

**STANDARDIZATION OF SEED RATE
FOR PROMISING GROUNDNUT
VARIETIES UNDER RAINFED
CONDITIONS OF SOUTHERN
TELANGANA ZONE,
ANDHRA PRADESH**

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B.Sc. (Ag.)

**MASTER OF SCIENCE IN AGRICULTURE
(AGRONOMY)**



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UNDER RAINFED CONDITIONS OF
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BY

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B.Sc. (Ag.)

**THESIS SUBMITTED TO THE ACHARYA N.G. RANGA
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CHAIRPERSON: Dr. K. B. SUNEETHA DEVI



**DEPARTMENT OF AGRONOMY
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2011

CERTIFICATE

Ms. B. SOUMYA, has satisfactorily prosecuted the course of research and that the thesis entitled **“STANDARDIZATION OF SEED RATE FOR PROMISING GROUNDNUT VARIETIES UNDER RAINFED CONDITIONS OF SOUTHERN TELANGANA ZONE, ANDHRA PRADESH ”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor part thereof has been previously submitted by her for a degree of any University.

Date:

(Dr. K.B.SUNEETHA DEVI)
Chairperson

CERTIFICATE

This is to certify that the thesis entitled “**STANDARDIZATION OF SEED RATE FOR PROMISING GROUNDNUT VARIETIES UNDER RAINFED CONDITIONS OF SOUTHERN TELANGANA ZONE, ANDHRA PRADESH**” submitted in partial fulfillment of the requirements for the degree of ‘Master of Science in Agriculture’ of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Ms. B. SOUMYA** under our guidance and supervision.

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

Thesis approved by the student advisory committee

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DECLARATION

I, **B. SOUMYA**, hereby declare that the thesis entitled, “**STANDARDIZATION OF SEED RATE FOR PROMISING GROUNDNUT VARIETIES UNDER RAINFED CONDITIONS OF SOUTHERN TELANGANA ZONE, ANDHRA PRADESH**” submitted to **Acharya N.G. Ranga Agricultural University** for the degree of **MASTER OF SCIENCE IN AGRICULTURE**, is the result of original research work done by me. It is further declared that the thesis nor any part thereof has not been published earlier in any manner.

Date:

(B. SOUMYA)

Place: Hyderabad

I. D. No.RAM/09-01

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LIST OF SYMBOLS AND ABBREVIATIONS

@	:	at the rate of
$^{\circ}\text{C}$:	Degree Centigrade
>	:	greater than
%	:	per cent
a. i	:	active ingredient
B:C	:	Benefit – Cost ratio
CD	:	Critical difference
CGR	:	Crop growth rate
Cm	:	Centimeter
cm^2	:	Square centimetre
CMIE	:	Centre for Monitoring Indian Economy
DAS	:	Days after Sowing
dsm^{-1}	:	decisiemens per meter
EC	:	Electrical conductivity
<i>et al.</i>	:	and others
g litre^{-1}	:	Gram per litre
g m^{-2}	:	grams per square meter
ha	:	Hectare
i.e.,	:	That is
K	:	Potassium
kg ha^{-1}	:	kilograms per hectare
LAI	:	Leaf area index
m^{-2}	:	per square metre
Max	:	Maximum
Mha	:	Million hectare
Min	:	Minimum
mm	:	milli metre
N	:	Nitrogen
No. m^{-2}	:	number per square metre
NS	:	non significant
P	:	Phosphorus
pH	:	Pussancea hydrogen (Potential hydrogen)
plant^{-1}	:	Per plant
pod^{-1}	:	Per pod
RBD	:	Randomized Block Design
RF	:	Rainfall
RGR	:	Relative growth rate
RH	:	Relative humidity
Rs. ha^{-1}	:	Rupees per hectare

SEm : Standard error of mean
Temp. : Temperature
viz., : Namely

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ABSTRACT

A field experiment entitled “Standardization of seed rate for promising groundnut varieties under rainfed conditions of southern Telangana zone, Andhra Pradesh” was conducted on sandy loam soil at college farm, college of Agriculture, Acharya N.G. Ranga Agricultural University during *kharif* 2010. The treatments consisted of four groundnut varieties (Narayani, ICGV 91114, K 6 and JCG 88) and four seed rates (75, 100, 125 and 150 kg ha⁻¹). The experiment was laid out in randomized block design with factorial concept and replicated thrice.

The results indicated that among the four varieties evaluated, the growth characters *viz.*, plant height, total dry matter production, LAI, CGR and RGR were higher with the variety Narayani followed by K 6 variety which were significantly superior than JCG 88 and ICGV 91114 varieties.

Similarly, the yield components like number of pods per plant, shelling percentage, pod yield, haulm yield, harvest index and oil yield were also higher with Narayani and closely followed by K 6 variety which were significantly better over JCG 88 and ICGV 91114 varieties. However oil percentage was higher in JCG 88 variety.

As regards to the effect of seed rates, each increment of seed rate (*i.e.*, 75 >100 >125 >150 kg ha⁻¹) significantly increased the growth characters *viz.*, plant height, LAI, dry matter production, CGR and RGR of all groundnut varieties. Similarly pod yield, haulm yield, kernel yield, harvest index and oil yield also increased with increase in seed rate and were more at seed rate of 150 kg ha⁻¹ and were at par with seed rate of 125 kg ha⁻¹. However the yield component *i.e.* number of pods per plant significantly decreased due to increase in seed rate.

Maximum 100 kernel weight (40.83 g) was recorded by ICGV 91114 and followed followed by JCG 88, K6 and Narayani. The 100 kernel weight was at par among 75, 100 and 125 kg ha⁻¹ seed rates and lower value was noticed with a seed rate of 150 kg ha⁻¹.

Interaction between varieties and seed rates was found significant and maximum LAI, dry matter production, CGR and pod yield (2150 kg ha⁻¹) was observed with Narayani variety at a seed rate of 150 kg ha⁻¹ which was at par with same variety at a seed rate of 125 kg ha⁻¹ which in turn was at par with K 6 at a seed rate of 150 kg ha⁻¹. However in JCG 88, they were maximum at a seed rate of 125 kg ha⁻¹ which was at par with same variety at 150 kg ha⁻¹ seed rate.

Maximum net returns were obtained with Narayani variety at a seed rate of 150 kg ha⁻¹ and then by same variety at the seed rate of 125 kg ha⁻¹. Next to Narayani higher returns were noticed with K 6 variety at a seed rate of 150 followed by 125 kg ha⁻¹ which were on par with each other. B: C ratio also followed similar trend as that of net returns and highest B: C ratio was recorded by Narayani variety at 150 kg ha⁻¹ seed rate and was on par with same variety at seed rate of 125 kg ha⁻¹. Benefit cost ratio of all varieties except JCG 88 was highest at seed rate of 150 kg ha⁻¹ and was at par with seed rate of 125 kg ha⁻¹. Whereas in JCG 88, benefit cost ratio at seed rate of 125 kg ha⁻¹ was higher (1.57) and was at par with that of 150 kg ha⁻¹ seed rate.

The results suggest that for obtaining maximum pod yields and economic returns, cultivation of the variety Narayani with a seed rate of 125 kg ha⁻¹ would be advisable under rainfed conditions of Southern Telangana zone, Andhra Pradesh.

Chapter I

Introduction

Chapter I

INTRODUCTION

Groundnut is the third most important source for edible oil production in the world. It provides high quality edible oil (48–50 %) with easily digestible protein (26–28 %) and nearly half of the 13 essential vitamins and 7 of the 20 essential minerals which are necessary for normal human growth, besides providing high quality fodder for livestock. It thus plays a significant role in the livelihoods of marginal farmers through generating income and nutritional security to their livestock. Groundnut is grown in an area of 26.4 million ha worldwide with a total production of 38.2 million metric tons (FAO, 2010). In India, groundnut is grown in an area of 6.16 million ha with a total production of 7.17 million tonnes and constitutes about 50 % of total oilseed production (CMIE, 2009). In Andhra Pradesh, it is the major oil seed crop grown over an area of 1.77 million ha with a production of 1.55 million tonnes (CMIE, 2009). Andhra Pradesh ranks second in area and production next to Gujarat. In India, productivity of groundnut is low (1164 kg ha⁻¹) and its productivity in Andhra Pradesh (876 kg ha⁻¹) is still low compared to national average. This has accentuated the need for improving its productivity in India in general and in Andhra Pradesh in particular.

Majority of the groundnut cropped area in Andhra Pradesh is under rainfed conditions which influence the production due to either low and erratic rainfall distribution or severe pests and disease incidence. In addition, other factors like lack of availability of improved varieties, low plant population and inadequate fertilizer application are also contributing to low productivity.

In Southern Telangana region of Andhra Pradesh, groundnut is the predominant oilseed crop grown in chalka soils under rainfed conditions during *kharif* season and as an irrigated crop during *rabi* season after rice.

Several improved high yielding groundnut varieties are being developed and released for cultivation. The improved variety should be fairly tolerant to foliar diseases and suitable to the climatic conditions of the area with high yield potential. Though several varieties are released, recommendation may not be possible unless such varieties are tested under a set of conditions for their suitability.

Next to variety, plant population per unit area was found to be directly correlated with pod yield up to certain point in groundnut crop (Babu, 1991). Sub optimal plant stand in groundnut cropped fields has been identified as one of the major constraints to realize full production potential of improved varieties. Optimum plant population helps in better utilization of growth resources like light, moisture and nutrients which consequently reduces the risk and ensures higher productivity and returns per unit area. Cost of groundnut seed itself constitutes about 35-50 % of total cost of cultivation and considered as an important costly input. Seed rate of groundnut is the single main factor that influence the plant population and it in turn depends on 100-seed weight. The test weight of promising groundnut varieties like K 6, Narayani, ICGV 91114 range from 43.0 to 66.6 g for bold seed size, 24.5 to 29.5 g for medium seed size (Sahadeva Reddy *et al.*, 2009). Hence, optimum seed rate may differ from variety to variety. The information on suitability of promising groundnut varieties and their recommended seed rates under Southern Telangana zone conditions of Andhra Pradesh is lacking.

Keeping the above considerations in view, the present study was designed and conducted on sandy loam soils during 2010 *kharif* season at Rajendranagar, Hyderabad with the following objectives

1. To standardize seed rate for promising groundnut varieties for achieving higher pod yield in *kharif* season under rainfed conditions of southern Telangana zone, A.P.
2. To evaluate the performance of promising varieties of groundnut.
3. To study the interaction of different seed rates on growth and yield of groundnut varieties.
4. Economic viability of optimum seed rate for promising groundnut varieties in rainfed conditions.

Chapter II

Review of Literature

Chapter II

REVIEW OF LITERATURE

In this chapter literature pertaining to the experiment entitled “Standardization of seed rate for promising groundnut varieties under rainfed conditions of southern Telangana zone, Andhra Pradesh” has been briefly reviewed under the following heads. Seed rate greatly influences plant population and spacing between the rows and plants with in the row. Hence, literature related to spacing and plant population along with seed rate is also reviewed in this chapter.

2.1 Performance of promising groundnut varieties under study (Narayani, ICGV 91114, K 6 and JCG 88)

2.2 Influence of seed rate on growth, yield attributes, yield and quality of groundnut

2.3 Interaction between groundnut varieties and seed rate on growth, yield attributes, yield and quality of groundnut

2.4 Effect of groundnut varieties and seed rate on economics

Among different components of crop production, high yielding variety and its optimum plant density are most important from the point of resource management and crop productivity. The maximum yield of any crop in a given set of environment may be obtained at a density at which inter plant competition is minimum. Beyond the optimum limit of population, possibilities of increase in yield are minimized for reasons of intra plant competition and below the optimum plant population, yield per unit area is generally less due to lack of compensation of yield loss by individual plant under reduced plant population conditions.

With increase in plant density, competition for space and other production factors increases considerably resulting in poor plant growth. Maximum exploitation of growth factors could be achieved only when the plant density exercise maximum pressure on soil nutrients, moisture, carbon dioxide and light (Donald, 1963).

Black (1966) reported that increasing the number of plants per unit area reduces the volume of air and soil that the individual plant can exploit resulting in increased competition among plants for moisture, carbon dioxide and light.

2.1 Performance of Promising Groundnut Varieties

2.1.1 Narayani

Sahadeva Reddy *et al.* (2009) conducted an experiment with four varieties of groundnut (TMV 2, K 6, Narayani and ICGV 91114) at Anantapur during *kharif* and revealed that Narayani recorded the highest pod yield (1557 kg ha⁻¹) which was on par with K 6. They further reported that highest net returns and B: C ratio was recorded with Narayani variety.

Vasanthi *et al.* (2003) evaluated the groundnut variety Narayani at various research stations from 1988 to 1992 as well as on farmers fields from 1995 and 1996 rainy season and 1998-99 post rainy season. At RARS Tirupati, Narayani was evaluated in both rainy and post rainy seasons. During the rainy season, it produced an average pod yield of 1675 kg ha⁻¹, which was 13 per cent higher than that of check variety JL 24. During the post rainy season also it produced an average pod yield of 2637 kg ha⁻¹, which was 23 per cent higher than that of JL 24. In the multilocational trial conducted during 1994 rainy season at three locations, Tirupati, Kadiri and Anantapur in Andhra Pradesh, it gave an average pod yield of 1086 kg ha⁻¹, which was 20 per cent higher than JL 24. In minikits organized on farmer's fields in Chittoor, Anantapur, and Kurnool districts of Andhra Pradesh during 1995 and 1996 rainy season, the overall average pod yield of Narayani was 1236 kg ha⁻¹, which was 43 per cent higher than that of JL 24.

Reddy *et al.* (1997) conducted an experiment at Kadiri, Andhra Pradesh during *kharif* season and reported that the variety Narayani produced an average pod yield of 1.77 t ha⁻¹ with shelling turnover of 69.9 per cent and recorded 33.2 grams 100 seed weight and 93.7 per cent sound mature kernels.

Ramesh and Durga Prasad (1996) conducted an experiment at Palem, Andhra Pradesh during *kharif* season and reported that the variety Narayani produced an average yield of 1.44 t ha⁻¹ with shelling turnover of 66.5 per cent and recorded 100-seed weight of 31 g and 40.8 per cent oil content.

2.1.2 ICGV 91114

Frontline demonstrations (FLDs) were conducted at 15 centers during *kharif* 2008 and 2009 in major groundnut growing states such as Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Manipur, Maharashtra, Punjab, Rajasthan, Tamil Nadu and West Bengal. The variety ICGV 91114 recorded an average pod yield of 1447 kg ha⁻¹ and haulm yield

3657 kg ha⁻¹ compared to average pod yield 1133 kg ha⁻¹ and haulm yield of 3377 kg ha⁻¹ with that of local variety showing 26 per cent increase of pod yield and 8 per cent increase of haulm yields compared to that of local variety. The economics indicated that the cost of cultivation ranged from Rs. 15,600 ha⁻¹ to Rs. 22,700 ha⁻¹ with an average of Rs. 19,010 ha⁻¹ compared to Rs. 15,280 ha⁻¹ with check variety. The gross monetary returns increased by 27 per cent and net returns increased by 40 per cent with improved variety compared to check variety TMV 2. The BCR also increased from 1.83 to 2.0 with improved variety ICGV 91114 (NRCG, 2010).

Kareem (2006) reported that understanding the need for an improved groundnut variety suitable to Anantapur conditions, a programme “Farmer participatory development of grain legumes in rainfed Asia” was launched during 2002. Apart of this during *kharif* 2002, a set of 8 groundnut varieties from ICRISAT and K-134 and local variety (TMV2) were provided to farmers in Danduvaripalli, West Narsapuram and Rekulakunta village to assess the varietal performance. Farmers observed that ICGV 91114 variety performed well and was therefore the preferred variety and significant observations made by farmers on ICGV 91114 groundnut variety was that it can withstand prolonged drought up to 43 to 47 days and pod yield and haulm yield is more than the local variety. The 100 seed weight of ICGV 91114 was 41 grams compared to 34 grams in TMV-2 though the shelling percentage was same.

Nigam *et al.* (2005) evaluated nine improved varieties and a local control (TMV 2) in two representative villages of the Anantapur district *i.e.* Dhanduvaripalli and Rekulakunta. Despite severe drought, ICGV 91114 produced significantly higher average pod yield (507 kg ha⁻¹) and haulm yield (1391 kg ha⁻¹) than TMV 2 (453 kg ha⁻¹ and 1111 kg ha⁻¹, respectively). ICGV 91114 variety recorded a higher average shelling out turn and more number of pods plant⁻¹ than the TMV 2 *i.e.* 59 per cent and 2.9 as compared with 55 per cent and 2.4 of TMV 2, respectively.

2.1.3 K 6

Frontline demonstrations on popularization of K 6 were conducted during 2009 and average pod yield of 823 kg ha⁻¹ was reported compared to 6485 kg ha⁻¹ with local variety. The pod yield increased by 27 per cent with improved variety compared to local variety. The economics indicated that the cost of cultivation ranged from Rs. 12,000 ha⁻¹ to Rs. 13,500 ha⁻¹ with an average of Rs. 12,335 ha⁻¹. The gross monetary returns increased by 44

per cent with improved variety compared to local variety. The BCR also increased 1.67 with improved one (NRCG, 2010).

Frontline demonstrations (FLDs) were conducted at 15 centres during *kharif* 2008 in major groundnut growing states such as Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Manipur, Maharashtra, Punjab, Rajasthan, Tamil Nadu and West Bengal. The results of 10 FLDs conducted at the centre Kadiri with improved variety K 6 recorded an average pod yield of 1098 kg ha⁻¹ compared to 785 kg ha⁻¹ with farmer's practice. The pod yield increased by 41 per cent with improved variety compared to local variety. The economics indicated that the cost of cultivation ranged from Rs. 13,000 ha⁻¹ to Rs.15,000 ha⁻¹ with an average of Rs.14,075 ha⁻¹ compared to Rs. 12,335 ha⁻¹ with local variety. The gross and net monetary returns increased by 38 per cent and 62 per cent with improved variety compared to local variety (NRCG, 2009).

2.1.4 JCG 88

The experiments were conducted in 2009 and average pod yield of 1539 kg ha⁻¹ obtained with JCG 88 compared to 1274 kg ha⁻¹ with local check variety (TMV 2). The pod yield increased by 17 per cent with improved variety compared to check variety (NRCG, 2010).

Frontline demonstrations (FLDs) were conducted at 15 centres during *kharif* 2008 in major groundnut growing states such as Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Manipur, Maharashtra, Punjab, Rajasthan, Tamil Nadu and West Bengal. The results of 20 FLDs conducted at RARS, Jagtial with improved variety JCG 88 recorded an average pod yield of 1941 kg ha⁻¹ compared to 1693 kg ha⁻¹ with local variety. The pod yield increased by 15per cent with improved variety compared to check variety (TMV 2). The economics indicated that the cost of cultivation ranged from Rs. 23,045 ha⁻¹ to Rs. 27,956 ha⁻¹ with an average of Rs. 17,316 ha⁻¹ compared to Rs. 23,232 ha⁻¹ with local variety. The gross and net monetary returns increased by 15 per cent and 33 per cent with improved variety compared to local variety (NRCG, 2009).

2.2 Influence of Seed Rate on Growth, Yield Attributes, Yield and Quality of Groundnut

2.2.1 Effect on growth

2.2.1.1 Plant Height

Hirwe *et al.* (2005) reported that plant height increased with increasing plant density and reached maximum with highest plant density of 93.45 plants m⁻² (10.7 x 10 cm).

Field study conducted by Tewolde *et al.* (2002) indicated that increasing the seeding rate increased the main stem height by 10 to 15 cm. Plants in the 22 seed m⁻² treatment were significantly taller than the 8 seed m⁻² treatment at all growth stages in both season.

Bharatha Lakshmi and Sambasiva Reddy (2001) studied the effect of variation in inter and intra row spacings on groundnut and reported that plant height with geometry of 60 x 5 cm was higher and was comparable to 52.5 x 5.7 cm and 45 x 6.7 cm spacings.

Deshmukh and Bhoi (1999) studied with a short stature groundnut variety TAG-24 during *kharif* and summer and they observed that higher mean plant height at a high plant density of 6.66 lakh plants ha⁻¹ and was significantly higher compared to 3.33 and 2.22 lakh plants ha⁻¹ (Ramajyothi, 1999). Igbokwe and Nkongolo (1996) carried out an experiment at Lorman, MS with three intra- row plant spacings 10.2, 15.2 and 20.3 cm spacings and noticed that plant height was highest (32.1cm) at the 10.2 cm plant spacing but was not different from plants in 20.3 cm spacing.

Bhoite and Nimbalkar (1995) recorded more plant height at a plant density of 3.33 lakh plants ha⁻¹ which was significantly higher over 2.22 lakh plants ha⁻¹ and was on par with 3.00 and 4.44 lakh plants ha⁻¹.

Plant height increased significantly with every increase in plant population level from 2.22 to 4.44 lakh ha⁻¹ (Srinivas Kumar, 1992).

Babu (1981) reported that plant height of variety TMV-2 increased significantly due to increase in plant population from 3.33 to 5.0 lakh plants ha⁻¹.

Muhammad and Dorairaj (1974) stated that in bunch groundnut (TMV-2) grown on coarse textured soils of lower Bhavanisagar area, the length of the main stem increased due to increase in the population from 1.11 to 4.44 lakh plants ha⁻¹. This increase was primarily attributed to decrease in available unit of soil area per plant at higher plant densities and caused more vertical growth than horizontal growth (Saini and Tripathi, 1974).

According to Naidu (1968) variation in plant population alter the growth pattern of groundnut. Higher plant population tended to produce plants with erect growth habit.

2.2.1.2 Dry Matter Production

Closer spacing of 30 x 10 cm significantly had highest dry matter production and lowest dry matter was observed with wider spacing of 45 x 15 cm during *kharif* season at Tamilnadu (Kathirvelan and Kalaiselvan, 2006).

