other treatments. There was a significant results were observed in between nutrient and land configuration interaction observation. The number of pods per plant were significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lower number of pods per plant. Other than this interaction none of the interactions were not shown significant difference.

There were significantly maximal weight of pods per plant in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}), Broad bed and furrow and cultivated variety ICGV 91114 treatment. Though, the weight of pods per plant were recorded in only recommended dose of fertilizer, flat bed and cultivated variety K 6 treatment. Framer's practice recorded significantly lower number of pods per plant than all other treatments. There was a significant results were observed in between nutrient and land configuration interaction observation. The number of pods per plant were significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lower number of pods per plant. Other than this interaction none of the interactions were not shown significant difference.

Pod yield significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}), broad bed & furrow and cultivated variety ICGV 91114 treatment than recommended dose of fertilizer, flat bed and cultivated variety K 6 treatment. Framer's practice recorded significantly lower pod yield than all other treatments. There was a significant results were observed in between nutrient and land configuration interaction. Pod yield was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lower pod yield. Other than this interaction none of the interactions were not shown significant difference.

Haulm yield significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed & furrow than recommended dose of fertilizer and flat bed treatment. There was non-significant difference was observed between varieties. Framer's practice recorded significantly lower haulm yield than all other treatments. There was a significant results were observed in between nutrient and land configuration interaction haulm yield was significantly higher in the association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment. Whereas, other treatment combination registered lower pod yield. Other than this interaction none of the interactions were non-significant.

Harvest index was significantly higher in cultivated variety ICGV 91114 than cultivated variety K 6. There was non-significant difference was observed in land configuration and nutrient management treatment. Framer's practice recorded significantly minimum harvest index compared to all other treatments. There was non-significant difference was observed in interaction.

100 seed weight was significantly higher in cultivated variety ICGV 91114 than cultivated variety K 6. There was non-significant difference was observed in land configuration and nutrient management treatment. There was significantly lowest 100 seed weight recorded in the farmer's practice as compared to all other treatments. There was non-significant difference was observed in interaction.

Shelling percent was significantly highest in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}), broad bed & furrow and cultivated variety ICGV 91114 treatment. Whereas lowest value recorded in recommended dose of fertilizer, flat bed and cultivated variety K 6 treatment. Framer's practice recorded significantly lower shelling percent than all other treatments. There was a significant results were observed in between land configuration and variety interaction observation. Where, shelling percent was significantly higher in the association of broad bed & furrow and cultivated variety ICGV 91114 treatments**.** Though, the other treatment combination registered lower shelling percent. Then other interactions were non-significant.

There was significantly higher oil percent and oil yield was recorded in in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}), broad bed & furrow and cultivated variety ICGV 91114. Framer's practice recorded significantly lower oil percent and oil yield than all other treatments. There was non-significance interaction recorded in oil percent. Similar interaction was recorded between nutrient and land configuration. Where maximum value recorded in association of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow treatment.

Protein percent was non-significantly differed among all treatments. Farmer's practice also non-significantly differed with other treatment. Interactions were also non-significantly differed.

Significant higher number of nodules per plant were observed in variety ICGV 91114 than variety K 6. Nutrient management and land configuration treatments were registered non-significant value. Farmer's practice registered significantly lower number of nodules per plant. There were none of the interactions were significant. Mycorrhizal infection percent was non-significantly differed among all treatments. Farmer's practice was also non-significantly differed with other treatment. Interactions were also non-significantly differed.

Soil pH, Electrical conductivity and soil organic matter were non-significantly differed by nutrient management, land configuration and variety treatment. Farmer's practice was also non-significantly differed with other treatment. Interactions were also non-significantly differed.

Broad bed and furrow land configuration recorded significantly more soil moisture at field capacity and permanent wilting point than flat bed. Other treatments shown non-significant difference. Farmer's practice registered significantly less soil moisture at field capacity and permanent wilting point as compared to other treatments. Interactions were recorded non-significant difference.