Hirwe *et al.* (2005) reported that dry matter production per plant was found to be declined significantly due to increasing plant density (from 40 plants m² to 93.45 plants m⁻²) because of greater competition for light, nutrients etc. produced at lower spacing.

Tewolde *et al.* (2002) reported higher dry matter per unit area at high plant density over low plant density but per plant dry matter was reverse in relation to plant densities.

Pore *et al.* (1992) conducted an experiment at Akola during *kharif* observed that dry matter production per plant was higher in paired row planting (45/15 cm) where in more space is available to plants over conventional method of planting (30 cm row spacing) with less space.

Dry matter per plant decreased with increase in plant population from 2.22 to 4.44 lakh plants ha⁻¹ and maximum dry matter per plant was registered at 2.22 lakh plants ha⁻¹ (Srinivas Kumar, 1992). The total dry matter per unit land area increased with increase in plant population from 0.83 to 2.86 lakh ha⁻¹ on alfisols of Hyderabad (Rao *et al.*, 1989).

Singh and Ahuja (1985) reported higher dry matter production per plant at low plant density. A low plant density of 1.11 lakh ha⁻¹ recorded significantly higher dry matter per plant than medium (1.48 lakh ha⁻¹) and high (2.22 lakh ha⁻¹) plant densities (Sampetch *et al.*, 1986). Similar findings were reported by Babu (1981) who stated that dry matter production per plant decreased with increase in population from 3.33 to 5.00 lakh ha⁻¹ in TMV 2 at Hyderabad. The total dry matter produced per unit area increased due to increase in plant density from 0.80 to 3.33 lakh ha⁻¹ (Cheema *et al.*, 1985).

Experimental study at Tirupati on sandy loam soils during *kharif* season with TMV-2 also revealed that dry matter production per unit area was maximum at 6.6 lakh plants ha⁻¹ compared to 4.4 and 3.3 lakh plants ha⁻¹. However dry matter production per plant was more at low plant density (NARP, 1980).

2.2.1.3 Leaf Area and Leaf Area Index

Closer spacing of 30 x 10 cm significantly had highest LAI and lowest was observed with wider spacing of 45 x 15 cm (Kathirvelan and Kalaiselvan, 2006). Hirwe *et al.* (2005) from Akola revealed that leaf area of individual plant decreased significantly because of the greater intra-specific competition produced by the shortening of distances between rows (from 25 cm to 10.7 cm). Leaf area index values increased with increase in plant density from 40.00 to 93.45 plants m⁻². Tewolde *et al.* (2002) also obtained similar results in respect to LAI.

Bharatha Lakshmi (1986) recorded maximum LAI at a spacing of 30 x 10 cm as compared to other spacings of both intra and inter rows.

Kaul (1999) observed that plants at a narrow spacing of 20 x 15 cm attained higher LAI over wider row of spacing 40 x 15 cm at all the growth stages of crop.

Plant population of 6.67 lakh ha⁻¹ produced higher LAI compared to 3.33 and 2.22 lakh ha⁻¹ (Ramajyothi, 1999). Basith (1992) found that the LAI with higher plant density of 4.16 lakh plants ha⁻¹ was higher compared to plant density of 3.33 lakh plants ha⁻¹.

Gajendra Giri and Ganga Saran (1986) revealed that the LAI recorded at 1.85 lakh plants ha⁻¹ was higher compared to 2.50 and 1.25 lakh plants ha⁻¹. Satyanarayana (1984) also reported significantly higher LAI with increase in plant population ranging from 2.0 to 4.0 lakh ha⁻¹ at all crop growth stages under irrigated conditions.

Murthy (1982) reported that the LAI of groundnut variety Kadiri 2 with a plant density of 6.67 lakh ha⁻¹ was higher followed by 4.44 and 3.333 lakh ha⁻¹ at 60 days after sowing.

2.2.1.4 Crop Growth Rate

Kathirvelan and Kalaiselvan (2006) studied four spacings (30 x 10, 30 x 15, 45 x 10 and 45 x 15 cm) during *kharif* at Aliyar Nagar, Tamil Nadu and observed that wider spacing of 45 x 15 and 45 x 10 cm significantly had the highest CGR at vegetative stage when compared to closer spacing.

2.2.1.5 Number of Branches per Plant

Tewolde *et al.* (2002) noticed that reducing the seeding rate from 22 to 8 seeds m⁻² increased number of branches per plant.

Mishra *et al.* (1998) reported that plant spacing of 40 x 20 cm resulted in higher number of branches per plant when compared with other spacings of 30 x 15, 30 x 20 and 40 x 15 cm spacing at Madhya Pradesh.

Kushwaha *et al.* (1978) also observed more number of branches per plant with wider spacing 45 x 23cm over 30 x 15 cm spacing.

2.2.1.6 Flowering

Subrahmaniyan *et al.* (2010) conducted an experiment at Tamil Nadu using groundnut variety VR 12 under plastic mulch and observed that total number of flowers per plant were more in plant geometry of 20 x 20 cm and at par with 20 x 15 cm and the number was low with plant geometry of 30 x 10 cm.

Ramesh and Sambasiva Reddy (2007) found that flower to peg and peg to pod percentages obtained with plant density of 3.33 and 4.44 lakh plants ha⁻¹ was on par and both were significantly superior to 6.67 lakh plants ha⁻¹.

Numbers of flowers per plant were higher with a plant density of 2.22 lakh ha⁻¹ compared to 3.33 and 6.67 lakh plants ha⁻¹ (Ramajyothi, 1999).

Venkateshwarlu *et al.* (1990) reported that the number of flowers per unit area significantly increased with increase in plant density from 3.33 to 10.0 lakh ha⁻¹.

Suraj Bhan and Misra (1972) studied performance of two varieties (AK 12-24 and PG1) and three row spacings (30, 45 and 60 cm) and observed that wider spacing maintained its superiority in early initiation of flowering.

2.2.2 Effect of Seed Rate on Yield Attributes

2.2.2.1 Pods per Plant

Ramesh *et al.* (2007) reported more number of total and filled pods per plant at low plant density of 3.33 lakh plants ha⁻¹ when compared to higher plant densities.

Senthil Kumar (2009) found that among different plant densities tried (3.3, 4.0 and 5.0 lakh plants ha⁻¹) 3.3 lakh plants ha⁻¹ (30 x 10 cm) recorded higher total pods per plant during *kharif* season in sandy loam soils at Neyveli.

Naeem Ahmed *et al.* (2007) conducted an experiment at Pakistan by using a bunch groundnut SP-2002 using three row spacings (30, 45 and 60 cm) and revealed that highest number of pods plant⁻¹ (27.1) recorded with 30 cm row spacing and lowest with the spacing of 60 cm.

Kathirvelan and Kalaiselvan (2006) revealed that wider spacing 45 x 15 cm had the highest number of mature pods plant⁻¹ and it was at par with 45 x 10 cm spacing.

Hirwe *et al.* (2005) observed that pods per plant were progressively increased with increasing plant density up to optimum level (66.66 plants m⁻²) and any deviation from this level caused reduction in pod number per plant.

Bharatha Lakshmi (1986) reported that total pods per plant were higher with crop geometry of 30 x 10 cm over other spacings of either closer wider.

Ramesh and Sabale (2001) reported that plant population of 3.33 lakh plants ha⁻¹ (30 x 10 cm) recorded significantly more pods per plant over other higher plant populations.

Deshmukh and Bhoi (1999) observed higher number of pods per plant with low plant density of 2.22 lakh plants ha⁻¹ (30 x 15 cm) as compared to other spacings studied.

Similarly the pods per plant obtained at a low plant density of 2.22 lakh plants ha⁻¹ were significantly more compared to the pod number per plant at higher plant population of 3.33 and 6.67 lakh ha⁻¹ (Ramajyothi, 1999). Ramachandra Reddy and Subbi Reddy (1998) noticed that the number of pods per plant due to variation in intra row spacings were not significant.

Raghavaiah *et al.* (1995) reported that a low plant density of 1.67 lakh plants ha⁻¹ gave significantly higher number of pods per plant than higher density of 3.33 lakh plants ha⁻¹ and 2.22 lakh plants ha⁻¹. Total pods per plant increased significantly with decrease in plant population from 4.44 to 2.22 lakh ha⁻¹ (Srinivas Kumar, 1992).

Ramesh Babu *et al.* (1984) studied the effect of plant density on Spanish groundnut (TMV 2) during summer season on sandy loam soils of Tirupati and found that plant density of 4.44 lakh plants ha⁻¹ resulted in more than 9 pods plant⁻¹ in both the years as against less than 7 pods with high densities. Usha Rani (1984) reported more pods per plant at a plant density of 1.33 lakh ha⁻¹; however the number decreased with increase in plant density up to 4.69 lakh ha⁻¹.

Murthy (1982) reported that maximum numbers of total pods per plant were recorded with groundnut variety Kadiri 2 at 3.33 lakh plants ha⁻¹ but decreased with increase in plant population from 3.33 to 6.67 lakh ha⁻¹.

2.2.2.2 100 Kernel Weight

The effect of plant densities on 100 kernel weight expressed by different workers was not consistent. Ramesh and Sambasiva Reddy (2007) noticed that maximum 100 kernel weight (35.2 g) obtained with a low plant population of 3.33 lakh plants ha⁻¹ when compared to higher plant densities. Ihejirika (2007) from Nigeria reported maximum test weight with optimum plant population of 2.5 lakh plants ha⁻¹ and any deviation from this range reduced the test weight.

Bharatha Lakshmi and Sambasiva Reddy (2001) reported that 100 kernel weight was higher with a crop geometry of 60 x 5 cm which was comparable with 52.5 x 5.7 cm, 45 x 6.7 cm, 37.5 x 8 cm and 30 x 10 cm.

Nagaraj *et al.* (2001) from Dharwad reported that plant density of 1.48 lakh plants ha⁻¹ recorded higher 100 kernel weight (72.98 g) as compared to lower plant densities in cultivar ICGV 86564.

Ramesh and Sabale (2001) reported that plant population of 3.33 lakh plants ha⁻¹ recorded significantly high kernels pod⁻¹, kernels plant⁻¹ and 100 kernel weight over other plant populations studied.

Kaushik and Chaubey (2000) from an experiment at Ujhani during *kharif* with two row spacings (30 and 45 cm) and three seed rates (60, 80 and 100 kg ha⁻¹) with bunch type of variety 'KAUSHAL' reported that these treatments had non significant effect on the 100 kernel weight.

Kaul (1999) observed that 100 kernel weight was highest under plant rectangularity of 30 x 15 cm closely followed by 45 x 10 cm, 40 x 15 cm and 20 x 15 cm rectangularities.

Attarde *et al.* (1998) reported that the seed rate of 120 kg ha⁻¹ had higher 100 kernel weight over 80 kg seed ha⁻¹. The row spacing of 30 cm produced higher 100 kernel weight than 45 cm spacing.

2.2.2.3 Shelling Percentage

Ramesh and Sambasiva Reddy (2007) from Hyderabad noticed maximum Shelling percentage (76.8) at low plant population of 3.33 lakh plants ha⁻¹ when compared to higher plant densities.

Kathirvelan and Kalaiselvan (2006) did not noticed significant variation in shelling percentage under varied plant densities.

However, Hirwe *et al.* (2005) reported that shelling percentage declined with decreasing row spacing from 25 to 10 cm by keeping intra row spacing of 10 cm as constant.

Nagaraj *et al.* (2001) from Dharwad reported that plant density of 1, 48,148 plants ha⁻¹ recorded higher shelling percentage (66.02) as compared to lower plant densities.

Kaushik and Chaubey (2000) also did not observed difference in shelling percentage due to varied seed rates and row spacings.

Ramajyothi (1999) obtained higher shelling percentage with low plant densities compared to high plant densities. In contrast, Satyanarayana (1984) reported higher shelling percentage with high plant density.

2.2.3 Effect on Yield

2.2.3.1 Pod Yield

Subrahmaniyan *et al.* (2010) reported that pod yield in groundnut was not influenced by varying plant spacings as uniform plant population of 33 plants m⁻² observed in all plant geometries.

Ramesh and Sambasiva Reddy (2009) stated that pod yield recorded by medium plant population density of 4.44 lakh plants ha⁻¹ was superior to either 3.33 or 6.67 lakh plants ha⁻¹ on sandy loam soils of Hyderabad.

Senthil Kumar (2009) found that among the different plant densities tried (3.3, 4.0 and 5.0 lakh plants ha⁻¹) maintaining 3.3 lakh plants ha⁻¹ recorded higher pod yield of 2.1 t ha⁻¹ and kernel yield of 1.6 t ha⁻¹ during *khariif* season on sandy loam soils at Neyveli.

Naeem Ahmed *et al.* (2007) also obtained highest pod yield of 5784 kg ha⁻¹ by a variety SP-2000 with seed rate of 150 kg ha⁻¹ at 30 cm row spacing.

A plant population of 4.44 lakh plants ha⁻¹ recorded significantly higher dry pod yield over the higher level of plant population *i.e.* 5.55 lakh plants ha⁻¹ during *rabi* season (Zagade *et al.*, 2007).

Kathirvelan and Kalaiselvan (2006) revealed that a spacing of 30 x 10 cm registered significant higher dry pod yield of 2360 kg ha⁻¹ over 45 x 15 cm spacing.

Senthil kumar *et al.* (2004) reported that higher pod yield (2.18 t ha⁻¹) obtained by maitaintaing a plant population of 3.3 lakh plants ha⁻¹.

Bharatha Lakshmi and Sambasiva Reddy (2001) recorded maximum pod yield with crop geometry of 30 x 10 cm.

Chaniyara *et al.* (2001) reported that among the four row spacings (22.5, 30.0, 37.5 and 45.0 cm) and plant population (3.0, 3.5 and 4.0 lakh plants ha⁻¹) tried, 30 cm row spacing gave significantly higher pod yield and it also increased with increase in plant density from 3.0 to 4.0 lakh plants ha⁻¹ during summer season at Junagadh on medium black soil.

Nagaraj *et al.* (2001) from Dharwad reported that plant density of 1.48 lakh plant ha⁻¹ recorded higher dry pod yield (1717 kg ha⁻¹) compared to lower plant density of 0.74 and 1.11 lakh plants ha⁻¹ in ICGV 86564 variety.

Ramesh and Sabale (2001) reported that plant population of 3.33 lakh plants ha⁻¹ (30 x 10 cm) significantly increased the dry pod yields over the higher densities.

Ramulu and Bucha Reddy (1998) obtained maximum pod yield at 5.5 lakh plants ha⁻¹ when compared to 5.0 and 4.5 lakh plants ha⁻¹ at Rajendranagar. Higher pod yield was recorded with a plant density of 4.44 lakh plants ha⁻¹ followed by 3.33 and 2.22 lakh plants ha⁻¹ at Akola (Bhale Rao *et al.*, 1996).

Raghavaiah *et al.* (1995) reported that a high plant density of 3.33 lakh plants ha⁻¹ gave significantly higher pod yield (4.05 t ha⁻¹) than low density of 2.22 lakh plants ha⁻¹ (3.88 t ha⁻¹) and 1.67 lakh plants ha⁻¹ (3.58 t ha⁻¹).

Jadhao *et al.* (1992) found that the pod yield was significantly influenced due to different plant densities. Pod yield obtained with plant densities of 2.22 and 3.33 lakh plants ha⁻¹ was on par and both gave significantly higher pod yield compared to 1.4 and 1.67 lakh plants ha⁻¹.

Chavan and Kalra (1983) reported higher pod yield (22.52 q ha⁻¹) in TG 1 at a plant density of 2.22 lakh ha⁻¹ than 1.78 and 1.48 lakh ha⁻¹ on clay loam soils.

Ajaya Kumar and Venkatachari (1971) conducted an experiment at Rajendranagar, Hyderabad on sandy loam soils with two groundnut varieties (Asiriya Mwitunde and Spanish improved), four different intra row spacings (7.5, 15.0, 22.5 and 30 cm) by keeping common inter row spacing of 30 cm and he reported that closest spacing treatment (30 x 7.5 cm) recorded maximum yield of 4682.4 kg pods ha⁻¹.

2.2.3.2 Haulm Yield

Ramesh and Sambasiva Reddy (2007) found that haulm yield produced with plant population 6.67 lakh plants ha⁻¹ was significantly higher than 3.33 and 4.44 lakh plants ha⁻¹.

Zagade *et al.* (2007) observed that plant population of 4.44 lakh plants ha⁻¹ recorded significantly higher haulm yield as compared to higher level of plant population 5.55 lakh plants ha⁻¹ at Dapoli during *rabi* season.

Hirwe *et al.* (2005) conducted an experiment at Akola during summer season on groundnut variety TAG-24 under polythene film mulch with five plant densities based on five plant spacings (25 x 10, 18.7 x 10, 15 x 10, 12.5 x 10 and 10.7 x 10 cm) reported that maximum haulm yield obtained with highest plant spacing of 10.7 x 10 cm. (93.45 plants m⁻²).

Bharatha Lakshmi and Sambasiva Reddy (2001) evaluated eight crop geometries (15.0 x 15.0, 17.3 x 17.3, 22.5 x 13.3, 30.0 x 10.0, 37.5 x 8.0, 45.0 x 6.7, 52.5 x 5.7 and 60.0 x 5.0 cm) with varying inter and intra row spacings and reported that haulm yield was higher with crop geometry of 30 x 10 cm.

Chaniyara *et al.* (2001) reported that among four row spacings (22.5, 30.0, 37.5 and 45.0 cm) and plant populations (3.0, 3.5 and 4.0 lakh plants ha⁻¹) tried, haulm yield increased with increase in plant population from 3.0 to 4.0 lakh plants ha⁻¹ and 22.5 cm row spacing gave higher haulm yield than rest of row spacings during summer season at Junagadh on medium black soil.

Jadhav *et al.* (2000) three row spacings (37.5, 30.0 and 22.5 cm) and two plant spacings (10 and 15 cm) on medium clay soils at Parbhani and opined that haulm yield increased with decreasing row and plant spacing to 22.5 and 10 cm respectively.

Krishna *et al.* (1995) observed that the haulm yield obtained with a plant density of 4.44 lakh plants ha⁻¹ was significantly higher compared to 3.33, 4.44 and 5.8 lakh plants ha⁻¹ at Jagtial.

2.2.3.3 Effect on Harvest Index

Ramesh and Sambasiva Reddy (2007) studied the influence of plant densities on sandy loam soils of Prakasam district using groundnut variety TMV-2 and found that maximum harvest index of 39.71 per cent recorded with a plant density of 3.33 lakh plants ha⁻¹.

Jadhav *et al.* (2000) carried out an experiment at Parbhani on medium clay soils with three row spacings (37.5, 30.0 and 22.5 cm) and two plant spacings (10 and 15 cm) and opined that closer row spacing of 22.5 cm recorded significantly higher harvest index over wider row spacings of 30 and 37.5 cm respectively.

Four plant geometries (20 x 15, 30 x 15, 40 x 15 and 45 x 15) were evaluated on loamy sandy soils of Ludhiana and revealed that among different spacings Harvest index was highest under 30 cm x 15 cm and lowest under 20 x 15 cm spacing (Kaul, 1999).

Ramajyothi (1999) reported that the harvest index was higher with 3.33 lakh plants ha⁻¹ compared to 6.67 and 2.22 lakh plants ha⁻¹.

Harvest index obtained with 2.5 lakh plants ha⁻¹ was higher compared to 5.0 and 3.33 lakh plants ha⁻¹ (Patel and Parmar, 1989). On contrary to the above findings, Gajendra Giri and Ganga Saran (1986) did not observe any significant differences in harvest index among the plant densities of 1.25, 1.85 and 2.50 lakh plants ha⁻¹.

2.2.3.4 Effect on Oil Content

Ramesh and Sambasiva Reddy (2007) from an experiment at Prakasam on sandy loam soils found that oil content increased with successive increase of plant density from 3.33 to 6.67 lakh plants ha⁻¹.

Morshed Alam *et al.* (2002) while working with groundnut variety 'Jhinga badam' under three hill densities noticed that hill density did not affect the oil content of kernels.

Ramesh and Sabale (2001) reported that oil content was maximum with 3.33 lakh plants ha⁻¹ (30 x 10 cm) and oil content increased with decrease in population from 5.0 to 3.3 lakh plants ha⁻¹.

Kaushik and Chaubey (2000) from an experiment at Ujhani during *kharif* with two row spacings (30 and 45 cm) and three seed rates (60, 80 and 100 kg ha⁻¹) with bunch type of variety 'KAUSHAL' reported that these treatments could not exert their significant influence on oil content of groundnut. .

For bunch groundnut GG 2 grown in northern Gujarat, seed oil content was not influenced by seed rate but oil yield increased with increase in seed rate and increase was not significant between 125 and 150 kg ha⁻¹ (Patel and Patel, 1995).

Ragahavaiah *et al.* (1995) studied two Spanish groundnut genotypes DRG 17 and Kadiri 3 and different plant populations observed that oil content of Kadiri-3 was more than that of DRG 17. The different plant densities could not bring about discernible variations in the oil content of groundnut kernels.

2.3 Interaction effect on Growth, Yield Attributes, Yield and Quality of Groundnut

Bharatha Lakshmi and Sambasiva Reddy (2001) conducted an experiment at Tirupati on variety JL 24 using eight crop geometries (15.0 x 15.0, 17.3 x 17.3, 22.5 x 13.3, 30.0 x 10.0, 37.5 x 8.0, 45.0 x 6.7, 52.5 x 5.7 and 60.0 x 5.0 cm) with varying inter and intra row spacings and revealed that the maximum pod yield of 2438 kg ha⁻¹ was obtained at a geometry of 30 x 10 cm but it was comparable with geometry of 60 x 5 cm.

Jadhav *et al.* (2000) tested two genotypes of groundnut (LGN-2 and TAG 24), three row spacings (37.5, 30.0 and 22.5 cm) and two plant spacings (10 and 15 cm) and noticed that the effect of genotypes x row and plant spacing interactions on dry pod yield were not evident. Increased plant density by closer row spacing lead to increased vegetative growth.

Three improved groundnut varieties (JL 11, JL 24 and DS 29) and four plant densities (1.11, 1.48, 1.67 and 2.22 lakh plants ha⁻¹) were tested at Ambikapur (MP) during *kharif*, season and reported that the variety J11 and JL24 gave higher pod yield at 30 x 15 cm spacing and pod yield decreased correspondingly with increase in spacing whereas variety DS 29 gave significantly higher yield at 30 x 20 cm plant spacing and decrease in yield observed at wider spacing of 45 x 15 cm and 45 x 20 cm (Mishra et al., 1998).

Bhale Rao *et al.* (1996) evaluated three Spanish bunch genotypes (JL 24, TAG 24 and AKG 6) at three plant densities (2.2, 3.3 and 4.4 lakh plants ha⁻¹) during *kharif* season and revealed that TAG 24 sown under plant density of 4.4 lakh ha⁻¹ produced significantly highest pod yield than rest of the combinations. The performance of TAG 24 was also better under 3.3 lakh ha⁻¹ as compared to JL 24 and AKG 6.

Ragavaiah *et al.* (1995) studied performance of two groundnut varieties (DRG 17 and Kadiri 3) at three plant spacings and observed that the variety DRG 17 yielded more at 30 x 10 cm spacing while Kadiri 3 performed equally both at 30 x 15 cm and 30 x 10 cm spacing. Interaction between spacing and genotype on kernel weight per plant was significant and found that 30 x 20 cm for DRG 17 and Kadiri 3 resulted in higher kernel weight per plant than less spacing.

Jadhao *et al.* (1992) evaluated two groundnut varieties SB XI, UF 70103 at six different plant spacings (30 x 10, 30 x 15, 30 x 20, 45 x 10, 45 x 15 and 45 x 20 cm) and found that interaction effect between varieties and spacing was non-significant.

Singh and Kalra (1983) noticed that pod yield decreased with every increase in plant spacing in varieties PG-1 and T-28. However, variety M-13 responded significantly better with 30 x 30 cm spacing and produced 3097.92 kg pods ha⁻¹.

Kushwaha and Misra (1978) observed variation in the response of groundnut varieties to plant density with bunch groundnut (Jyothi) and recorded highest pod yield at plant population of 3.37 lakh plants ha⁻¹ while semi spreading variety (GG-71-3) gave highest yield with a plant population of 3.33 lakh plants ha⁻¹.

2.4 Effect on Economics

Ramesh and Sambasiva Reddy (2007) while working with four *rabi* groundnut varieties (TMV 2, TPT 2, TAG 24 and K 134) at three plant populations (3.33, 4.44 and 6.67 lakh plants ha⁻¹) revealed that maximum gross returns (Rs.43081 ha⁻¹), net returns

(Rs. 29704 ha⁻¹) and benefit: cost ratio (2.20) were obtained in K-134 at a plant density of 4.44 lakh plants ha⁻¹.

Zagade *et al.* (2007) observed that higher net returns (Rs.51135) and B: C Ratio (3.25) were obtained with plant population of 4.44 lakh plants ha⁻¹ compared to higher level of plant population 5.55 lakh plants ha⁻¹.

Hirwe *et al.* (2005) evaluated groundnut variety TAG-24 under polythene film mulch with five plant spacings (25 x 10, 18.7 x 10, 15 x 10, 12.5 x 10 and 10.7 x 10 cm) and revealed that highest gross monetary returns (Rs.1,78,457) and net monetary returns (Rs.1,36,849) obtained with highest plant density of 10.7 x 10 cm (93.45 plants m⁻²) but higher cost of cultivation affect the cost benefit ratio of higher plant density. B: C ratio was maximum (4.31) when groundnut spaced at 15 x 10 cm (66.66 plants m⁻²). Therefore optimum plant population of 6.66 lakh ha⁻¹ with spacing of 15 x 10 cm was more economical and better option for cultivation of groundnut under polythene film mulch.

Chaniyara *et al.*(2001) reported that among the various four row spacings (22.5, 30.0, 37.5 and 45.0 cm) and plant population (3.0, 3.5 and 4.0 lakh plants ha⁻¹) tried, high gross and net income was obtained with a row spacing of 22.5 cm and plant population of 3.5 lakh plants ha⁻¹ during summer season at Junagadh on medium black soil.

Nagaraj *et al.* (2001) from Dharwad reported that plant density of 1,48,148 plants ha⁻¹ recorded higher B: C ratio (2.50) compared to lower plant density of 74,074 and 1, 11,111 plants ha⁻¹ by using groundnut cultivar ICGV 86564.

Attarde *et al.* (1998) studied four seed rates (80, 100, 120 and 140 kg ha⁻¹) and two inter row spacings (30 and 45) and revealed that the seed rate of 120 and 140 kg seed ha⁻¹ were at par with each other and recorded significantly higher gross monetary returns over 80 and 100 kg seed ha⁻¹. The row spacing of 30 cm produced significantly more returns than 45 cm spacing.

Chapter III

Materials and Methods

Chapter III

MATERIAL AND METHODS

The experiment entitled “Standardization of seed rate for promising groundnut varieties under rainfed conditions of Southern Telangana zone, Andhra Pradesh” was conducted during *kharif*, 2010. The details of the experimental materials used and methods adopted in the present investigation are elucidated in this chapter under appropriate headings.

3.1 Geographical Location of the Experimental Site

The present investigation was carried out at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The farm is geographically situated at an altitude of 542.6 m above mean sea level on 18° 50' N latitude and 77.53° E longitude and falls under the Southern Telangana Agro climatic zone of Andhra Pradesh.

3.2 Climate

3.2.1 Weather Conditions during Crop Growth Period

The meteorological parameters were recorded from meteorological observatory located at Agricultural Research Institute, Rajendranagar and presented in Table 3.1 and illustrated in Figure 3.1 and 3.2.

The weekly mean maximum temperature during the crop period (11 June 2010 – 6 Nov 2010) ranged from 25.4 to 32°C with an average of 29.5°C. The weekly mean minimum temperature during the crop period ranged from 18.7°C to 23.1°C with an average of 21.8°C. The weekly mean relative humidity at 7.30 hrs and 16.00 hrs during the crop period ranged from 76.3 to 94 and 51.4 to 82.1 per cent respectively. The total rainfall received during the crop growth period was 733.2 mm in 44 rainy days.

The weekly mean sunshine hours per day ranged from 0.3 to 7 with an average of 4.4. During the crop period, the evaporation (measured from USWB class A open pan evaporimeter) ranged from 2.3 to 3.8 mm day⁻¹ with an average of 2.7 mm day⁻¹. The weekly mean wind speed ranged from 2.2 to 11.7 km hr⁻¹ with an average of 5.4 km hr⁻¹.

3.3 Characteristics of the Experimental Field

3.3.1 Physical and Chemical Properties

Soil samples were drawn from top 0-30 cm depth in experimental field and analysed for their physical and chemical properties by adopting standard procedures and the results are summarized in Table 3.2. The results of physico-chemical analysis revealed that the soil was sandy loam in texture, slightly alkaline in reaction, low in organic carbon, high in available nitrogen and potassium, low in available phosphorus.

Table 3.2. Physico-chemical properties of the experimental site

Properties	Results	Method adopted
Physical properties		
Soil fraction	% composition	Bouyoucos hydrometer method (Piper, 1966)
Sand	60.3	
Silt	21.3	
Clay	18.4	
Textural class	Sandy loam	
Chemical properties		
Soil reaction (pH) (1:2.5 soil : water)	7.3	Glass electrode pH meter (Jackson, 1967)
Electrical conductivity (dS m ⁻¹)	0.20	Solubridge method & Digital EC meter (Jackson, 1967)
Organic carbon (%)	0.32	Wet digestion method (Walkey and Black, 1934)
Available Nitrogen (kg N ha ⁻¹)	223.0	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available phosphorus (kg P ₂ O ₅ ha ⁻¹)	28.6	Olsen's method using colorimeter (Olsen <i>et al.</i> , 1954)
Available potassium (kg K ₂ O ha ⁻¹)	252.9	Neutral ammonium acetate method using flame photometer (Muhr <i>et al.</i> , 1963)

3.4 Previous Crop History

The cropping history of the experimental site for the previous three years is summarized below.

S. No.	Year	<i>Kharif</i>	<i>Rabi</i>
1	2008	Maize	Sunflower
2	2009	Maize	Sunflower
3	2010	Present study	

3.5 Experimental Details

3.5.1 Treatmental Details

The experiment was carried out with following 16 treatments replicated thrice. The details are as follows.

Main treatment plots (Varieties): 4

V₁: Narayani

V₂: ICGV 91114

V₃: K 6

V₄: JCG 88

Sub treatment plots (Seed rates): 4

S₁: 75 kg ha⁻¹ kernel

S₂: 100 kg ha⁻¹ kernel

S₃: 125 kg ha⁻¹ kernel

S₄: 150 kg ha⁻¹ kernel

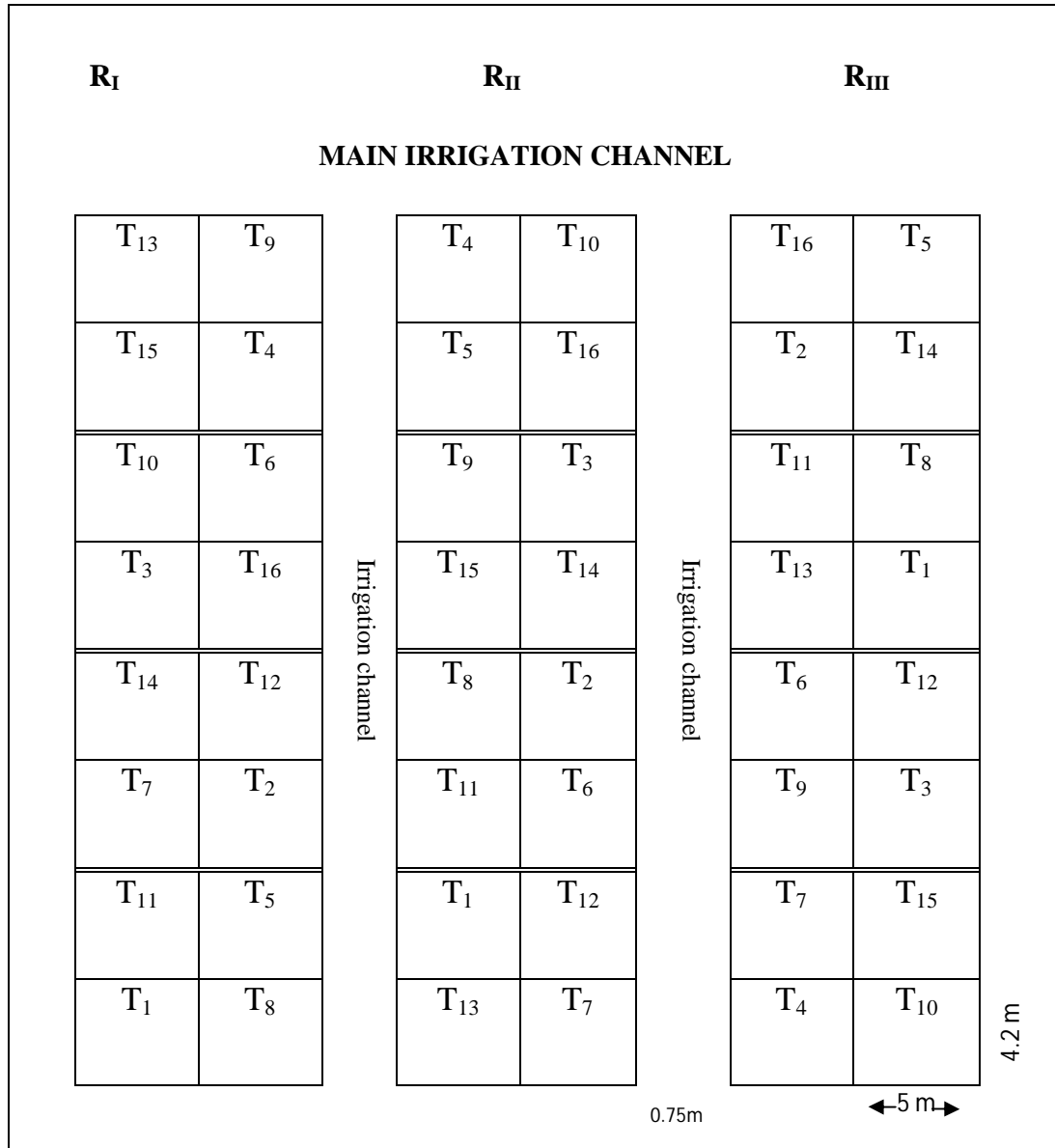
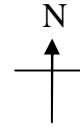


Figure 3.3. Layout plan of experimental field

3.5.2 Design and Layout

The experiment was laid out in a factorial randomized block design with three replications. The layout plan is given in Figure 3.3.

3.5.3 Plot Size

Gross : 5.0 m × 4.2 m

Net : 4.5 m × 3.6 m

3.6 Crop Varieties

- **Narayani** (TCGS 29): TCGS 29 was developed from cross between JL 24 × Ah 316/S following the mass pedigree method of breeding and was found promising for the required attributes, *i.e.*, earliness, and high pod and kernel yields. Andhra Pradesh State Varietal Release Committee released TCGS 29 as Narayani in July 2002. TCGS 29 is an early-maturing (100 days), spanish bunch (*A. hypogaea* sub sp *fastigiata* var *vulgaris*) variety released from Regional Agricultural Research station Tirupati, ANGRAU. It is recommended for cultivation in both rainy (June/July to October/November) and post rainy (November/December to March/April) seasons. The leaflets of TCGS 29 are long, elliptical and green. The stem is angular with light greenish purple pigmentation. It is tolerant to mid-season drought. There is no resistance to major pests and diseases. Its growth habit is determinate and erect. It possesses four primary branches and the secondary branches are more. TCGS 29 has medium-sized pods (100-pod weight of 90.99 g and 100-seed weight of 42.4 g) with moderate reticulation and constriction. Seeds have light red testa with oil content of 47.49 % and shelling outturn of 74.76 %. The other important desirable attribute of TCGS 29 is synchronous maturity of all pods in a plant.
- **ICGV 91114**: It was bred and developed at ICRISAT, Patancheru, Hyderabad. It was derived through the bulk pedigree method from the ICGV 86055 x ICGV 86533 cross. It is a high-yielding variety, tolerant to rust and late leaf spot and has early maturity (100 days) and has uniform maturity, tolerant of mid-season and end-of-season drought. It has shelling turnover of 75 %. Oil content and protein content are 48 % and 27 % respectively. It has attractive pod and seed shape. It has better digestibility and palatability of haulms thus used as dual-purpose groundnut.

- **Kadiri-6 (K 6):** It is an early maturing high yielding Spanish bunch type variety. It was derived following the pedigree method from the JL 24 x Ah 316/S cross. This variety was released from Agricultural Research Station, Kadiri, Anantapur, ANGRAU during 2002. It is suitable for *kharif* and *rabi* seasons. Duration of the variety is 100-105 days. Pod yield ranges from 1000-2400 kg ha⁻¹ during *kharif* and 3800-4200 kg ha⁻¹ in *rabi* seasons. Shelling percentage is 69-72 % and oil content is 48 %.
- **JCG-88:** It is a Spanish bunch type variety. It has tolerance to leaf spot disease. It was derived following the pedigree method from the J 11 x TG (E) -1cross. It is suitable for cultivation in all seasons. Duration is 95-105 days (*kharif*), 105-110 days (*rabi*) and 110-120 days (summer). Shelling percentage is 74 % and oil content is 48-56 %. This variety was released from Regional Agricultural Research Station, Jagtial, ANGRAU during 1993.

3.7 Cultivation Details

3.7.1 Preparatory Cultivation

The experimental field was prepared thoroughly by working with tractor mounted disc plough followed by tractor drawn harrow and cultivator to achieve optimum tilth, subsequently leveling was done and plots were laid out as per the lay out plan (Figure 3.3).

3.7.2 Fertilizers

The crop was supplied with recommended fertilizer dose of 20 Kg N, 60 Kg P₂O₅ and 30 Kg K₂O ha⁻¹ through urea (46 % N), single superphosphate (16 % P₂O₅) and muriate of potash (60 % K₂O), respectively. The entire dose of phosphorus and potassium and half of nitrogen was applied as basal through placement in the furrows made with hand hoes 5 cm away from the seed rows at a depth of 5 cm and the remaining half of nitrogen was applied as split application at 30 DAS. Gypsum @ 500 kg ha⁻¹ applied at 35 days after sowing.

3.7.3 Seeds and Sowing

The truthful labeled seed of four groundnut varieties *viz.*, Narayani, ICGV 91114, K 6, JCG 88 having good germination (95 %) was selected and treated with Carbendizem @ 2 g kg⁻¹ of seed. Seeds were sown by dibbling using one seed per hill in open furrows made with hand hoe, at a depth of 3-4 cm adopting a spacing of 30 cm between the rows and intra row spacing was adjusted according to the seed rate. 20, 15, 12 and 10 cm were

maintained for 75, 100, 125 and 150 kg ha⁻¹ seed rate respectively. The furrows were covered immediately after sowing. The crop was sown on 17-07-2010.

3.7.4 Gap Filling

Gap filling was done 8-10 days after sowing to maintain uniform stand and expected population as per the treatments.

3.7.5 After Cultivation

3.7.5.1 Hand Weeding: Hand weeding was done with hand hoes at 20 and 40 days after sowing.

3.7.5.2 Irrigation: One pre sowing irrigation was given on 16-07-2010. Supplemental irrigation was not given as the rainfall (733.2 mm) was well distributed with 44 rainy days throughout the crop growth period.

3.7.6 Plant Protection

Spraying of Monocrotophos @ 1.6 ml litre⁻¹, and Acephate + Dithane M-45 @ 2 g litre⁻¹ was done at 30, 60 days after sowing respectively to check spodoptera and leaf spot disease.

3.7.7 Harvesting

The crop was considered mature when more than 75 % of pods of randomly selected plants showed dark streaks on the inner side of the shell. Border rows around each plot were harvested first and removed leaving the net plot intact. Then five plants in each plot were harvested separately to record post harvest observations by hand pulling. After hand pulling, the pods were stripped and sun dried till reaches to a constant dry weight. Similarly, haulm from individual plots was also dried to reach a constant weight. The pods and haulm of the sampled plants were added to the net plot produce to arrive at the pod and haulm yields per plot.

3.8 Pre-Harvest observations on Crop Growth

Observations on crop growth at 30, 60 and 90 DAS were taken from five plants, which were randomly selected and labeled in each plot.

3.8.1 Initial and Final Plant Stand

Initial and final plant stand was calculated by counting the number of plants in each net plot area at 15 DAS and at harvest and expressed as lakhs ha⁻¹.

3.8.2 Germination Percentage

Germination percentage was arrived by counting the number of seedlings germinated at 10 and 20 DAS in each plot area and was expressed by percentage.

3.8.3 Seedling Mortality

It is the mortality of germinated seedlings that was observed at 20 DAS and expressed in percentage.

3.8.4 Plant Height (cm)

Plant height (cm) was measured from the base of the plant to the terminal end of the unfolded leaf at 30, 60 and 90 DAS.

3.8.5 Leaf Area Index (LAI)

Leaf area index was calculated by dividing the total leaf area by corresponding land area as suggested by Watson (1952) at 30, 60 and 90 DAS. LAI was calculated by using the formula given below (Watson, 1952)

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Ground area}}$$

3.8.6 Dry Matter Production

Five plants representing the population were randomly collected for recording dry matter production at 30, 60 and 90 DAS. The plants were removed along with root system. The roots were separated from each plant, above ground parts were cleaned, transferred to properly labelled brown paper bags and partially dried under shade for 2 days and dried in hot air oven at a temperature of 60°C for 48 hours. Then, it was weighed and expressed as kg ha⁻¹.

3.8.7 Number of Branches per Plant

Numbers of branches for five labelled plants were counted at 30, 60 and 90 DAS.

3.8.8 Days to 50 % Flowering

The number of days required for 50 per cent flowering was determined as and when 50 per cent of the plants in each plot produced flowers.

3.8.9 Days to Maturity

The crop was considered mature when more than 75 per cent of pods of randomly selected plants in individual plots showed dark streaks on the inner side of the shell.

3.8.10 Crop Growth Rate (CGR)

Mean Crop growth rate (CGR) was calculated by using the following formula at 30, 60 and 90 DAS.

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_1 and W_2 represent the dry weights at times t_1 and t_2 respectively from unit area and expressed as $\text{g m}^{-2} \text{day}^{-1}$.

3.8.11 Relative Growth Rate (RGR)

Mean relative growth rate (RGR) was calculated with the following formula.

$$\text{RGR} = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)}$$

Where, W_1 and W_2 represents the plant dry weights (g plant^{-1}) at times t_1 and t_2 respectively and expressed as $\text{g g}^{-1} \text{day}^{-1}$.

3.9 Post Harvest Observations

3.9.1 Number of Pods per Plant

Five plants were chosen at random from the net area of each plot at harvest. Number of pods per plant were recorded and average of five plants is taken.

3.9.2 Number of Seeds Pod⁻¹

Pods from five destructive sampled plants were shelled and number of seeds per pod from each plant were recorded and averaged.

3.9.3 Hundred Kernel Weight

Weight of 100 randomly selected kernels in each plot (obtained from shelled pods) was recorded and expressed in grams.