Soil available nitrogen, phosphorus and potassium, sulphur were non-significantly differed by nutrient management, land configuration and variety treatment. Farmer's practice was also non-significantly differed with other treatment. Interactions were also non-significantly differed.

Significantly higher values found in case of recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) than recommended dose of fertilizer in case of available zinc and boron. Other treatments did not shown any significant difference. Farmer's practice registered significantly less available zinc and boron as compared to other treatments. Interactions were recorded non-significant difference.

Nitrogen uptake of haulm at 45 DAS and harvest significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 was recorded significantly highest nutrient uptake at 45 DAS than variety K 6 but non-significant at harvest. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of nitrogen uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, the nitrogen uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower nitrogen uptake of haulm. Other interactions were non-significantly differed.

Phosphorus uptake of haulm at 45 DAS and harvest significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 was recorded significantly highest nutrient uptake at 45 DAS than variety K 6 but non-significant at harvest. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of phosphorus uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, phosphorus uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower phosphorus uptake of haulm. Other interactions were non-significantly differed.

Potassium uptake of haulm at 45 DAS and harvest significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 was recorded significantly highest nutrient uptake at 45 DAS than variety K 6 but non-significant at harvest. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of potassium uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, potassium uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower potassium uptake of haulm. Other interactions were non-significantly differed.

There was significantly maximum sulphur uptake of haulm at 45 DAS and harvest recorded in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 did not shown any significant difference with variety K 6 at both the observation. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of sulphur uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, sulphur uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower sulphur uptake of haulm. Other interactions were non-significantly differed.

There was significantly maximum zinc uptake of haulm at 45 DAS and harvest recorded in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 did not shown any significant difference with variety K 6 at both the observation. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of zinc uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, zinc uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower zinc uptake of haulm. Other interactions were non-significantly differed.

Boron uptake of haulm at 45 DAS and harvest significantly higher in recommended dose of fertilizer along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1}& Borax @ 10 kg ha^{-1}) and broad bed furrow than recommended dose of fertilizer and flat bed. Variety ICGV 91114 was recorded significantly highest nutrient uptake at 45 DAS than variety K 6 but non-significant at harvest. Farmer's practice observed significantly lower values compared to all treatments. There was a significant interaction of boron uptake of haulm was recorded in between nutrient and land configuration at 45 DAS and harvest. Where, boron uptake of haulm was significantly highest in the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment whereas, other treatment combination registered lower boron uptake of haulm. Other interactions were non-significantly differed.

Higher cost of cultivation, gross return, net return and B:C ratio of groundnut was recorded in recommended dose of fertilizer along with micro nutrient than recommended dose of fertilizer. In land configuration treatment broad bed and furrow recorded higher cost of cultivation, gross return, net return and B:C ratio than flat bed. In case of varietal treatment variety ICGV 91114 exhibited maximum cost of cultivation, gross return, net return and B:C ratio however, minimum values observed in variety K 6. Farmer's practice registered lowest cost of cultivation, gross return, net return and B:C ratio of groundnut.

CONCLUSIONS

Based on the findings of the experiment, the following conclusion could be drawn:

1. Application of recommended dose of fertilizer (25:50:25 NPK+ Gypsum @ 500kg ha^{-1} at 30 DAS) along with micro nutrient ($ZnSO_4$ @ 25 kg ha^{-1} & Borax @ 10 kg ha^{-1} at basal application) gave higher growth characters *viz.,* plant height, leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, relative growth rate, and yield attributes & yield *viz.,* number of pods $plant^{-1}$, weight of pods $plant^{-1}$, pod yield, haulm yield of groundnut crop.
2. Using broad bed and furrow configuration registered higher growth characters *viz.,* plant height, leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, relative growth rate and yield attributes & yield *viz.,* number of pods $plant^{-1}$, weight of pods $plant^{-1}$, pod yield, haulm yield of groundnut crop.
3. Growing of cultivated variety ICGV 91114 leads to get more growth characters *viz.,* plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, relative growth rate and yield attributes & yield *viz.,* number of pods $plant^{-1}$, weight of pods $plant^{-1}$, pod yield, harvest index of groundnut crop.
4. Application of recommended dose of fertilizer along with micro nutrient, broad bed furrow configuration and improved variety ICGV 91114 given higher oil percent, oil yield and nutrient uptake in haulm.
5. Most of the parameters *viz.,* leaf area $plant^{-1}$, total dry matter $plant^{-1}$, leaf area index, crop growth rate, and relative growth rate, number of pods $plant^{-1}$, weight of pods $plant^{-1}$, pod yield, haulm yield, oil yield, uptake of nitrogen, phosphorus, potassium, sulphur, zinc and boron in haulm registered interaction between land configuration and nutrient, where the association of recommended dose of fertilizer along with micro nutrient and broad bed furrow treatment registered the higher value than the other treatment association.
6. Pod and haulm yield of recommended dose of fertilizer along with micro nutrient was 1633.95 and 2059.89 kg ha^{-1} respectively, in case of broad bed and furrow

1697.69 and 2143.89 kg ha^{-1} respectively and cultivated variety ICGV 91114 1616.91 and 1913.31 kg ha^{-1}.

7. Economic viability of groundnut proved superior in recommended dose of fertilizer along with micro nutrient than recommended dose of fertilizer. Broad bed and furrow was superior over flat bed. Cultivated variety ICGV 91114 superior to cultivated variety K 6. Farmer's practice registered the lowest value for economics compared to all treatments.
8. Maximum net returns (₹ 33318.00) and B:C ratio (1.97) recorded in recommended dose of fertilizer along with micro nutrient. Among land configuration treatments broad bed and furrow shown Maximum net returns (₹ 35339.00) and B:C ratio (2.02). In case of variety treatment cultivated variety ICGV 91114 recorded maximal net returns (₹ 30282.00) and B:C ratio (1.91).

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Appendix I: Weakly weather data during cropping year (2016), at Karnataka State Natural Disaster Monitoring Centre:

Date	Temp.(º C)		Rainfall(mm)	RH (%)	
	Min.	Max.		Min.	Max.
1 Aug-7 Aug	20.1	28.1	5.16	58.1	95.4
8 Aug-14 Aug	20.8	30.0	9.92	53.7	99.0
15 Aug-21 Aug	20.8	29.7	1.42	53.3	94.9
22 Aug-28 Aug	22.4	30.2	7.13	50.6	94.7
29 Aug-4 Sept	21.3	28.5	21.79	62.0	95.6
5 Sept-11 Sept	20.3	29.6	7.53	49.5	94.6
12 Sept-18 Sept	21.7	30.0	7.14	49.7	93.7
19 Sept-25 Sept	21.4	29.0	5.96	55.1	94.4
26 Sept-2 Oct	21.7	29.7	2.88	54.9	95.5
3 Oct -9 Oct	19.5	31.3	4.68	38.8	93.7
10 Oct-16 Oct	20.7	31.2	71.84	44.1	91.9
17 Oct- 23 Oct	18.1	34.0	0.0	29.8	81.6
24 Oct -30 Oct	18.7	31.6	0.0	30.4	76.7
31 Oct- 6 Nov	20.8	31.7	6.55	39.9	87.2
7 Nov-13 Nov	17.2	30.8	0.0	27.9	81.6
14 Nov-20 Nov	21.0	32.2	0.0	38.1	91.6
Total			**152**		