3.9.4 Shelling Percentage

Three separate random samples (250 g) of pods were drawn from each treatment, shelled, kernels were separated and weight of kernels was recorded. The per cent of kernels to pods was worked out using the following formula.

$$\text{Shelling percentage} = \frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100$$

3.9.5 Pod Yield

Pods obtained from net plot including pods obtained from the labeled plants were completely dried and cleaned. Thus obtained pod yield was weighed and expressed in kg ha⁻¹.

3.9.6 Haulm Yield

Similar to pod yield, the dried haulms from each net plot were weighed separately and the haulm yield was expressed in kg ha⁻¹.

3.9.7 Harvest Index (HI)

Harvest index was calculated by using the following formula.

$$\text{HI} = \frac{\text{Pod yield (kg ha}^{-1}\text{)}}{\text{Total dry matter (kg ha}^{-1}\text{)}} \times 100$$

3.10 Chemical Analysis

3.10.1 Soil

Soil samples were drawn from 0-30 cm depth after harvest in each treatmental plot, and analysed for available nitrogen using alkaline permanganate method, (Subbaiah and Asija, 1956), available phosphorous using Olsen's method using colorimeter (Olsen *et al.*, 1954) and available potassium using Neutral ammonium acetate method (Muhr *et al.*, 1963).

3.10.2 Oil Content

Oil content in groundnut was estimated in Nuclear Magnetic Resonance spectroscopy (NMR) technique by saturation of seed samples followed by soxlet analysis and calibration (Jambunathan, 1985).

3.11 Economics

3.11.1 Cost of Cultivation

The cost of cultivation ha⁻¹ was calculated for the individual treatment on the basis of inputs used and prevailing market price of the produce.

3.11.2 Gross Returns

Gross monetary returns (in Rs ha⁻¹) were estimated by multiplying economic yield with prevailing market price of groundnut pods.

3.11.3 Net Returns

Net monetary returns (in Rs ha⁻¹) were calculated by deducting cost of cultivation from gross monetary returns for each treatment.

3.11.4 Benefit-Cost Ratio

Benefit - cost (B: C) ratio was calculated by dividing net returns with cost of cultivation

$$\text{Benefit - cost ratio} = \frac{\text{Net returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3.12 Statistical Analysis

The data recorded on growth and yield parameters of groundnut were analysed statistically following the factorial RBD design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with F test at 5 per cent level of probability. Linear regression model ($Y=a + bx$) was tested to draw economic optimum level of seed rate for tested groundnut varieties as suggested by Panse and Sukhatme (1985).

Table 3.1. Weekly meteorological data during crop growth period (11-07-2010 to 06-11-2010)

Standard week	Date & Month	Temperature (°C)		Mean Relative humidity (%)		Mean sun shine hours day ⁻¹	Mean evaporation (mm day ⁻¹)	Rainfall (mm)	Wind speed Km hr ⁻¹	Mean Temperature (°C)	Rainy days
		Max	Min	I	II						
28	11-17 July	30.7	22.7	90.6	69.6	4.4	3.8	108.6	7.1	26.7	4
29	18-24 July	29.4	22.8	88.0	79.9	3.3	3.3	36.3	9.7	26.1	3
30	25-31 Aug	27.2	22.4	91.3	81.7	0.3	2.4	33.4	11.7	24.7	4
31	1-7 Aug	28.7	22.0	89.6	70.7	3.8	2.8	28.8	10.6	25.4	3
32	8-14 Aug	30.7	22.9	89.3	74.1	5.0	3.1	37.5	5.0	30.0	2
33	15-21 Aug	30.8	23.1	93.7	76.0	4.3	2.7	33.2	3.0	27.0	3
34	22-28 Aug	31.4	22.4	93.3	72.4	5.7	3.4	68.6	3.3	22.8	3
35	29-4 Sep	28.4	22.6	88.3	82.1	1.5	2.3	44.4	8.4	27.0	2
36	5-11 Sep	26.9	22.2	88.9	77.0	1.9	2.4	78	8.0	25.5	4
37	12-18 Sep	29.9	22.3	93.3	72.6	3.6	2.8	81.8	3.6	24.5	3
38	19-25 Sep	30.1	21.9	87.6	67.4	6.0	2.6	61.8	2.2	26.1	2
39	26-2 Oct	30.9	21.6	84.4	61.0	6.3	2.3	42.8	2.9	26.3	3

40	3-9 Oct	30.9	22.0	87.0	64.6	6.3	3.0	14	2.2	26.5	2
41	10-16 Oct	29.4	20.2	93.6	51.4	6.8	2.7	0	2.8	26.1	0
42	17-23 Oct	32.0	21.4	76.3	77.1	3.7	2.4	47.2	3.2	24.7	3
43	24-30 Oct	25.4	18.7	85.7	61.4	7.0	2.4	2.4	3.5	21.4	1
44	31-6 Nov	28	19.8	94	71	4.4	2.3	14.4	3.8	23.9	2
Total (or) Average		29.5	21.8	89.1	71.2	4.4	2.7	733.4	5.4	25.6	44



Plate 3.1. General view of the experimental field.

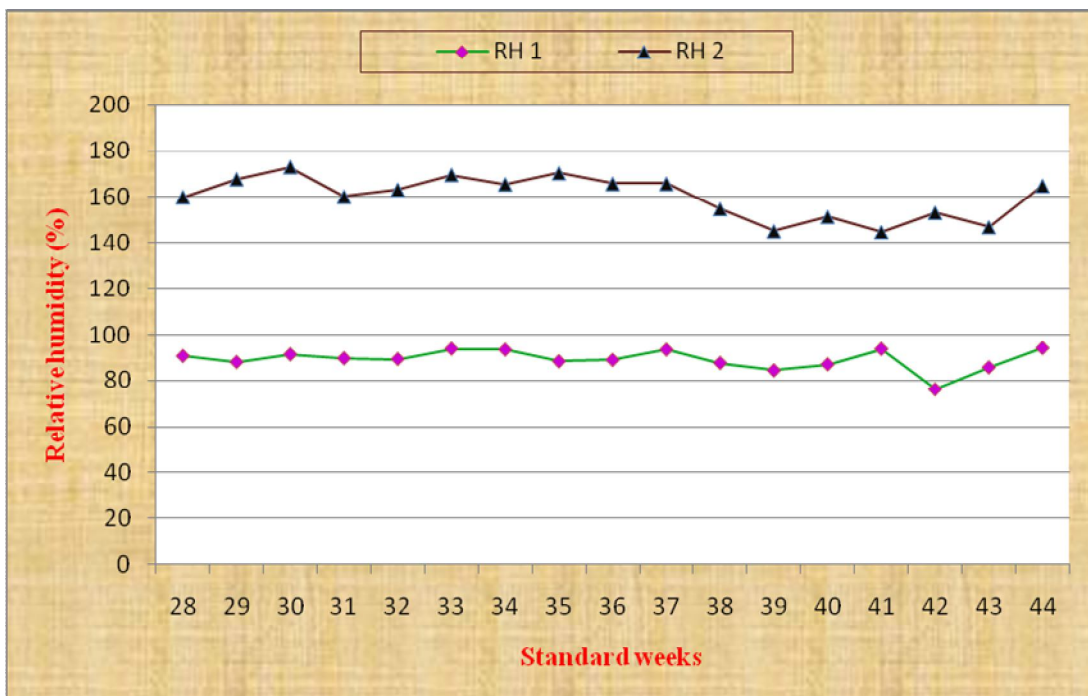
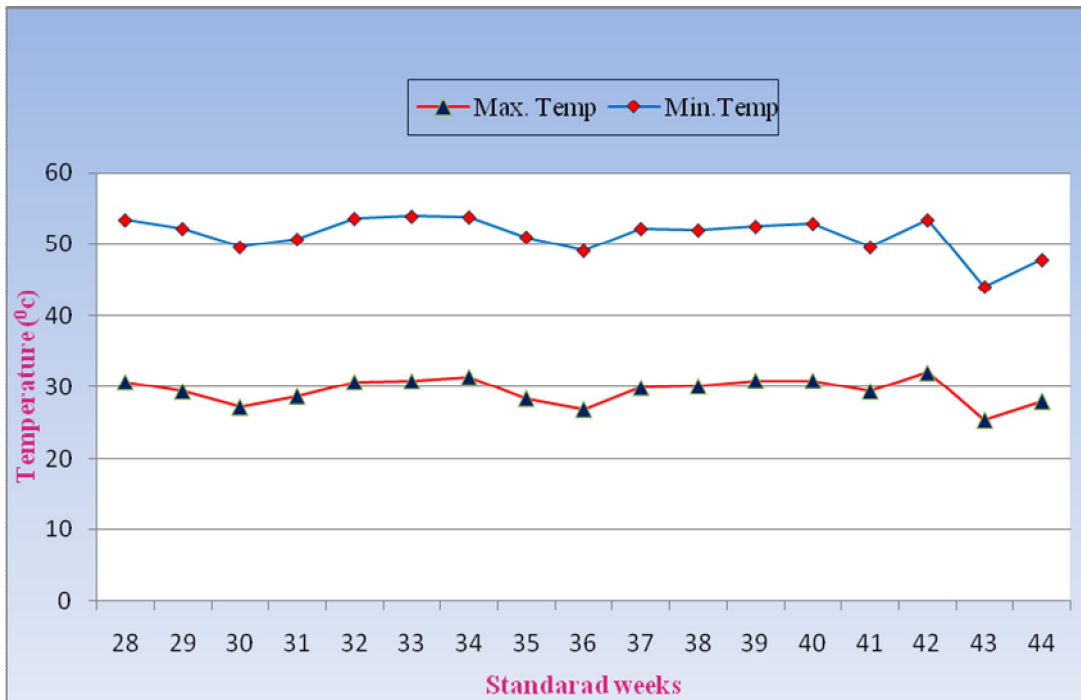


Figure 3.1. Weekly meteorological data during the crop growth period

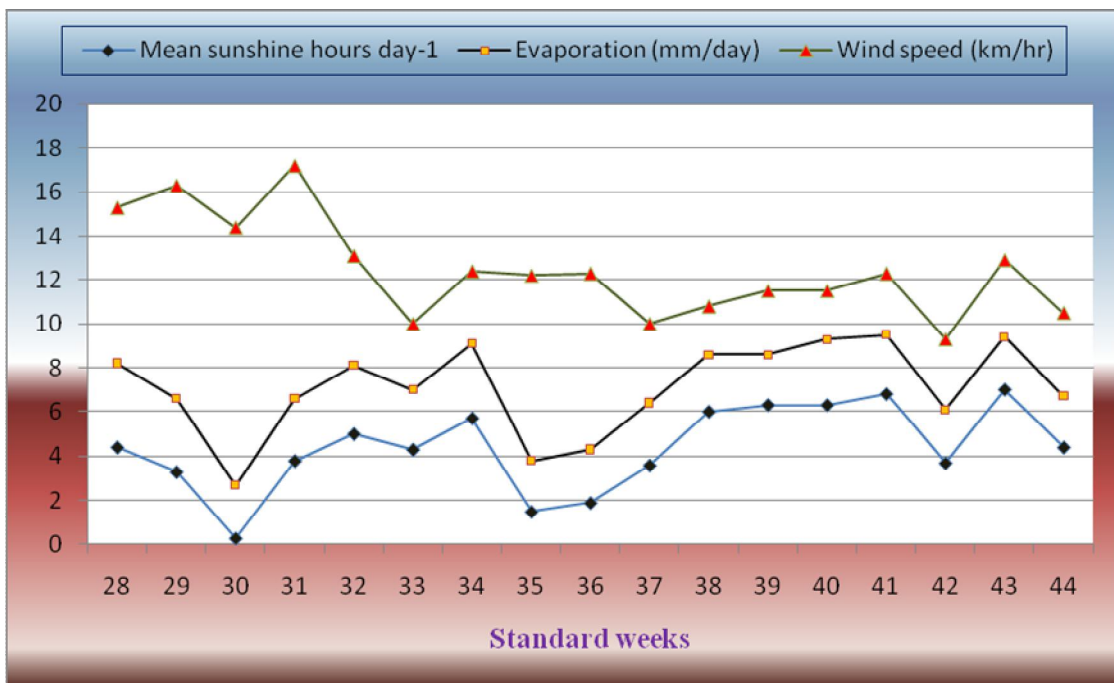
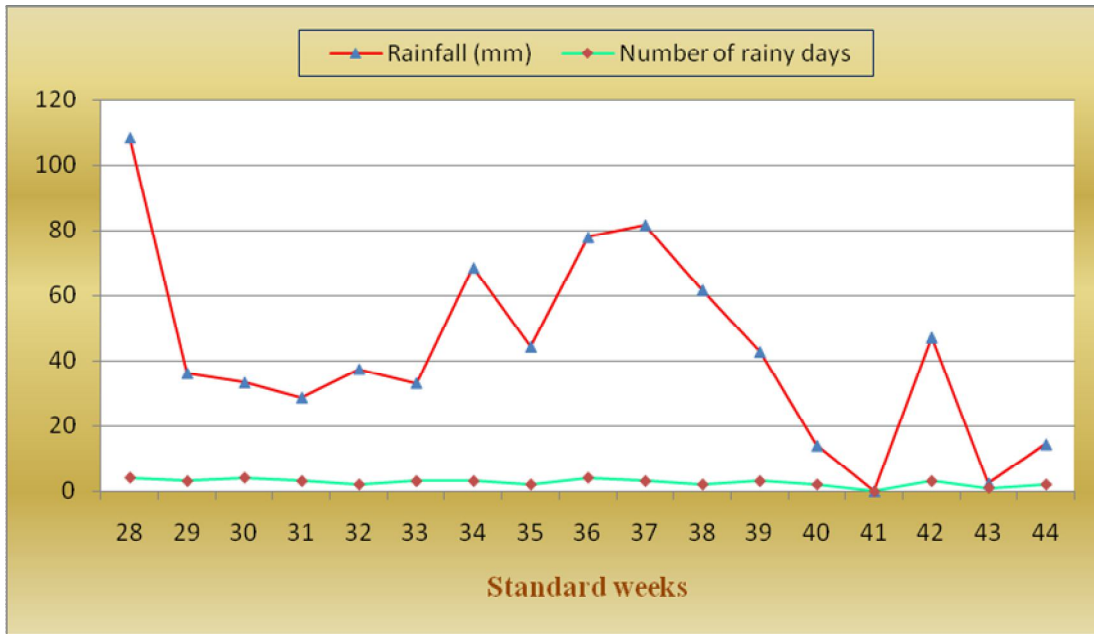


Figure 3.2. Weekly meteorological data during the crop growth period

Chapter IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

Results of the present field experiment entitled “Standardization of seed rate for promising groundnut varieties under rainfed conditions of Southern Telangana zone, Andhra Pradesh” conducted during *khariif* 2010 at the College Farm, College of Agriculture, Rajendranagar, Hyderabad are presented in this chapter. Experimental data were statistically analyzed apportioned under various heads and subheads, furnished in tables and illustrated through figures wherever necessary. Interaction tables were also given for characters which were found significant. The results were discussed critically with cause and effect relationship under following headings.

4.1 Growth Parameters

4.1.1 Germination Percentage (%)

The data on germination percentage as influenced by different varieties and seed rates is presented in Table (4.1).

The varieties did not differ significantly in terms of germination percentage at 10 and 20 DAS. However seed rates significantly influenced the germination percentage. Each increment in seed rate from 75 to 150 kg ha⁻¹ increased the germination percent and maximum was with 150 kg ha⁻¹ seed rate. This might be due to more number of seeds sown and germinated at higher seed rate.

Germination percentage at 10 and 20 DAS of the crop was not significant due to interaction between varieties and seed rates.

4.1.2 Seedling Mortality

The data on seedling mortality as influenced by different varieties and seed rates is presented in Table (4.1).

It was noticed that the varieties and seed rates did not influence the seedling mortality to a significant level. Their interaction effects were also not significant on seedling mortality.

4.1.3 Initial and Final Plant Stand

Perusal of the data pertaining to initial and final plant stand as influenced by varieties and seed rates are given in Table (4.2) and shown in Figure (4.1) indicated no significant differences among varieties on plant stand of crop both at initial and final stages.

Table 4.1. Germination percentage (%) and Seedling mortality (%) of groundnut as influenced by varieties and seed rates

Treatment	Germination percentage		Seedling mortality
	10 DAS	20 DAS	
Varieties			
V ₁ : Narayani	80.40 (63.99)	84.90 (67.53)	11.75 (20.01)
V ₂ : ICGV 91114	81.63 (64.76)	86.21 (68.37)	12.00 (20.22)
V ₃ : K 6	82.39 (65.39)	86.97 (69.26)	12.03 (20.24)
V ₄ : JCG 88	81.48 (64.92)	86.22 (69.04)	11.40 (19.71)
S.Em ±	0.74	0.96	0.45
CD (P=0.05)	NS	NS	NS
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	74.28 (59.60)	79.28 (63.07)	11.40 (19.67)
S ₂ : 100	79.35 (63.02)	84.35 (66.81)	11.55 (19.84)
S ₃ : 125	84.12 (66.52)	88.12 (69.89)	12.00 (20.24)
S ₄ : 150	88.14 (69.92)	92.56 (74.44)	12.23 (20.42)
S.Em ±	0.74	0.96	0.45
CD (P=0.05)	2.13	2.76	NS
Varieties x Seed Rates			
S.Em ±	1.47	1.91	0.90
CD (P=0.05)	NS	NS	NS

Figures in the parentheses are angular transformed values.

Table 4.2. Initial and final plant stands (lakh ha⁻¹) of groundnut as influenced by varieties and seed rates

Treatment	Plant stand (lakh ha ⁻¹)	
	Initial	Final
Varieties		
V ₁ : Narayani	2.760	2.255
V ₂ : ICGV 91114	2.598	2.036
V ₃ : K 6	2.694	2.171
V ₄ : JCG 88	2.643	2.110
S.Em ±	0.050	0.060
CD (P=0.05)	NS	NS
Seed Rates (kg ha⁻¹ kernel)		
S ₁ : 75	1.879	1.773
S ₂ : 100	2.380	1.980
S ₃ : 125	2.941	2.278
S ₄ : 150	3.495	2.541
S.Em ±	0.050	0.060
CD (P=0.05)	0.144	0.175
Varieties x Seed Rates		
S.Em ±	0.100	0.120
CD (P=0.05)	NS	NS

However, plant stand was significantly varied due to seed rate. Increasing the seed rate from 75 to 150 kg ha⁻¹ increased the plant stand at initial and final stages of crop. Similar increase in plant stand due to increase in seed rate was noticed by Ramachandra Reddy and Subbi Reddy (1998), Ramulu and Bucha Reddy (1998).

4.1.4 Plant Height (cm)

Data pertaining to plant height of groundnut as influenced by varieties and seed rates at different growth stages are presented in Table (4.3) and shown in Figure (4.2).

The plant height was affected significantly by varieties at different growth stages (30, 60 and 90 DAS). The plant height progressively increased with the crop age. Among the varieties tested, significantly higher plant height was recorded by the variety Narayani at all the stages of crop over other varieties and was followed by K 6 and ICGV 91114 varieties. Minimum plant height was observed with JCG 88 at all the stages of crop growth. At 30 DAS, plant height of K 6 and ICGV 91114 was at par with each other. Plant height is partially a genetic character and the genetic makeup of varieties has resulted in such variation among varieties.

Plant height increased significantly with every increase in seed rate from 75 to 150 kg ha⁻¹ at all the stages of crop growth. At early growth stage, plant height did not vary due to seed rates, but significant differences in plant height were observed at later crop growth stages. More plant height was recorded at higher seed rate. This might be due to lanky growth of plants at densely populated situation for want of sufficient light. Similar findings were reported by Hirwe *et al.* (2005), Bharatha Lakshmi and Sambasiva Reddy (2001), Ramajyothi (1999), Bhoite and Nimbalkar (1995).

4.1.5 Leaf Area Index (LAI)

The data on LAI are presented in Table (4.4). The results revealed that leaf area index was significantly influenced by both varieties and seed rates at all stages of crop growth. Leaf area index was low at 30 DAS and gradually increased with increase in age of the crop and reached its peak at 60 DAS and thereafter shown declined trend towards maturity.

An insight in to the data on LAI, it was observed that the variety Narayani maintained its superiority over the other three varieties up to 60 DAS. But at 90 DAS the variety JCG 88 over taken Narayani and recorded maximum LAI of 2.04. The other two varieties namely K 6 and ICGV 91114 followed the variety Narayani at all stages of crop

Table 4.3. Plant height (cm) of groundnut as influenced by varieties and seed rates at different stages of crop growth

Treatment	Days after sowing		
	30 DAS	60 DAS	90 DAS
Varieties			
V ₁ : Narayani	15.45	35.88	50.75
V ₂ : ICGV 91114	12.78	28.18	44.63
V ₃ : K 6	13.43	32.50	48.13
V ₄ : JCG 88	9.18	23.53	34.28
S.Em ±	0.30	0.55	0.78
CD (P=0.05)	0.89	1.58	2.27
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	11.03	26.40	40.75
S ₂ : 100	12.50	29.63	43.63
S ₃ : 125	13.23	31.28	45.40
S ₄ : 150	14.08	32.78	48.00
S.Em ±	0.30	0.55	0.78
CD (P=0.05)	0.89	1.58	2.27
Varieties x Seed Rates			
S.Em ±	0.62	1.09	1.57
CD (P=0.05)	NS	NS	NS

Table 4.4. Leaf area index (LAI) of groundnut as influenced by varieties and seed rates at different stages of crop growth

Treatment	Days after sowing		
	30 DAS	60 DAS	90 DAS
Varieties			
V ₁ : Narayani	0.94	3.76	1.88
V ₂ : ICGV 91114	0.84	3.42	1.49
V ₃ : K 6	0.88	3.62	1.75
V ₄ : JCG 88	0.88	3.56	2.04
S.Em ±	0.01	0.02	0.02
CD (P=0.05)	0.03	0.05	0.05
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	0.82	3.32	1.64
S ₂ : 100	0.86	3.54	1.72
S ₃ : 125	0.91	3.70	1.84
S ₄ : 150	0.95	3.80	1.96
S.Em ±	0.01	0.02	0.02
CD (P=0.05)	0.03	0.05	0.05

growth. The indeterminate nature of the variety JCG 88 continued its vegetative growth up to 90 DAS.