Appendix II: Price of inputs and outputs

Sl. No.	Particular	Price (₹)
	Input	
1.	**Land preparation**	
a.	Land rent	1000 ha^{-1}
b.	Tractor cultivator	750 hr^{-1}
c.	Harrowing (bullock pair)	50 hr^{-1}
2.	Seed	
a.	ICGV91114	57 kg^{-1}
b.	K6	55 kg^{-1}
3.	Fertilizer	
a.	Urea	10.80 kg^{-1}
b.	MOP	17.86 kg^{-1}
c.	DAP	25.32 kg^{-1}
d.	Gypsum	2 kg^{-1}
e.	Zinc	42 kg^{-1}
f.	Borax	68 kg^{-1}
4.	Plant Protection	
a.	Chlorphyryphos (SULBAN)	250 l^{-1}
b.	Lambda –cyhalothrin(KARATE)	650 l^{-1}
c.	Mancozeb (DAITHANE M-45)	300 kg^{-1}
5.	Bio – inoculums	
a.	*Rhizobium japonicum*	80 kg^{-1}
b.	*Trichoderma viridae*	100 kg^{-1}
6.	Herbicide rate	
a.	Alachlor	400 l^{-1}
7.	Labour wages	
a.	Men	200 day^{-1}
b.	Women	150 day^{-1}
	Out put	
	Seed	38 kg^{-1}
	Haulm	0.5 kg^{-1}

Appendix III: COST OF CULTIVATION OF ALL REPLICATIONS:

Cost of cultivation of Farmer: 1 (R 1)

Sl. No.		Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.		**Land preparation**									
	a)	Tractor drawn operation	3000	3000	3000	3000	3000	3000	3000	3000	3000
	b)	Harrowing (bullock pair)	800	800	800	800	800	800	800	800	800
	c)	BBF making	3000	3000	-	-	3000	3000	-	-	-
2.		Sowing	700	700	700	700	700	700	700	700	700
3.		Seed cost	7125	6875	7125	6875	7125	6875	7125	6875	6875
4.		**Fertilizer cost**									
	a)	Urea	128	128	128	128	128	128	128	128	-
	b)	DAP	2752	2752	2752	2752	2752	2752	2752	2752	2532
	c)	MOP	745	745	745	745	745	745	745	745	893
	d)	Gypsum	250	250	250	250	250	250	250	250	-
	e)	Zinc sulphate	-	-	-	-	1050	1050	1050	1050	-
	f)	Borax	-	-	-	-	680	680	680	680	-
		Application charges	300	300	300	300	450	450	450	450	300
5.		Bio – inoculums	450	450	450	450	450	450	450	450	-
6.		Plant Protection	550	550	550	550	550	550	550	550	550
		Application charges	350	350	350	350	350	350	350	350	350
7.		Irrigation charges	1000	1000	1000	1000	1000	1000	1000	1000	1000
		Application charges	800	800	800	800	800	800	800	800	800
8.		**Herbicides cost**									
	a)	Alachlor	600	600	600	600	600	600	600	600	600
		Application charges	350	350	350	350	350	350	350	350	350
9.		Inter cultivation	800	800	800	800	800	800	800	800	800
10.		Hand weeding	600	600	600	600	600	600	600	600	600
11.		Harvesting, threshing, storage & transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000
12.		Land rent	1000	1000	1000	1000	1000	1000	1000	1000	1000
		Cost of cultivation (₹ ha^{-1})	**34300**	**34050**	**31300**	**31050**	**36180**	**35930**	**33180**	**32930**	**30150**

Cost of cultivation of Farmer: 2 (R 2)