The increase in seed rate from 75 to 150 kg ha⁻¹ significantly increased LAI values and maximum LAI was recorded by 150 kg ha⁻¹ at 30, 60 and 90 DAS. The increase in LAI at higher seed rate was due to more number of plants per unit area and more leaves per plant. The present results are in conformity with findings of Hirwe *et al.* (2005), Kaul (1999), Ramajyothi (1999), Basith (1992) and Murthy (1982).

Table 4.5. Interaction between varieties and seed rates on LAI of groundnut at 30 and 60 DAS of crop growth

Treatments	30 DAS				60 DAS			
	Seed rate (kg ha ⁻¹)				Seed rate (kg ha ⁻¹)			
	75	100	125	150	75	100	125	150
V ₁ : Narayani	0.83	0.90	0.97	1.05	3.49	3.72	3.82	4.00
V ₂ : ICGV 91114	0.79	0.83	0.85	0.89	3.10	3.38	3.50	3.70
V ₃ : K 6	0.82	0.84	0.91	0.96	3.38	3.55	3.74	3.80
V ₄ : JCG 88	0.83	0.86	0.92	0.89	3.32	3.52	3.74	3.68
S.Em ±		0.02				0.03		
CD (P=0.05)		0.06				0.09		

The interaction effect between varieties and seed rates (Table 4.5) indicated that at 30 DAS, the three varieties namely Narayani, ICGV 91114 and K 6 recorded increased LAI values with corresponding increase in seed rate from 75 to 150 kg ha⁻¹. Whereas, the variety JCG 88 was found with the highest LAI at 125 kg ha⁻¹ seed rate (0.92) as compared at other seed rates *i.e.* 75, 100 and 150 kg ha⁻¹ seed rate. At 60 DAS the response of above three varieties was similar as in case of 30 DAS. But the variety JCG 88 again recorded maximum LAI (3.74). The results suggest that in case of JCG 88 variety, the seed rate 125 kg ha⁻¹ is sufficient to achieve maximum LAI. Whereas, for other varieties 150 kg ha⁻¹ seed rate is required to obtain highest LAI. At 90 DAS, the interaction was not significant.

Table 4.6. Total dry matter (g m^{-2}) of groundnut as influenced by varieties and seed rates at different stages of crop growth

Treatment	Days after sowing		
	30 DAS	60 DAS	90 DAS
Varieties			
V ₁ : Narayani	69.88	191.98	437.15
V ₂ : ICGV 91114	47.18	144.18	297.48
V ₃ : K 6	66.75	188.30	402.55
V ₄ : JCG 88	61.60	172.93	357.98
S.Em \pm	0.92	2.06	9.15
CD (P=0.05)	2.67	5.94	26.44
Seed Rates (kg ha^{-1} kernel)			
S ₁ : 75	50.3	156.38	321.60
S ₂ : 100	57.45	168.20	350.15
S ₃ : 125	67.58	179.38	402.58
S ₄ : 150	70.08	193.43	420.83
S.Em \pm	0.92	2.06	9.15
CD (P=0.05)	2.67	5.94	26.44

4.1.6 Dry Matter Production (g m^{-2})

The dry matter production was found (Table 4.6 & Figure 4.3) significantly influenced by both varieties and seed rates at 30, 60 and 90 DAS. Rapid improvement in dry matter accumulation was noticed between 60 & 90 DAS. Maximum dry matter accumulation was observed at 90 DAS and lowest was at 30 DAS. Among the varieties, Narayani recorded the highest dry matter at 30 DAS and closely followed by K 6 at all the crop growth stages. However at 60 DAS, Narayani and K 6 were at par with each other and these two varieties were found significantly superior to ICGV 91114 and JCG 88. The variety JCG 88 was in turn superior to ICGV 91114. Higher dry matter production by Narayani variety was due to more plant height (Table 4.3) and higher LAI (Table 4.4). The dry matter production of JCG 88 was less because of short stature of plant as compared to other varieties like Narayani and K 6.

Table 4.7. Interaction between varieties and seed rates on dry matter (g m^{-2}) of groundnut at 30 and 60 DAS of crop growth

Treatments	30 DAS				60 DAS			
	Seed rate (kg ha^{-1})				Seed rate (kg ha^{-1})			
	75	100	125	150	75	100	125	150
V ₁ : Narayani	54.40	65.10	77.60	82.40	165.20	186.70	186.70	229.30
V ₂ : ICGV 91114	40.30	45.30	49.60	53.50	130.70	137.50	148.10	160.40
V ₃ : K 6	55.10	60.60	71.90	79.40	170.60	179.80	197.50	205.30
V ₄ : JCG 88	51.40	58.80	71.20	65.00	159.37	168.20	179.37	193.43
S.Em \pm		1.85				4.11		
CD (P=0.05)		5.34				11.88		

At all the crop growth stages, there was an increase in dry matter accumulation due to increase in seed rate from 75 to 150 kg ha^{-1} . Maximum dry matter production was observed with a seed rate of 150 kg ha^{-1} and found superior to rest of the seed rates. At 30 and 90 DAS, dry matter produced by seed rate of 150 and 125 kg ha^{-1} were at par. Though the individual plant performance was better under wider spacing, but could not produce higher LAI and dry matter production per unit area due to low plant population per unit

Table 4.8. Crop growth rate (CGR) $\text{g m}^{-2} \text{day}^{-1}$ of groundnut as influenced by varieties and seed rates at different stages of crop growth

Treatment	Days after sowing		
	0-30 DAS	30-60 DAS	60-90 DAS
Varieties			
V ₁ : Narayani	2.329	4.070	8.173
V ₂ : ICGV 91114	1.573	3.233	5.110
V ₃ : K 6	2.225	4.052	7.142
V ₄ : JCG 88	2.053	3.711	6.168
S.Em \pm	0.009	0.072	0.300
CD (P=0.05)	0.027	0.209	0.866
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	1.677	3.536	5.508
S ₂ : 100	1.915	3.692	6.065
S ₃ : 125	2.252	3.727	7.440
S ₄ : 150	2.336	4.112	7.580
S.Em \pm	0.009	0.072	0.300
CD (P=0.05)	0.027	0.209	0.866

area. An increase in dry matter accumulation with increase in seed rate was also reported by Kathirvelan and Kalaiselvan (2006), Srinivas Kumar (1992), Rao *et al.* (1989) and Cheema *et al.* (1985).

The interaction between varieties and seed rates (Table 4.7) revealed that except the variety JCG 88, the other three varieties showed positive influence with increasing seed rates *i.e.* from 75 to 150 and recorded the highest dry matter at 150 kg ha⁻¹ seed rate. But the variety JCG 88 behaved in similar pattern as in case of LAI where in it produced highest dry matter of 71.2 g m⁻² at 125 kg ha⁻¹ seed rate. At 60 DAS, the relationship between varieties and seed rates was found just similar as that of 30 DAS.

4.1.7 Crop Growth Rate (g m⁻² day⁻¹)

Perusal of data pertaining to crop growth rate (Table 4.8) revealed that maximum CGR values were associated with Narayani variety followed by K 6 and both of them were significantly superior to JCG 88 and ICGV 91114 at all the stages of crop growth. Lowest crop growth rate was observed with ICGV 91114 variety at all crop growth stages. At 60 DAS, crop growth rate of Narayani and K 6 were at par with each other.

Table 4.9 Interaction between varieties and seed rates on crop growth rate (g m⁻² day⁻¹) of groundnut at 30 and 60 DAS of crop growth

Treatments	0-30 DAS				30-60 DAS			
	Seed rate (kg ha ⁻¹)				Seed rate (kg ha ⁻¹)			
	75	100	125	150	75	100	125	150
V ₁ : Narayani	1.813	2.170	2.587	2.747	3.693	4.053	3.637	4.897
V ₂ : ICGV 91114	1.343	1.510	1.653	1.783	3.013	3.073	3.283	3.563
V ₃ : K 6	1.837	2.020	2.397	2.647	3.850	3.973	4.187	4.197
V ₄ : JCG 88	1.713	1.960	2.373	2.167	3.587	3.667	3.800	3.790
S.Em ±		0.018				0.145		
CD (P=0.05)		0.053				0.419		

Each increment in seed rate from 75 to 150 kg ha⁻¹ significantly enhanced the CGR values and higher CGR values were registered by 150 kg ha⁻¹ at all the stages. At 30-60 DAS, the CGR values of 75, 100 and 125 kg ha⁻¹ were at par with each other. At 60-90 DAS, the differences between seed rates were not significant.

The interaction effect on CGR (Table 4.9) revealed that the three varieties *i.e.* Narayani, ICGV 91114, and K 6 recorded an increased CGR values due to increasing seed rates from 75 to 150 kg ha⁻¹. Whereas the variety JCG 88 was found with maximum CGR at a seed rate of 125 kg ha⁻¹ and found superior than other seed rates the highest seed rate of 150 kg ha⁻¹. This suggest that for a variety like JCG 88, a seed rate of 125 kg ha⁻¹ would be sufficient to achieve higher growth rates. Whereas, in other varieties 150 kg ha⁻¹ seed rate is required to obtain higher crop growth rates.

4.1.8 Relative Growth Rate (g g⁻¹ day⁻¹)

Data pertaining to relative growth rate of groundnut as influenced by varieties and seed rates at different growth stages were expressed in Figure (4.4).

At 30 DAS, among the varieties evaluated significantly higher relative growth rate was recorded by Narayani followed by K 6 and JCG 88 which were significantly superior to ICGV 91114. At 60 DAS, maximum relative growth rate was observed with ICGV 91114 followed by K 6, JCG 88 and Narayani which were at par. This might be due to early maturity of the variety which accumulated photosynthates at faster rate compared to rest of varieties. At 90 DAS higher RGR was with Narayani variety which was at par with K 6 variety and followed by JCG 88 and ICGV 91114 which in turn were at par.

Relative growth rate decreased significantly due to increase in seed rate from 75 to 150 kg ha⁻¹ at all the stages of crop growth. However at 60 DAS, relative growth rate at seed rate of 125 and 150 kg ha⁻¹ were at par and at 90 DAS the differences between the seed rates were meager.

4.1.9 Number of Branches per Plant

The data on number of branches plant⁻¹ (Table 4.10) revealed that branches per plant recorded at 30 DAS were higher and showed marginal increase with increase in age of crop after 30 DAS and reached maximum at 90 DAS in all the treatments. It was influenced by varieties and seed rates at 30, 60 and 90 DAS.

The number of branches per plant recorded by JCG 88 variety was significantly higher compared to the rest of varieties at all stages of crop growth and was followed by Narayani. Varieties K 6 and ICGV 91114 were at par with each other at 30 DAS and 90 DAS. At 60 DAS, Narayani and K 6 were at par with each other and are significantly superior to ICGV 91114.

Among the seed rates, number of branches plant⁻¹ decreased with increase in seed rate from 75 to 150 kg ha⁻¹. Maximum number of branches was observed with a lower seed

Table 4.10. Number of branches per plant of groundnut as influenced by varieties and seed rates at different stages of crop growth

Treatment	Days after sowing		
	30 DAS	60 DAS	90 DAS
Varieties			
V ₁ : Narayani	5.3	5.4	5.8
V ₂ : ICGV 91114	4.8	5.0	5.3
V ₃ : K 6	4.8	5.3	5.5
V ₄ : JCG 88	6.0	6.6	7.0
S.E.m ±	0.1	0.1	0.1
CD (P=0.05)	0.2	0.2	0.3
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	5.8	6.2	6.5
S ₂ : 100	5.5	5.8	6.0
S ₃ : 125	4.9	5.4	5.6
S ₄ : 150	4.6	5.0	5.4
S.E.m ±	0.1	0.1	0.1
CD (P=0.05)	0.2	0.2	0.3
Varieties x Seed Rates			
S.E.m ±	0.2	0.1	0.2
CD (P=0.05)	NS	NS	NS

rate of 75 kg ha⁻¹ (5.8). This could be attributed to the fact that lesser intra plant competition for light, nutrients and availability of more space for expansion of root volume for exploring more moisture. Higher plant densities resulted in reduced number of branches plant⁻¹ because of more intra plant and inter plant competition for edaphic and climatic requirement that caused lesser dry matter production per plant thus depressing the initiation of branches. Such a reduction in the number of branches per plant with a corresponding increase in plant density was also observed by several workers like Tewolde *et al.* (2002), Mishra *et al.* (1998), Kushwaha *et al.* (1978).

4.1.10 Days to 50 % Flowering and Days to Maturity

The data on days to 50 % flowering and days to maturity are presented in Table 4.11. Significant differences were noticed between varieties, but the effect of seed rate was seen only on days to 50 % flowering but not on days to maturity.

The variety ICGV 91114 was early to flower followed by Narayani, K 6 and JCG 88. Number of days taken for maturity by ICGV 91114 was minimum compared to other varieties. Narayani and K 6 followed ICGV 91114. Maximum number of days was taken by JCG 88 to attain 50 % flowering and maturity stages. This was observed mainly due to difference in duration of varieties. Similar observations were made by Suraj Bhan and Misra (1972), Thakur and Chowdhury (1967).

Among the seed rates, 75 kg ha⁻¹ took maximum days to 50 % flowering. Number of days to 50 % flowering increased with every decrease in seed rate from 150 to 75 kg ha⁻¹. This may be due to elimination of inter plant competition which enhanced photosynthetic efficiency and translocation of photosynthates and resulted in delayed flowering at lower plant density. Days to maturity was found non significant among seed rates.

4.2 Post Harvest Observations

4.2.1 Number of Pods Plant⁻¹

Varieties and seed rates significantly influenced the number of pods plant⁻¹ (Table 4.12). Among the varieties tested, higher number of pods plant⁻¹ were produced by Narayani variety which was closely followed by K 6 and both were significantly superior to JCG 88 and ICGV 91114. Lowest number of pods plant⁻¹ was recorded by ICGV 91114. Higher number of pods in Narayani was due to production of more branches per plant in turn more flowers and pegs and finally resulted in more number of pods per plant.

Table 4.11. Days to 50 % flowering and days to maturity of groundnut as influenced by varieties and seed rates

Treatment	Days to 50% flowering	Days to maturity
Varieties		
V ₁ : Narayani	32.20	108.24
V ₂ : ICGV 91114	31.32	100.12
V ₃ : K 6	33.08	109.95
V ₄ : JCG 88	35.76	115.27
S.Em ±	0.04	1.18
CD (P=0.05)	0.10	3.42
Seed Rates (kg ha⁻¹ kernel)		
S ₁ : 75	33.27	108.85
S ₂ : 100	33.14	108.53
S ₃ : 125	33.03	108.22
S ₄ : 150	32.90	107.98
S.Em ±	0.04	1.18
CD (P=0.05)	0.10	NS
Varieties x Seed Rates		
S.Em ±	0.07	2.37
CD (P=0.05)	NS	NS

With every decrease in seed rate from 150 to 75 kg ha⁻¹, the numbers of pods plant⁻¹ increased significantly. At the seed rate of 75 kg ha⁻¹, number of pods plant⁻¹ was maximum (22.75) which was significantly superior to all other seed rates. This might be due to sufficient space available for individual plants which grown more vigorously and produced more branches and more pods per plant. Plants at lower density experienced minimum inter plant competition for space, light, nutrients and moisture and resulted in more partitioning efficiency. These results are in accordance with the findings of Senthil Kumar (2009), Kathirvelan and Kalaiselvan (2006), Srinivas Kumar (1992), Murthy (1982) and Suraj Bhan and Misra (1972).

4.2.2 Number of Seeds Pod⁻¹

The data on number of seeds pod⁻¹ presented in Table 4.12 showed variations due to varieties and seed rates.

Higher number of seeds pod⁻¹ were observed in K 6 and found at par with Narayani and JCG 88 which in turn were superior to variety ICGV 91114 in recording more number of seeds per pod. The varieties with good growth in terms of LAI, dry matter, branch number recorded their superiority in terms of seeds per pod.

The effect of seed rates and interaction between varieties and seed rates on number of seeds pod⁻¹ was found to be non significant and this indicates that number of seeds pod⁻¹ was more of genetically controlled factor and is less influenced by seed rates.

4.2.3 Hundred Kernel Weight (g)

The 100 kernel weight (g) of groundnut was significantly influenced by varieties and seed rates Table (4.13).

100-kernel weight of ICGV 91114 (40.83 g) was significantly higher over other varieties and was closely followed by JCG 88 which was superior to K 6 and Narayani varieties which were at par. More 100-kernel weight of ICGV 91114 was also reported by Kareem (2006) and Nigam *et al.* (2005). The experimental results clearly showed that promising groundnut varieties differ in 100-kernel weight ranging between 43.0 to 66.6 g for bold seed, 24.5 to 29.5 g for medium seed and in turn differ in the recommendation of seed rate for optimum pod yield (Sahadeva Reddy *et al.*, 2009).

Among the seed rates tested, the 100 kernel weight at 75, 100 and 125 kg ha⁻¹ was on par with each other but differed significantly from 150 kg ha⁻¹ which was lower than other seed rates.

Interaction effect of varieties and seed rate was found to be non significant.

Table 4.12. Total number of pods per plant and number of seeds per pod of groundnut as influenced by varieties and seed rates

Treatment	Total pods plant⁻¹	Number of seeds pod⁻¹
Varieties		
V ₁ : Narayani	23.83	1.80
V ₂ : ICGV 91114	16.88	1.73
V ₃ : K 6	22.20	1.82
V ₄ : JCG 88	18.75	1.80
S.Em ±	0.36	0.02
CD (P=0.05)	1.04	0.06
Seed Rates (kg ha⁻¹ kernel)		
S ₁ : 75	22.75	1.82
S ₂ : 100	21.10	1.81
S ₃ : 125	19.53	1.76
S ₄ : 150	18.28	1.77
S.Em ±	0.36	0.02
CD (P=0.05)	1.04	NS
Varieties x Seed Rates		
S.Em ±	0.72	0.04
CD (P=0.05)	NS	NS

4.2.4. Shelling Percentage (%)

Significant difference in shelling percentage was observed due to varieties and seed rates (Table 4.13).

Shelling percentage recorded with Narayani (72.88) was significantly more compared to other varieties. Next to Narayani, K 6, ICGV 91114 and JCG 88 followed and were on par. Higher shelling percentage recorded by Narayani variety might be due to its varietal character with thin shell development and bunch type varieties have higher shelling out turn over runner types.

Shelling percentage showed increased trend with increase in seed rate from 75 to 150 kg ha⁻¹. However this increase in shelling percentage was just marginal. Similar results were recorded by Nagaraj *et al.* (2001), Attarde *et al.* (1998), Satyanarayana (1984) and Misra *et al.* (1967).

Interaction between varieties and seed rates on shelling percentage was not significant.

4.2.5 Pod Yield (kg ha⁻¹)

The data pertaining to pod yield of groundnut varieties as influenced by different seed rates are presented in Table 4.14 and depicted in Figure 4.5.

Maximum pod yield of 1835 kg ha⁻¹ was recorded by Narayani variety followed by K 6 (1651 kg ha⁻¹) and JCG 88 (1365 kg ha⁻¹) varieties which were significantly superior to ICGV 91114 (1125 kg ha⁻¹). Similar high yields with Narayani were reported by (NRCG, 2009) and Sahadeva Reddy *et al.* (2009). The lower yield noticed in K 6 variety compared to Narayani was due to heavy rains which affected pod filling and resulted in more number of pops. As Narayani is genetically efficient in expressing more LAI, DMP and high CGR and RGR over other varieties might have resulted in increased yield components and final pod yield. Narayani and K 6 varieties completed vegetative growth period earlier and diverted their photosynthates towards developing pegs and pods and thus they were able to take full advantage of favorable environment for a longer time. But JCG 88, because of its prolonged vegetative growth period attained flowering stage late and vegetative growth and flowering overlapped and continued even up to maturity stage of crop as a result of this, photosynthates might have distributed to these parts and thus created intra plant competition for photosynthates that resulted in lower yields.

There was increase in pod yield due to increase in seed rates from 75 to 150 kg ha⁻¹. Significantly higher pod yield (1733 kg ha⁻¹) was obtained at a seed rate of 150 kg

Table 4.13. 100-Kernel weight (g) and shelling per cent of groundnut as influenced by varieties and seed rates

Treatment	100-Kernel weight	Shelling %
Varieties		
V ₁ : Narayani	37.25	72.88
V ₂ : ICGV 91114	40.83	72.35
V ₃ : K 6	38.20	72.60
V ₄ : JCG 88	39.55	72.33
S.Em ±	0.34	0.09
CD (P=0.05)	0.99	0.27
Seed Rates (kg ha⁻¹ kernel)		
S ₁ : 75	39.50	72.10
S ₂ : 100	39.28	72.40
S ₃ : 125	39.05	72.93
S ₄ : 150	38.00	72.73
S.Em ±	0.34	0.09
CD (P=0.05)	0.99	0.27
Varieties x Seed Rates		
S.Em ±	0.68	0.19
CD (P=0.05)	NS	NS

Table 4.14. Pod yield, Haulm yield (kg ha⁻¹) and harvest index (HI) of groundnut as influenced by varieties and seed rates

Treatment	Pod yield	Haulm yield	Harvest index
Varieties			
V ₁ : Narayani	1835.00	2850.50	38.99
V ₂ : ICGV 91114	1125.00	2112.50	34.69
V ₃ : K 6	1651.00	2677.75	37.91
V ₄ : JCG 88	1365.00	2410.50	35.99
S.Em ±	23.50	39.28	0.51
CD (P=0.05)	67.88	113.44	1.49
Seed Rates (kg ha⁻¹ kernel)			
S ₁ : 75	1224.24	2236.75	35.22
S ₂ : 100	1352.50	2393.50	35.90
S ₃ : 125	1665.75	2684.75	38.01
S ₄ : 150	1733.00	2736.25	38.46
S.Em ±	23.50	39.28	0.51
CD (P=0.05)	67.88	113.44	1.49
Varieties x Seed Rates			
S.Em ±	47.01	78.56	1.03
CD (P=0.05)	135.77	NS	NS

ha⁻¹. However it was at par with 125 kg ha⁻¹ seed rate. Lowest pod yield of 1224 kg ha⁻¹ was obtained with lower seed rate of 75 kg ha⁻¹. Although the individual plant productivity was highest at lower seed rates, but due to higher plant density at higher seed rate of 125 kg ha⁻¹, the higher pod yield per hectare was realized. The results suggest that to achieve optimum plant density to facilitate higher pod yields, a minimum seed rate of 125 kg ha⁻¹ should be adopted. These results are in line with those of Naeem Ahmed *et al.* (2007), Chaniyara *et al.* (2001), Nagaraj *et al.* (2001), Ramulu and Bucha reddy (1998), Bhale rao *et al.* (1996), Raghavaiah *et al.* (1995), Jadhao *et al.* (1992), Chavan and Kalra (1983) and Ajaya Kumar *et al.* (1971).

Table 4.15. Interaction between varieties and seed rates on pod yield and kernel yield (kg ha⁻¹) of groundnut

Treatments	Pod yield			
	Seed rate (kg ha ⁻¹)			
	75	100	125	150
V ₁ : Narayani	1440.00	1710.00	2040.00	2150.00
V ₂ : ICGV 91114	966.00	1030.00	1200.00	1304.00
V ₃ : K 6	1386.00	1430.00	1820.00	1968.00
V ₄ : JCG 88	1105.00	1240.00	1603.00	1510.00
S.Em ±		47.01		
CD (P=0.05)		135.77		

The interaction effect between varieties and seed rates (Table 4.15) indicated that the variety Narayani gave significantly more pod yield under seed rate of 100 kg ha⁻¹ over 75 kg ha⁻¹ seed rate, but it has recorded at par yields under 125 and 150 kg ha⁻¹ seed rate. The other two varieties ICGV 91114 and K 6 gave at par pod yields at 75 and 100 kg ha⁻¹ seed rates and same trend at 125 and 75 kg ha⁻¹ seed rates. All the three varieties *i.e.* Narayani, ICGV 91114 and K 6 recorded maximum pod yields at 150 kg ha⁻¹ seed rate. Whereas the variety JCG 88 realized the highest pod yield at 125 kg ha⁻¹ seed rate. The present experimental results suggest that for all varieties tested, a seed rate range of 125kg ha⁻¹ may be adopted.

4.2.6 Haulm Yield (kg ha⁻¹)

Haulm yield (kg ha⁻¹) recorded by different varieties as influenced by seed rates are presented in Table 4.14 and shown in Figure 4.5. The differences in haulm yields were significant due to varieties and seed rates, while interactions were found to be non significant.

Among the varieties tested, the haulm yield recorded by Narayani was significantly higher over the rest of the varieties and it was followed by K6 and JCG 88 which were superior to ICGV 91114.

Seed rates of 150 kg ha⁻¹ and 125 kg ha⁻¹ being on par with each other and recorded significantly superior yield over 100 kg ha⁻¹ and 75 kg ha⁻¹. Lower haulm yield was obtained with a lower seed rate of 75 kg ha⁻¹. This was due to less number of plants per unit area at lower plant density. These findings are in agreement with the results reported by Ramesh and Sambasiva Reddy (2007), Hirwe *et al.* (2005), Chainyara *et al.* (2001), Jadhav *et al.* (2000) and Krishna *et al.* (1995).

4.2.7 Harvest Index (HI)

Data on harvest index (%) as influenced by varieties and seed rates are presented in Table (4.14).

Maximum harvest index was recorded by Narayani and K 6 varieties which were on par and significantly superior to JCG 88 and ICGV 91114 which in turn were at par with each other.

Harvest index increased with increase in seed rate from 75 to 150 kg ha⁻¹. Maximum Harvest index recorded by 150 and 125 kg ha⁻¹ which were on par but significantly superior to harvest index observed with seed rate of 100 and 75 kg ha⁻¹ which in turn were on par. Similar results were also indicated by Jadhav *et al.* (2000) and Ramajyothi (1999). The interactions between varieties and seed rates were found to be non significant on harvest index.

4.3 Quality Parameters

4.3.1 Oil Content (%)

The oil content (Table 4.16) was significantly influenced by varieties. Among the varieties tested, JCG 88 recorded higher oil content which was at par with K 6 and Narayani varieties and were superior to the oil content obtained with ICGV 91114 variety.

Table.4.16. Oil content (%) and oil yield (kg ha⁻¹) of groundnut as influenced by varieties and seed rates

Treatment	Oil content (%)	Oil yield (kg ha⁻¹)
Varieties		
V ₁ : Narayani	48.85	653.01
V ₂ : ICGV 91114	44.42	362.33
V ₃ : K 6	49.20	590.33
V ₄ : JCG 88	49.99	480.52
S.Em ±	0.76	12.29
CD (P=0.05)	2.20	35.50
Seed Rates (kg ha⁻¹ kernel)		
S ₁ : 75	48.11	424.15
S ₂ : 100	48.12	470.56
S ₃ : 125	48.13	585.16
S ₄ : 150	48.12	606.33
S.Em ±	0.76	12.29
CD (P=0.05)	NS	35.50
Varieties x Seed Rates		
S.Em ±	1.52	24.58
CD (P=0.05)	NS	NS

The effect of seed rates and interaction between varieties and seed rates on oil content was non significant and this indicates that oil content is more of genetically controlled factor and is less influenced by seed rates. This was in conformity with the findings of Morshed Alam *et al.* (2002), Kaushik and Chaubey (2000), Ragahavaiah *et al.* (1995) and Patel and Patel (1995).

4.3.2 Oil Yield (kg ha⁻¹)

The data pertaining to oil yield as influenced by varieties and seed rates was presented in Table (4.16). Significantly higher oil yield was recorded by Narayani (653.01 kg ha⁻¹) followed by K 6 variety. Lower oil yield of 362.33 kg ha⁻¹ was recorded with ICGV 91114 variety.

Each increase in seed rate from 75 to 150 kg ha⁻¹ had significantly increased the oil yield. Maximum oil yield was recorded with seed rate of 150 kg ha⁻¹ which was at par with seed rate of 125 kg ha⁻¹. These were in conformity with the findings of Ramesh and Sambasiva Reddy (2007) and Patel and Patel (1995).

Interaction between varieties and seed rates on oil yield was found to be non significant.

4.4 Economics

The data pertaining to economics in terms of gross returns, net returns and benefit-cost ratio as influenced by varieties and seed rates are presented in Table 4.17 and shown in Figure 4.6.

Maximum gross returns (38535 Rs ha⁻¹), net returns (25632.50 Rs ha⁻¹) and benefit-cost ratio (1.98) were obtained with Narayani variety and closely followed by K 6 which was superior to JCG 88 and ICGV 91114. Low monetary returns were obtained with ICGV 91114.

Plant density also significantly influenced the economics of groundnut. With each increase in seed rate from 75 to 150 kg ha⁻¹ gross returns, net returns and benefit-cost ratio increased, however at the seed rate of 125 and 150 kg ha⁻¹ there were no significant difference in gross, net returns and benefit-cost ratio.

The interaction effect indicated that as regards to gross returns, the higher gross returns of 45,150 ha⁻¹ were recorded by Narayani variety at a seed rate of 150 kg ha⁻¹. However it remained at par with 125 kg ha⁻¹. The lowest gross returns were recorded by JCG 88 at lower seed rate of 75 kg ha⁻¹.

Table 4.18. Initial and final values of soil properties of the experimental site

Soil properties	Initial	Final
Soil reaction (pH) (1:2.5 soil : water)	7.3	7.1
Electrical conductivity (ds/m)	0.20	0.30
Organic carbon (%)	0.32	0.34
Available Nitrogen (kg N ha ⁻¹)	223.0	238.4
Available phosphorus (kg P ₂ O ₅ ha ⁻¹)	28.6	27.7
Available potassium (kg K ₂ O ha ⁻¹)	252.9	260.4

As regards to net returns and B: C ratio, the response of varieties in relation to seed rates was almost similar. The highest net returns (31, 635 ha⁻¹) and B: C ratio of 2.34 was found with Narayani variety at higher seed rate of 150 kg ha⁻¹. But the net returns and B: C ratio due to Narayani variety at seed rates of both 150 and 125 kg ha⁻¹ were statistically at par. Therefore, for realizing maximum pod yields, Narayani variety with a seed rate range of 125-150 kg ha⁻¹ may be adopted in sandy loam soils of Southern Telangana zone, Andhra Pradesh.

4.5 Soil Analysis

Initial and final analysis of soil (Table 4.18) revealed that pH of soil remained neutral (7.1) and EC slightly increased when compared to the initial value. The P and K status of soil was not much changed however the nitrogen content was slightly increased as groundnut is a leguminous crop.

4.6 Regression Based on Seed Rates for Predicting Maximum Pod Yield and Economic Optimum Level of Tested Varieties.

Linear regression coefficients are calculated for predicting maximum pod yield and economic optimum of groundnut varieties using the linear regression equation *i.e.* $Y = a + bx$ and were presented in Figures 4.7, 4.8, 4.9 and 4.10. Pod yield, gross returns and net returns of groundnut varieties *i.e.* Narayani, ICGV 91114, K 6 and JCG 88 were significantly ($p=0.05$) and positively correlated to seed rate up to 150 kg ha⁻¹. However, economic optimum cannot be fixed within the tested level of seed rates. Hence there is need to study the effect of higher levels of seed rate on groundnut varieties for predicting maximum yield and economic optimum level.



Plate 4.1. Indeterminate growth habit of JCG 88 at 90 DAS of crop.

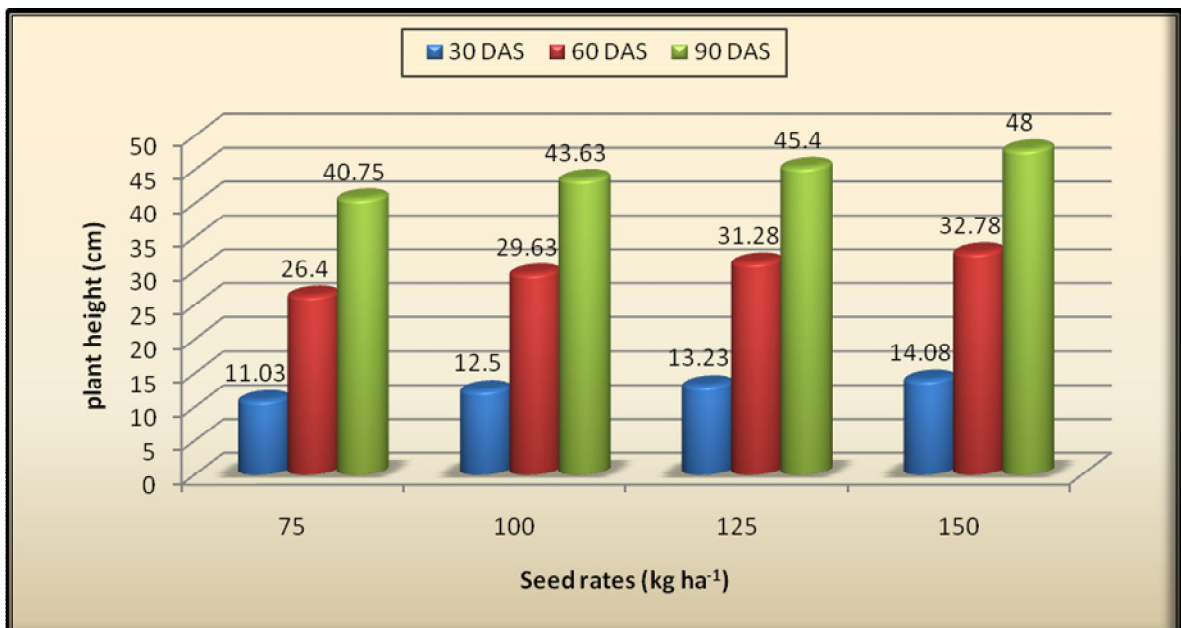
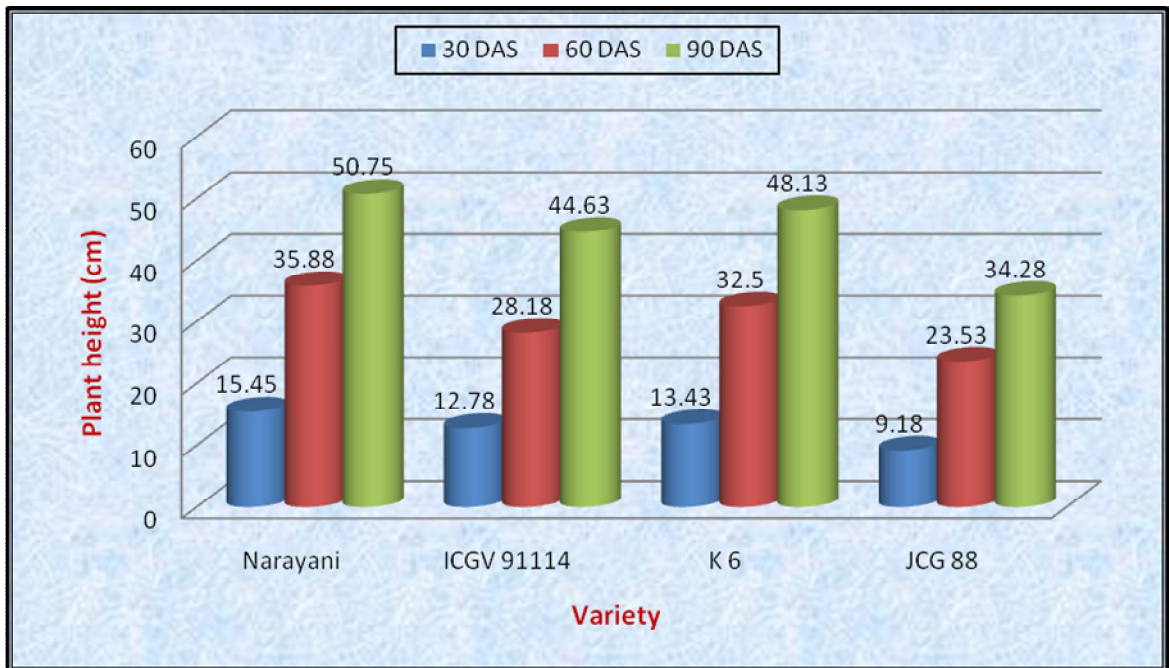


Figure 4.2. Plant height (cm) of groundnut as influenced by varieties and seed rates at different stages of crop growth.

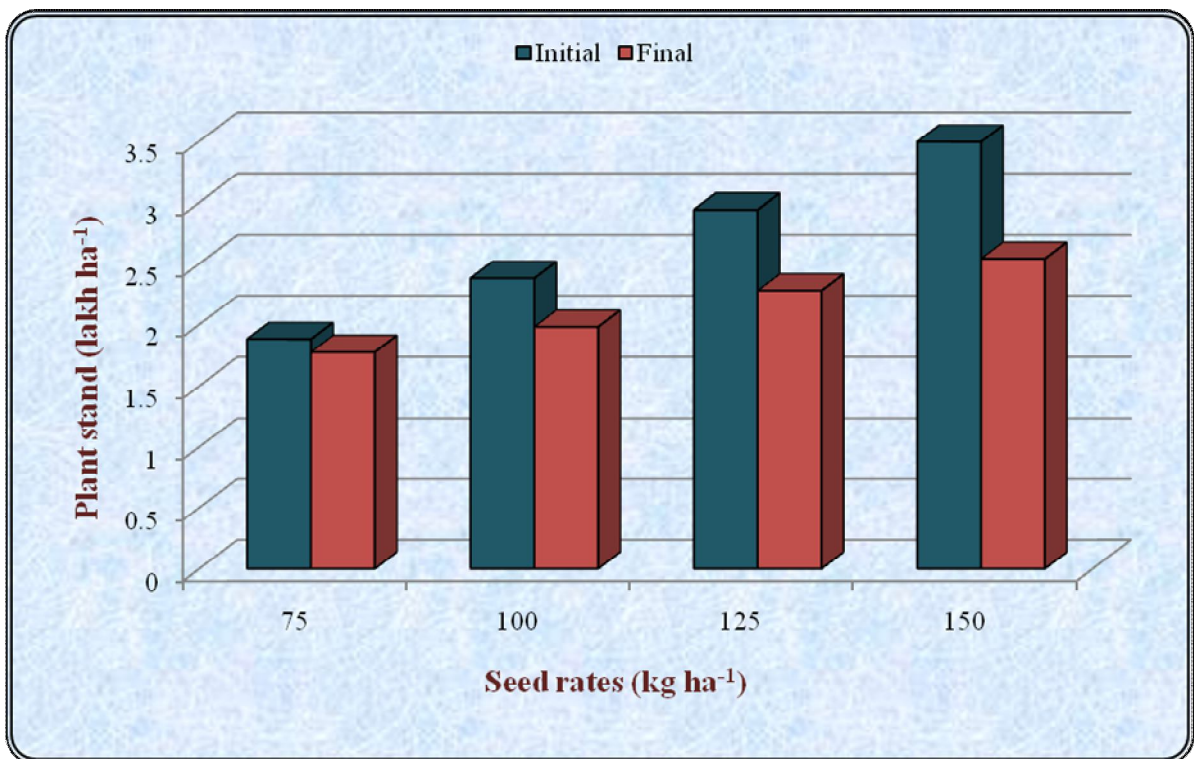
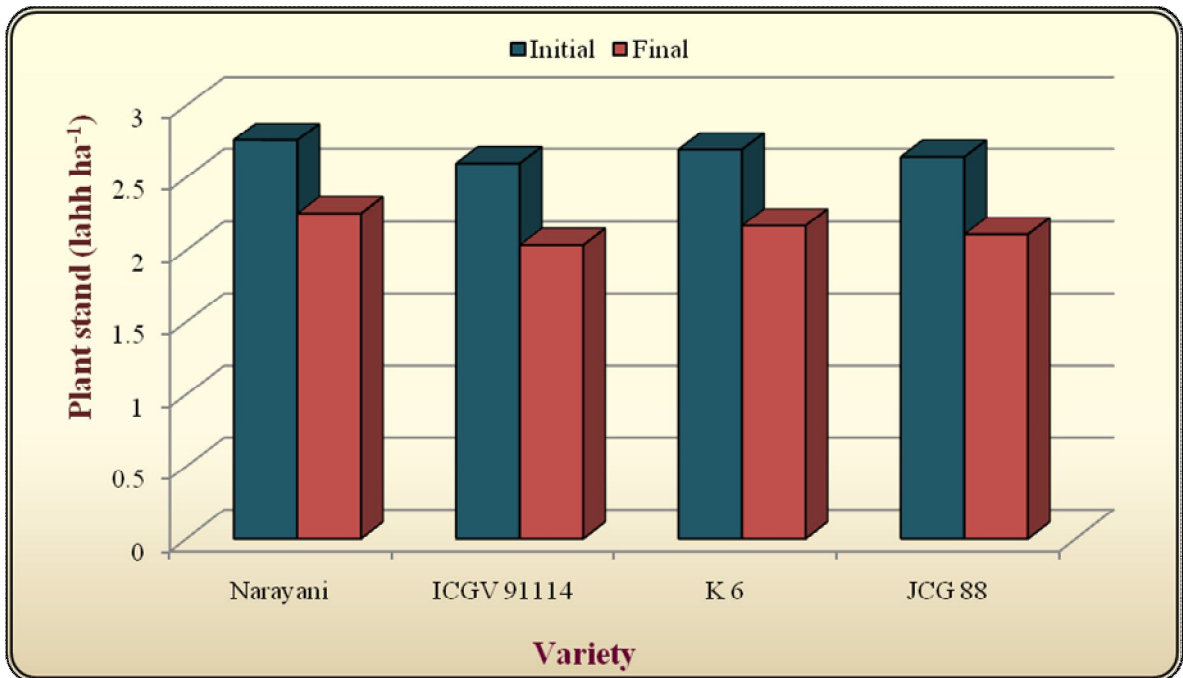


Figure 4.1. Initial and final plant stand (lakh ha⁻¹) of groundnut as influenced by varieties and seed rates.