Sl. No.	Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.	**Land preparation**									
a)	Tractor drawn operation	3000	3000	3000	3000	3000	3000	3000	3000	3000
b)	Harrowing (bullock pair)	800	800	800	800	800	800	800	800	800
c)	BBF making	3000	3000	-	-	3000	3000	-	-	-
2.	Sowing	700	700	700	700	700	700	700	700	700
3.	Seed cost	7125	6875	7125	6875	7125	6875	7125	6875	6875
4.	**Fertilizer cost**									
a)	Urea	128	128	128	128	128	128	128	128	-
b)	DAP	2752	2752	2752	2752	2752	2752	2752	2752	2532
c)	MOP	745	745	745	745	745	745	745	745	893
d)	Gypsum	250	250	250	250	250	250	250	250	-
e)	Zinc sulphate	-	-	-	-	1050	1050	1050	1050	-
f)	Borax	-	-	-	-	680	680	680	680	-
	Application charges	300	300	300	300	450	450	450	450	300
5.	Bio – inoculums	450	450	450	450	450	450	450	450	-
6.	Plant Protection	550	550	550	550	550	550	550	550	550
	Application charges	350	350	350	350	350	350	350	350	350
7.	Irrigation charges	1000	1000	1000	1000	1000	1000	1000	1000	1000
	Application charges	800	800	800	800	800	800	800	800	800
8.	**Herbicides cost**									
a)	Alachlor	600	600	600	600	600	600	600	600	600
	Application charges	350	350	350	350	350	350	350	350	350
9.	Inter cultivation	800	800	800	800	800	800	800	800	800
10.	Hand weeding	600	600	600	600	600	600	600	600	600
11.	Harvesting, threshing, storage & transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000
12.	Land rent	1000	1000	1000	1000	1000	1000	1000	1000	1000
	Cost of cultivation (₹ ha^{-1})	**34300**	**34050**	**31300**	**31050**	**36180**	**35930**	**33180**	**32930**	**30150**

Cost of cultivation of Farmer: 3 (R 3)

Sl. No.		Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.		**Land preparation**									
	a)	Tractor drawn operation	3000	3000	3000	3000	3000	3000	3000	3000	3000
	b)	Harrowing (bullock pair)	800	800	800	800	800	800	800	800	800
	c)	BBF making	3000	3000	-	-	3000	3000	-	-	-
2.		Sowing	700	700	700	700	700	700	700	700	700
3.		Seed cost	7125	6875	7125	6875	7125	6875	7125	6875	6875
4.		**Fertilizer cost**									
	a)	Urea	128	128	128	128	128	128	128	128	-
	b)	DAP	2752	2752	2752	2752	2752	2752	2752	2752	2532
	c)	MOP	745	745	745	745	745	745	745	745	893
	d)	Gypsum	250	250	250	250	250	250	250	250	-
	e)	Zinc sulphate	-	-	-	-	1050	1050	1050	1050	-
	f)	Borax	-	-	-	-	680	680	680	680	-
		Application charges	300	300	300	300	450	450	450	450	300
5.		Bio – inoculums	450	450	450	450	450	450	450	450	-
6.		Plant Protection	550	550	550	550	550	550	550	550	550
		Application charges	350	350	350	350	350	350	350	350	350
7.		Irrigation charges	250	250	250	250	250	250	250	250	250
		Application charges	200	200	200	200	200	200	200	200	200
8.		**Herbicides cost**									
	a)	Alachlor	600	600	600	600	600	600	600	600	600
		Application charges	350	350	350	350	350	350	350	350	350
9.		Inter cultivation	800	800	800	800	800	800	800	800	800
10.		Hand weeding	600	600	600	600	600	600	600	600	600
11.		Harvesting, threshing, storage & transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000
12.		Land rent	1000	1000	1000	1000	1000	1000	1000	1000	1000
		Cost of cultivation (₹ ha^{-1})	**32950**	**32700**	**29950**	**29700**	**34830**	**34580**	**31830**	**31580**	**28800**

Cost of cultivation of Farmer: 4 (R 4)