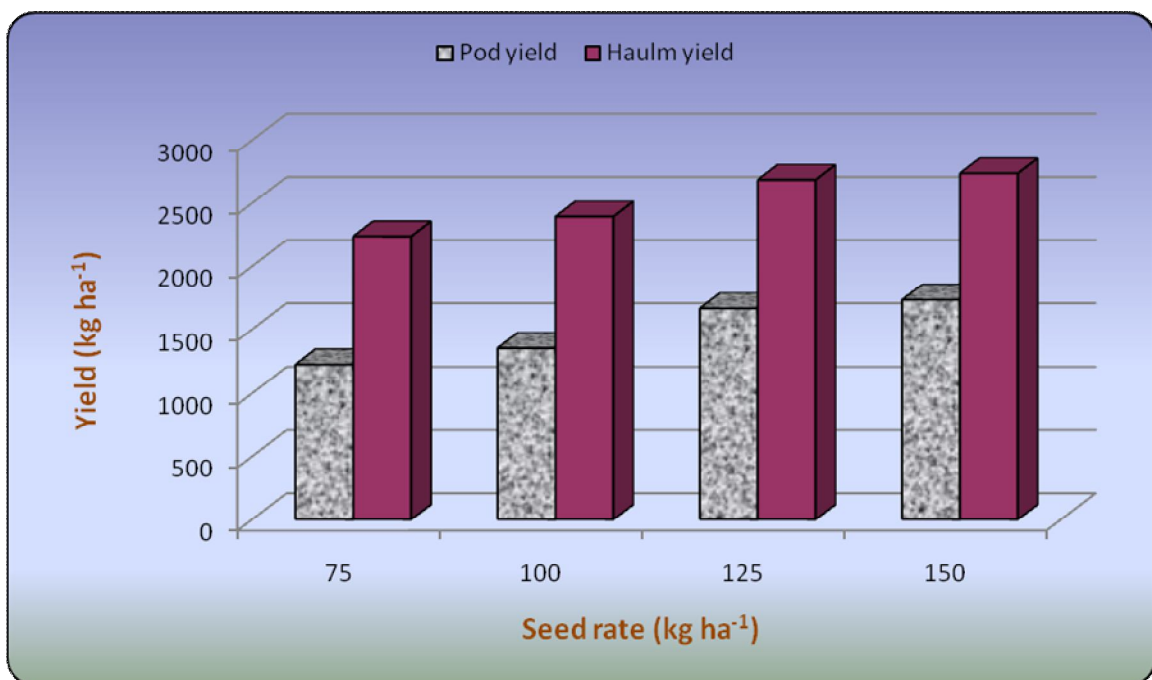
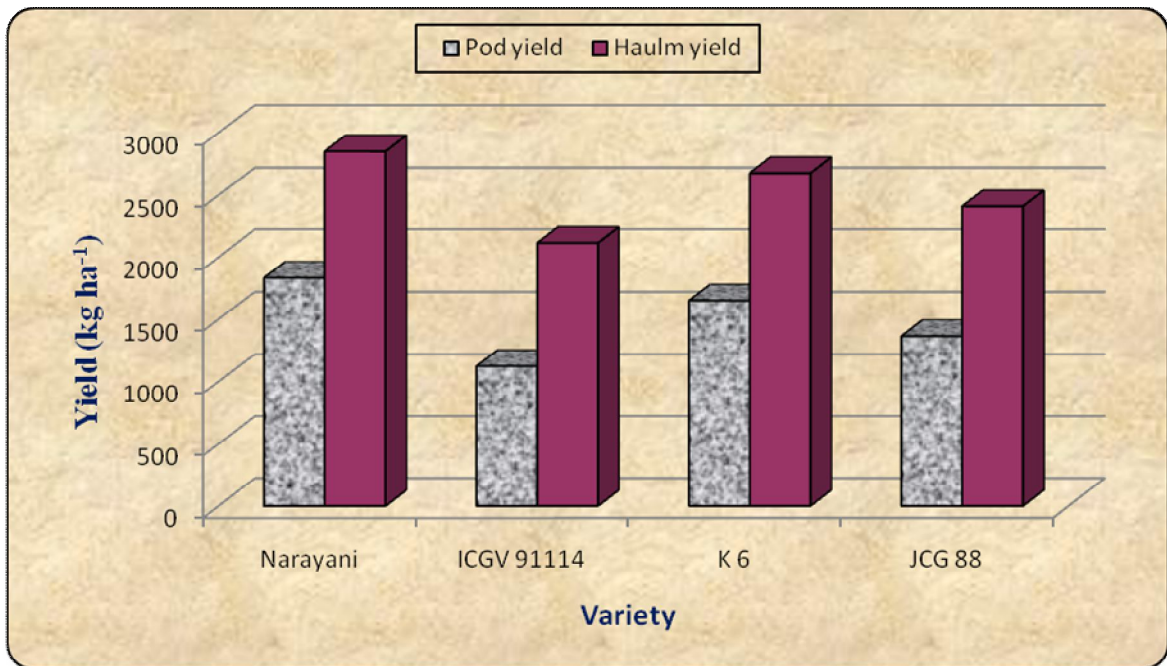


Figure 4.5. Pod yield and haulm yield (kg ha⁻¹) of groundnut as influenced by varieties and seed rates.

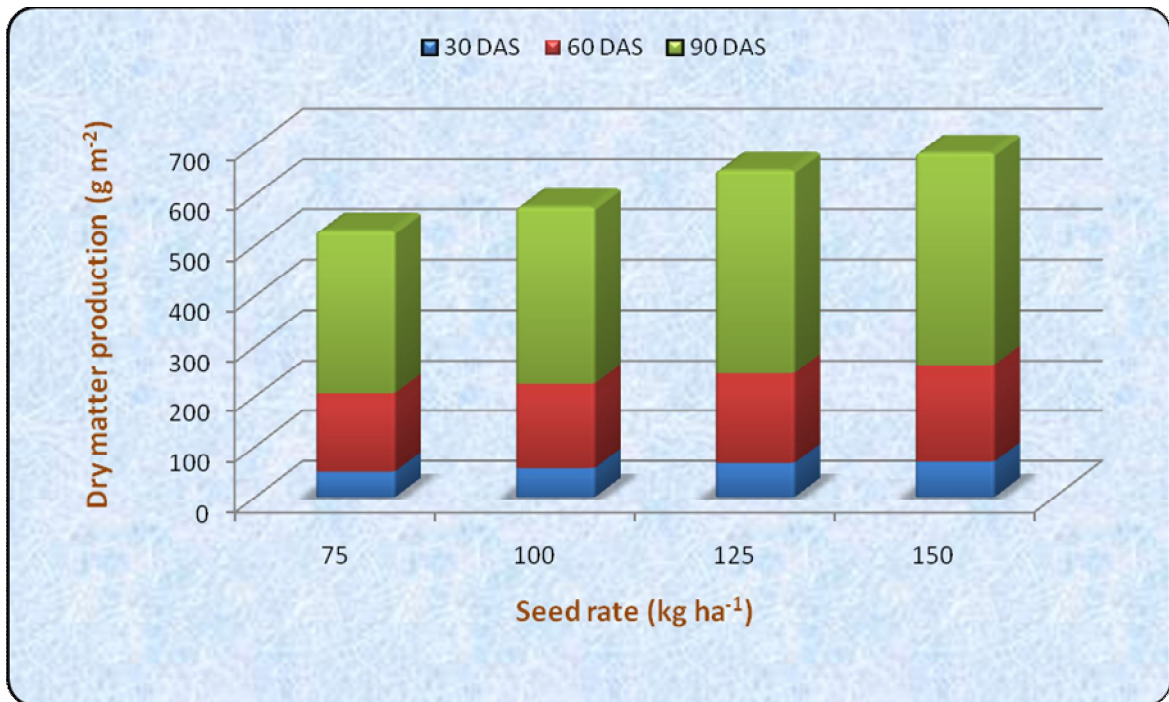
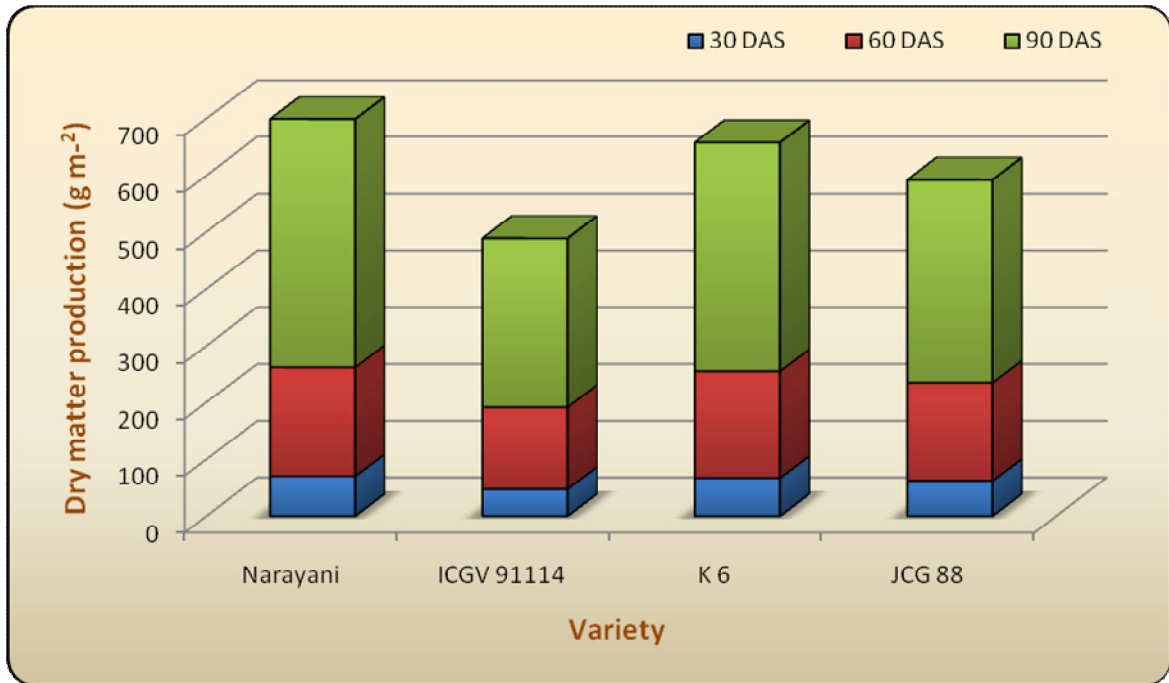


Figure 4.3. Total dry matter (g m⁻²) of groundnut as influenced by varieties and seed rates at different stages of crop growth.

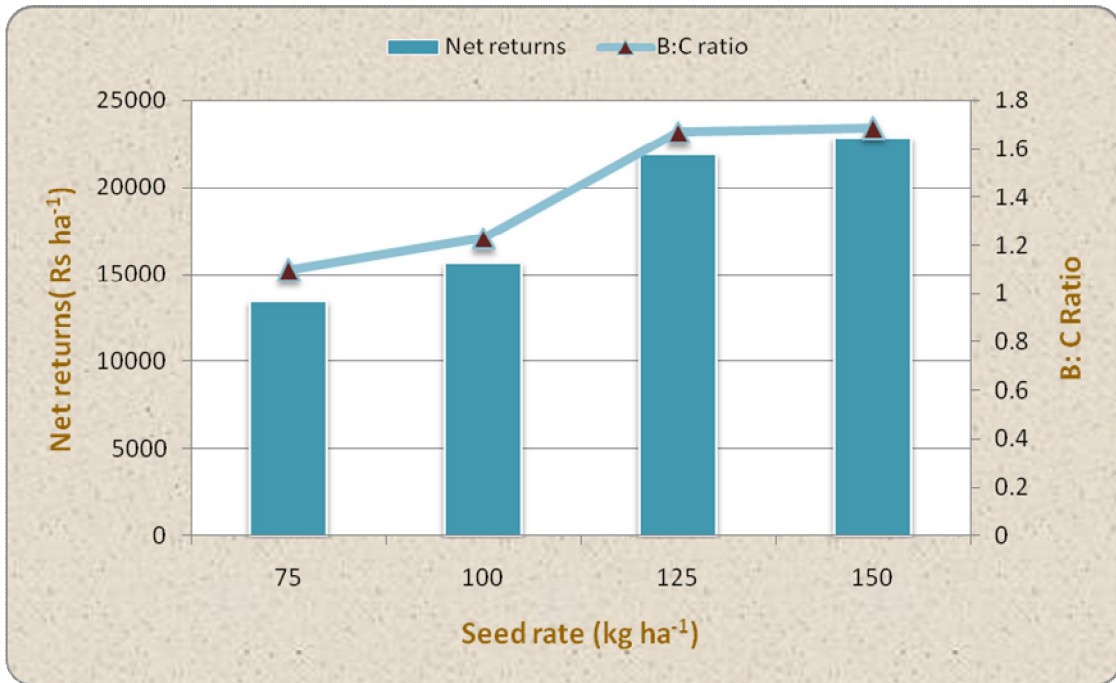
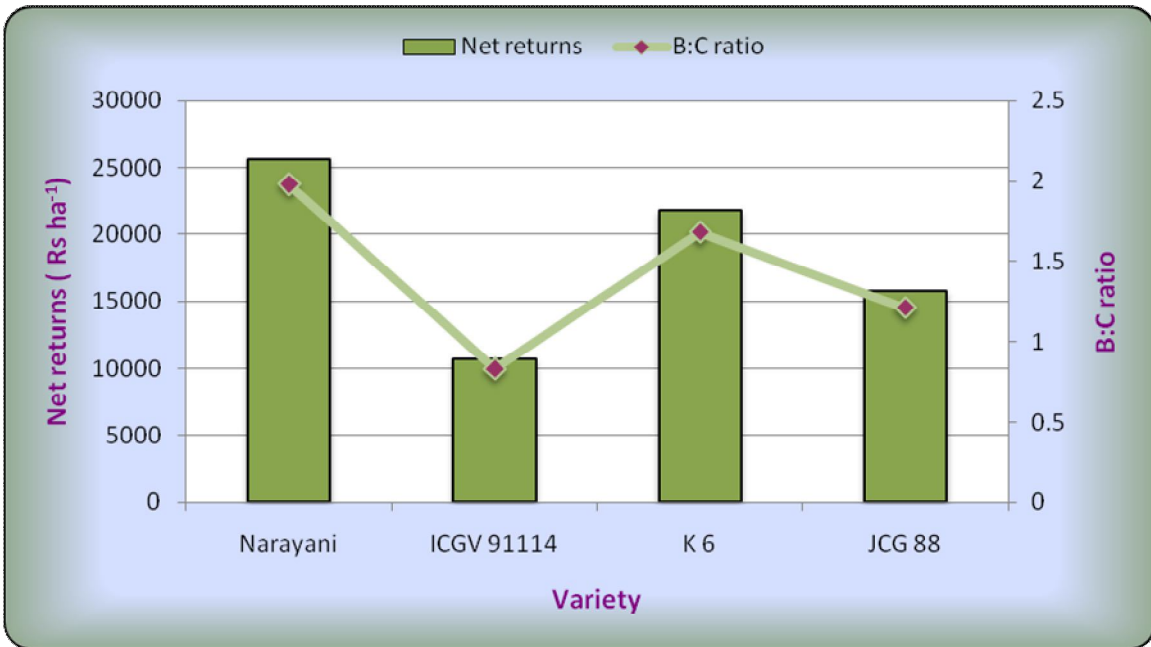


Figure 4.6. Net returns (Rs ha⁻¹) and B: C ratio of groundnut as influenced by varieties and seed rates.

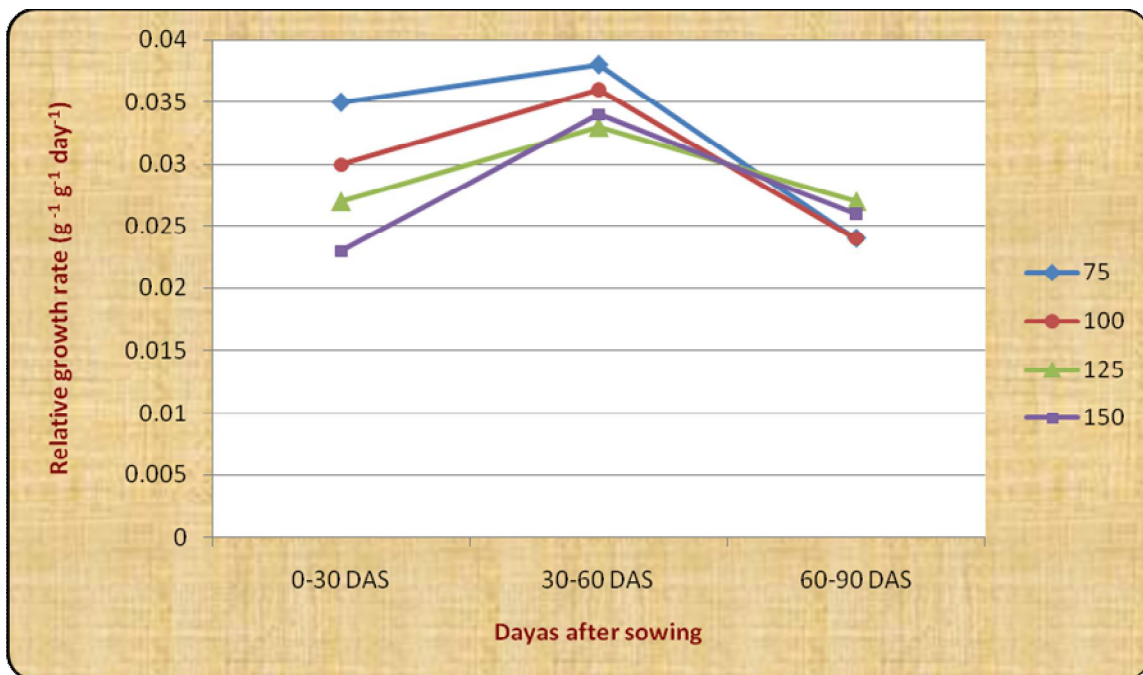
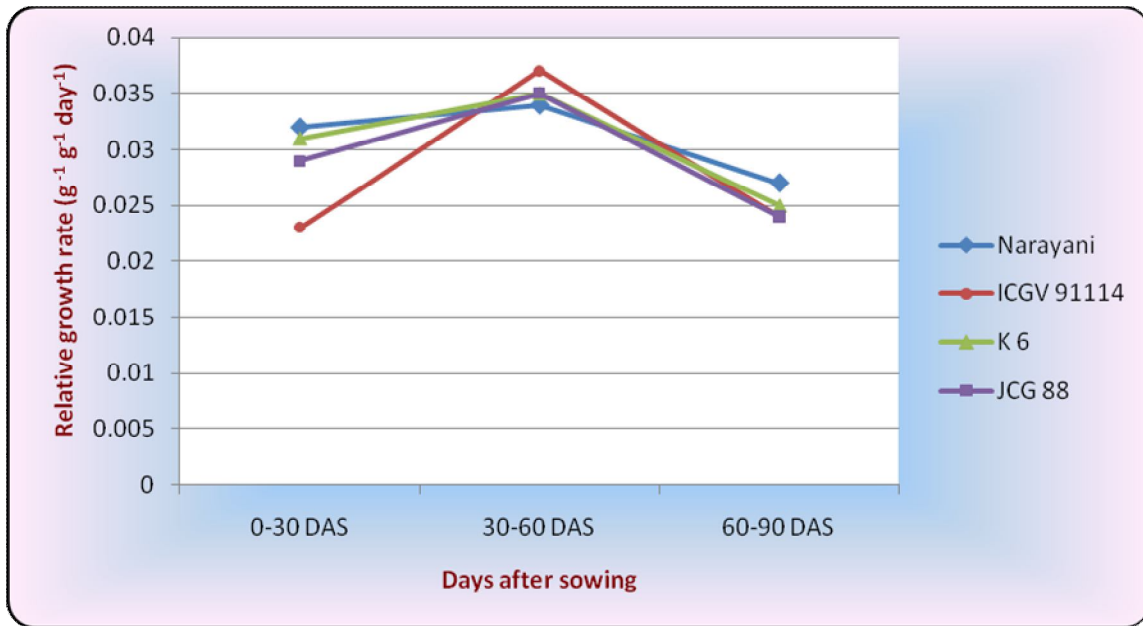


Figure 4.4. Relative growth rate (RGR) $g g^{-1} day^{-1}$ of groundnut as influenced by varieties and seed rates at different stages of crop growth.

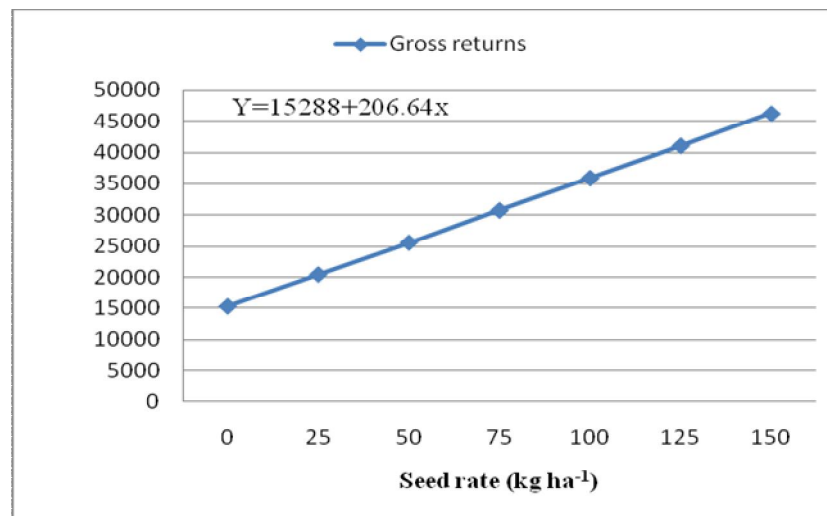
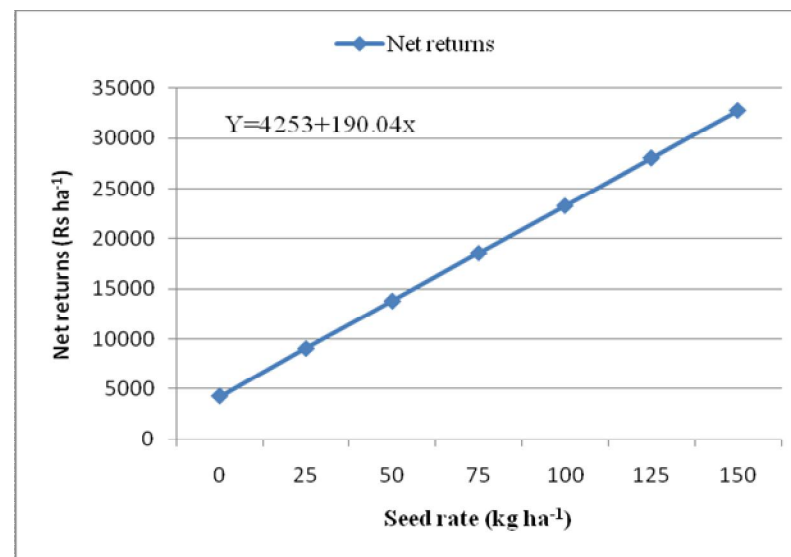
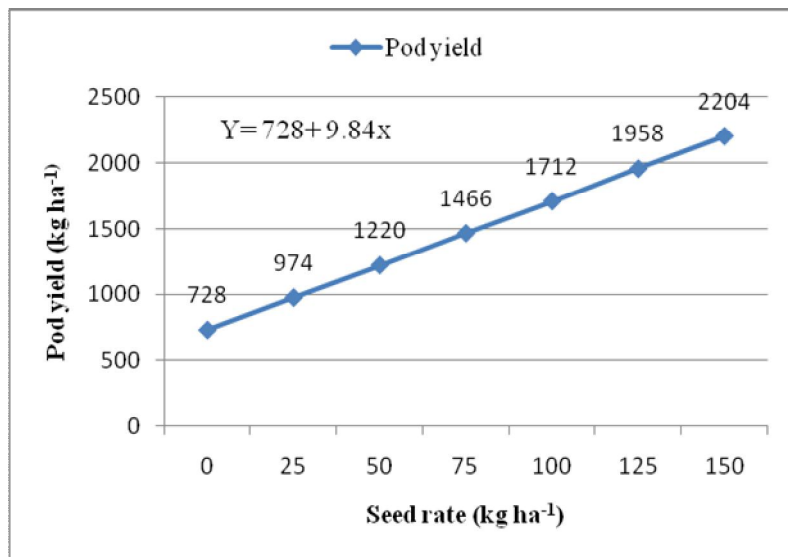


Figure 4.7. Linear regression model representing effect of seed rate on pod yield, gross returns and net returns of groundnut variety Narayani.