Sl. No.		Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.		**Land preparation**									
	a)	Tractor drawn operation	3000	3000	3000	3000	3000	3000	3000	3000	3000
	b)	Harrowing (bullock pair)	800	800	800	800	800	800	800	800	800
	c)	BBF making	3000	3000	-	-	3000	3000	-	-	-
2.		Sowing	700	700	700	700	700	700	700	700	700
3.		Seed cost	7125	6875	7125	6875	7125	6875	7125	6875	6875
4.		**Fertilizer cost**									
	a)	Urea	275	275	275	275	275	275	275	275	-
	b)	DAP	2752	2752	2752	2752	2752	2752	2752	2752	2532
	c)	MOP	745	745	745	745	745	745	745	745	893
	d)	Gypsum	250	250	250	250	250	250	250	250	-
	e)	Zinc sulphate	-	-	-	-	1050	1050	1050	1050	-
	f)	Borax	-	-	-	-	680	680	680	680	-
		Application charges	300	300	300	300	450	450	450	450	300
5.		Bio – inoculums	450	450	450	450	450	450	450	450	-
6.		Plant Protection	550	550	550	550	550	550	550	550	550
		Application charges	350	350	350	350	350	350	350	350	350
7.		Irrigation charges	1000	1000	1000	1000	1000	1000	1000	1000	1000
		Application charges	800	800	800	800	800	800	800	800	800
8.		**Herbicides cost**									
	a)	Alachlor	600	600	600	600	600	600	600	600	600
		Application charges	350	350	350	350	350	350	350	350	350
9.		Inter cultivation	800	800	800	800	800	800	800	800	800
10.		Hand weeding	600	600	600	600	600	600	600	600	600
11.		Harvesting, threshing, storage & transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000
12.		Land rent	1000	1000	1000	1000	1000	1000	1000	1000	1000
		Cost of cultivation (₹ ha^{-1})	**34447**	**34197**	**31447**	**31197**	**36327**	**36077**	**33327**	**33076**	**30150**

Cost of cultivation of Farmer: 5 (R 5)

Sl. No.	Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.	**Land preparation**									
a)	Tractor drawn operation	3000	3000	3000	3000	3000	3000	3000	3000	3000
b)	Harrowing (bullock pair)	800	800	800	800	800	800	800	800	800
c)	BBF making	3000	3000	-	-	3000	3000	-	-	-
2.	Sowing	700	700	700	700	700	700	700	700	700
3.	Seed cost	7125	6875	7125	6875	7125	6875	7125	6875	6875
4.	**Fertilizer cost**									
a)	Urea	275	275	275	275	275	275	275	275	-
b)	DAP	2752	2752	2752	2752	2752	2752	2752	2752	2532
c)	MOP	745	745	745	745	745	745	745	745	893
d)	Gypsum	250	250	250	250	250	250	250	250	-
e)	Zinc sulphate	-	-	-	-	1050	1050	1050	1050	-
f)	Borax	-	-	-	-	680	680	680	680	-
	Application charges	300	300	300	300	450	450	450	450	300
5.	Bio – inoculums	450	450	450	450	450	450	450	450	-
6.	Plant Protection	550	550	550	550	550	550	550	550	550
	Application charges	350	350	350	350	350	350	350	350	350
7.	Irrigation charges	1000	1000	1000	1000	1000	1000	1000	1000	1000
	Application charges	800	800	800	800	800	800	800	800	800
8.	**Herbicides cost**									
a)	Alachlor	600	600	600	600	600	600	600	600	600
	Application charges	350	350	350	350	350	350	350	350	350
9.	Inter cultivation	800	800	800	800	800	800	800	800	800
10.	Hand weeding	600	600	600	600	600	600	600	600	600
11.	Harvesting, threshing, storage & transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000
12.	Land rent	1000	1000	1000	1000	1000	1000	1000	1000	1000
	Cost of cultivation (₹ ha^{-1})	**34447**	**34197**	**31447**	**31197**	**36327**	**36077**	**33327**	**33076**	**30150**

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Board of Secondary Education	2009	Karnataka Secondary Education Board
Pre-University Board	2011	Department of Pre-University Education, Karnataka
B.Sc. (Agriculture)	2015	University of Agricultural Sciences, Dharwad, Karnataka
M.Sc. (Ag) Agronomy	2017	Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.)

Professional Experience (If any): Rural Agricultural Work Experience Programme

Membership of Professional Societies (If any):

Awards / Recognitions (If any):

Publications (If any):

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