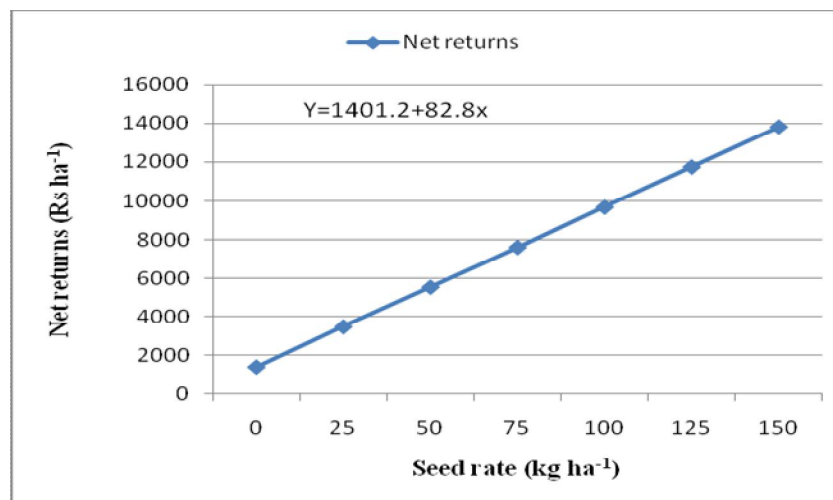
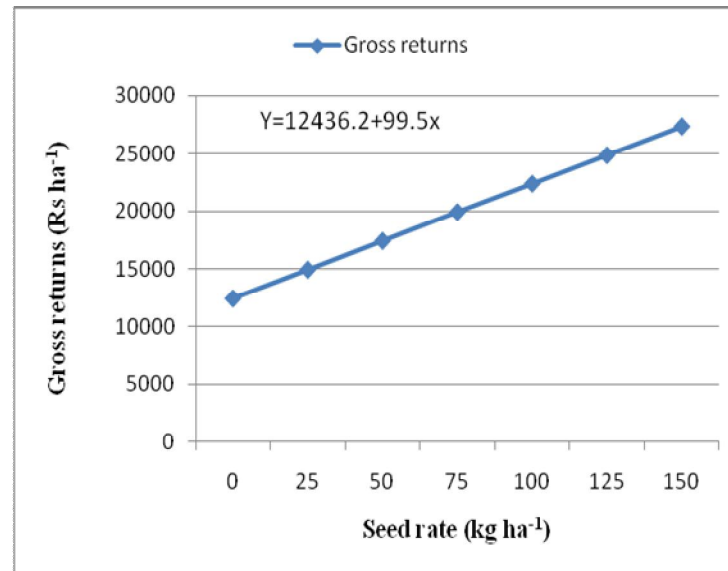
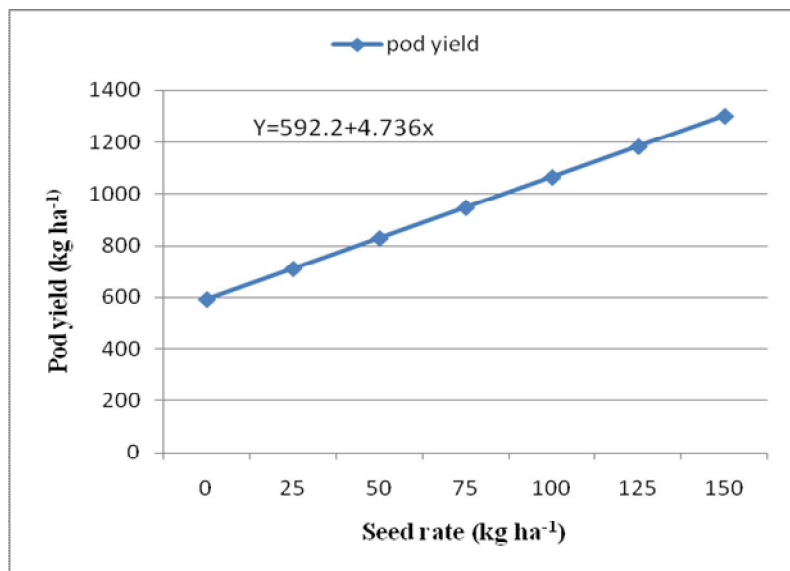


Figure 4.8. Linear regression model representing effect of seed rate on pod yield, gross returns and net returns of groundnut variety ICGV 91114.

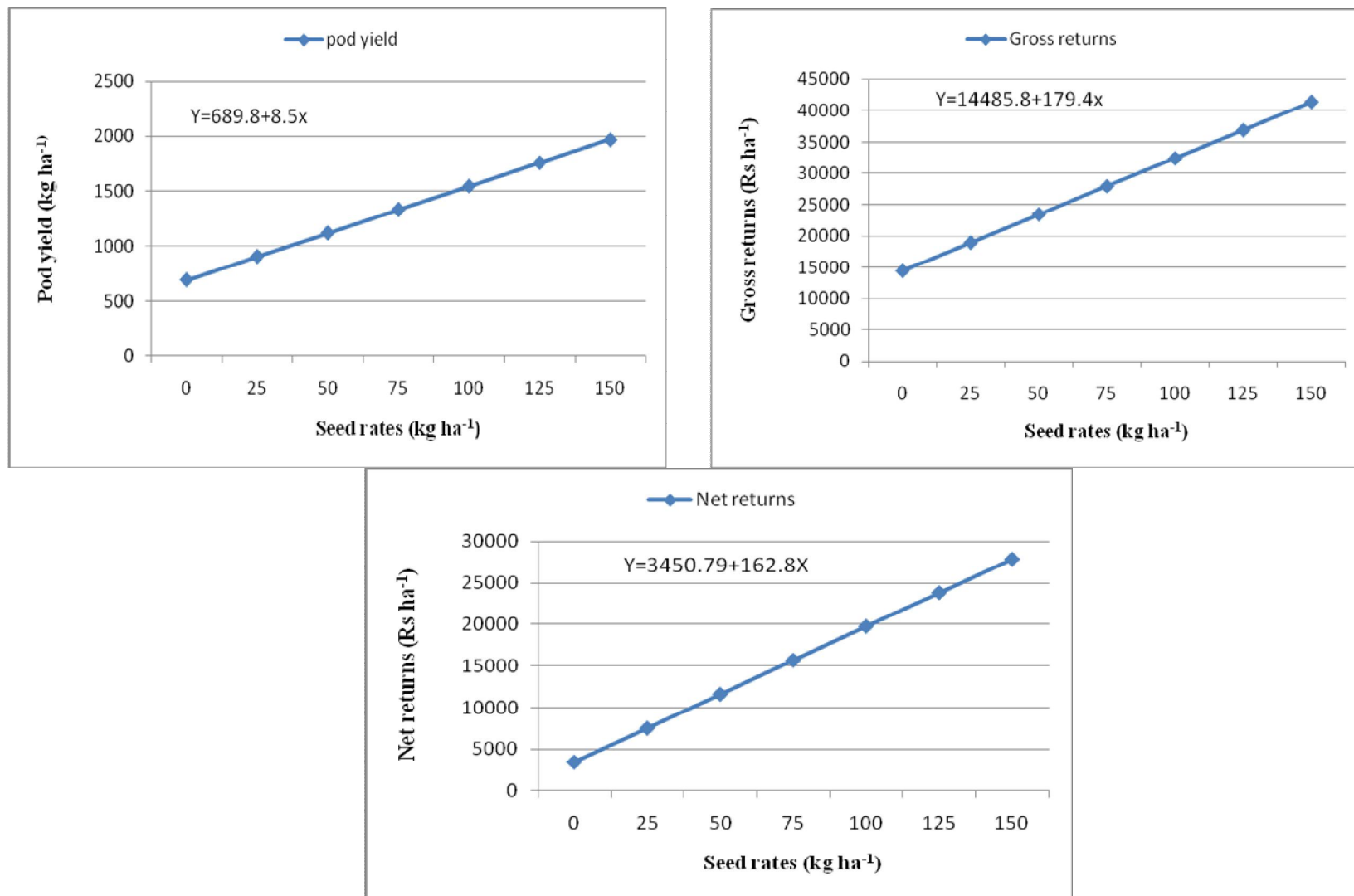


Figure 4.9. Linear regression model representing effect of seed rate on pod yield, gross returns and net returns of groundnut variety K 6.

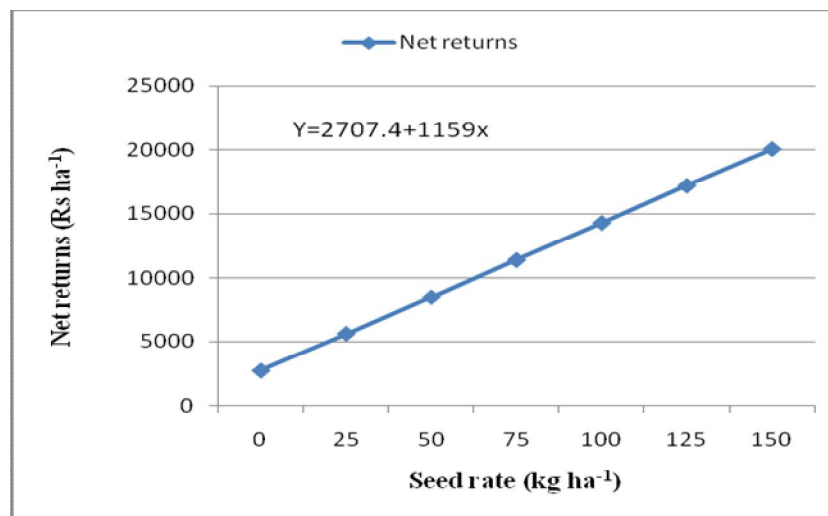
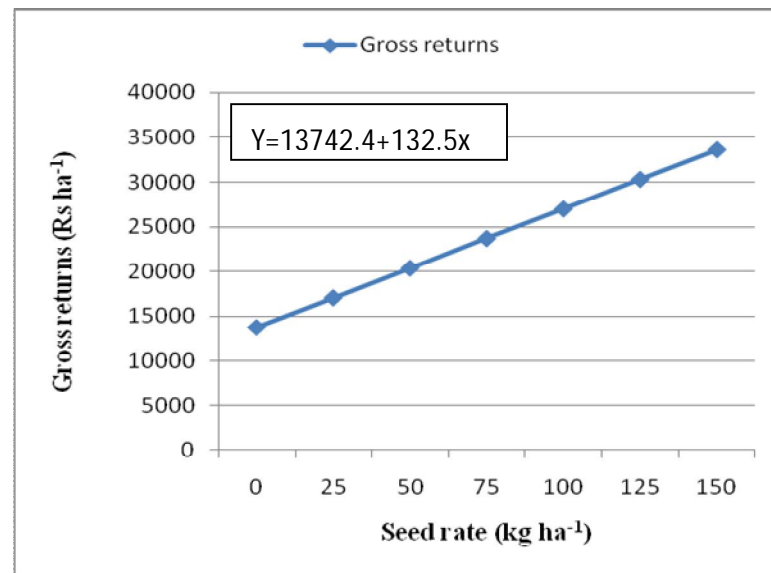
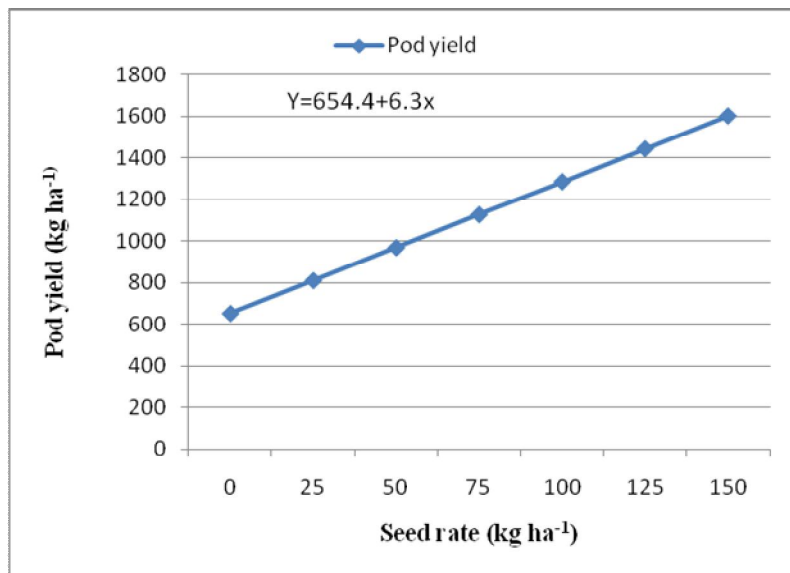


Figure 4.10. Linear regression model representing effect of seed rate on pod yield, gross returns and net returns of groundnut variety JCG 88.

4.17. Gross returns (Rs ha⁻¹), Net returns (Rs ha⁻¹) and Benefit-cost ratio of groundnut as influenced by varieties and seed rates

Treatment	Gross returns				Net returns				B: C ratio			
Variety												
V ₁ : Narayani	38535				25632.5				1.98			
V ₂ : ICGV 91114	23625				10722.5				0.83			
V ₃ : K 6	34671				21768.5				1.68			
V ₄ : JCG 88	28655				15752				1.21			
S.E.m ±	493.58				493.58				0.04			
CD (P=0.05)	1425.56				1425.56				0.11			
Seed Rates												
(kg ha⁻¹ kernel)												
S ₁ : 75	25709				13469.3				1.10			
S ₂ : 100	28403				15637.5				1.23			
S ₃ : 125	34981				21890.8				1.67			
S ₄ : 150	36393				22878				1.69			
S.E.m ±	493.58				493.58				0.04			
CD (P=0.05)	1425.56				1425.56				0.11			
Varieties x Seed Rates	S₁	S₂	S₃	S₄	S₁	S₂	S₃	S₄	S₁	S₂	S₃	S₄
V ₁ : Narayani	30240	35910	42840	45150	18000	23145	29750	31635	1.47	1.81	2.27	2.34
V ₂ : ICGV 91114	20286	21630	25200	27384	8046	8865	12110	13869	0.66	0.70	0.93	1.03
V ₃ : K 6	29106	30030	38220	41328	16866	17265	25130	27813	1.38	1.35	1.92	2.06
V ₄ : JCG 88	23205	26040	33663	31710	10965	13275	20573	18195	0.9	1.04	1.57	1.35
S.E.m ±	987.16				987.16				0.08			
CD (P=0.05)	2851.12				2851.12				0.22			

Chapter V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

A field experiment entitled “Standardization of seed rate for promising groundnut varieties under rainfed conditions of southern Telangana zone, Andhra Pradesh” was conducted on sandy clay loam soil at College Farm, College of Agriculture, Rajendranagar, Hyderabad to evaluate the performance of promising varieties of groundnut (V₁-Narayani, V₂-ICGV 91114, V₃- K 6 and V₄-JCG 88) and to standardize seed rate for promising groundnut varieties (S₁-75 kg ha⁻¹, S₂-100 kg ha⁻¹, S₃-125 kg ha⁻¹ and S₄-150 kg ha⁻¹) during *kharif* season under rainfed conditions of Southern Telangana climatic zone of Andhra Pradesh. The experiment was laid out in Factorial Randomized Block Design with three replications. The salient findings of the experiment are summarized here under.

The germination percentage at 10, 20 DAS and also seedling mortality of groundnut crop at 20 DAS were not varied due to varieties and seed rates.

There were no significant differences among varieties in respect of plant stand of crop at initial and final stages of crop. However, increased seed rate from 75 to 150 kg ha⁻¹ increased the plant population and maximum plant stand was recorded by 150 kg ha⁻¹ seed rate. Plant height of Narayani variety was significantly higher as compared to other varieties. Shorter plants were found with JCG 88. Plant height increased with every increase in seed rate from 75 to 150 kg ha⁻¹.

The LAI progressed up to 60 DAS and thereafter shown declined trend towards maturity. At 60 DAS, Narayani variety recorded significantly higher LAI compared to rest of the varieties and was followed by K 6, JCG 88 and ICGV 91114 respectively. At 90 DAS, JCG 88 recorded higher LAI due to indeterminate growth habit of plant. Minimum LAI was found with ICGV 91114 at all stages of crop growth. Increase in seed rate significantly increased LAI and maximum was observed at a seed rate of 150 kg ha⁻¹. Interaction between varieties and seed rates found significant at 30 and 60 DAS and indicated that maximum LAI was obtained with Narayani at a seed rate of 150 kg ha⁻¹. In JCG 88 variety, maximum LAI value was noticed at a seed rate of 125 kg ha⁻¹ and was at par with LAI obtained at seed rate of 150 kg ha⁻¹.

Maximum and minimum dry matter production was recorded by Narayani and ICGV 91114 varieties respectively at all stages of crop growth. There was an increase in dry

matter accumulation with every increase in seed rate from 75 to 150 kg ha⁻¹ and maximum was observed with seed rate of 150 kg ha⁻¹. Interaction between varieties and seed rates was found significant at 30 and 60 DAS. At 30 DAS, maximum dry matter was noticed with Narayani variety sown with 150 kg ha⁻¹ seed rate which was at par with 125 kg ha⁻¹. However at 60 DAS, significantly higher dry matter was recorded with Narayani at a seed rate of 150 kg ha⁻¹. Lowest dry matter was produced by JCG 88 at a seed rate of 75 and 100 kg ha⁻¹ which were comparable.

Maximum number of branches per plant were noticed with a short statured JCG 88 variety compared to rest of the varieties and it was followed by Narayani variety. As the seed rate increased from 75 to 150 kg ha⁻¹ number of branches per plant decreased.

The variety ICGV 91114 took minimum number of days to 50 % flowering and maturity and maximum days were taken by JCG 88. Number of days taken to 50 % flowering increased with decrease in seed rate from 150 to 75 kg ha⁻¹. Whereas days to maturity was not influenced by seed rates.

Number of pods (23.83) per plant were significantly higher with Narayani variety and was followed by K 6, JCG 88 and ICGV 91114 varieties. Total pods per plant decreased with increment in seed rate from 75 to 150 kg ha⁻¹ and were maximum at a seed rate of 75 kg ha⁻¹.

Seeds per pod were higher with K 6 and was at par with Narayani and JCG 88. Lower number of seeds per pod were recorded by ICGV 91114. The effect of seed rates and interaction between varieties and seed rates on number of seeds pod⁻¹ was found to be non significant.

Maximum 100 kernel weight (40.83 g) was recorded by ICGV 91114 and followed by JCG 88, K6 and Narayani. The 100 kernel weight with seed rate of 75, 100 and 125 kg ha⁻¹ was comparable and lower value was noticed with a seed rate of 150 kg ha⁻¹.

Shelling percentage was significantly higher with Narayani followed by K 6 variety. Shelling percentage of ICGV 91114 and JCG 88 was at par. Shelling percentage increased due to increase in seed rate from 75 to 150 kg ha⁻¹. However the shelling percentage with 125 and 150 kg ha⁻¹ were at par.

Significantly higher pod yield of 1835 kg ha⁻¹ was recorded by Narayani variety followed by K 6 (1651 kg ha⁻¹), JCG 88 (1365 kg ha⁻¹) and ICGV 91114 (1125 kg ha⁻¹). An increase in seed rate from 75 to 150 kg ha⁻¹, increased pod yield and Maximum (1733 kg ha⁻¹) pod yield was obtained with a seed rate of 150 kg ha⁻¹ which was at par with 125

kg ha⁻¹. Lowest pod yield of 1224 kg ha⁻¹ obtained with lower seed rate of 75 kg ha⁻¹. Interaction between varieties and seed rates revealed that the maximum pod yield of 2150 kg ha⁻¹ was found with Narayani variety at a seed rate of 150 kg ha⁻¹ which was at par with same variety at a seed rate of 125 kg ha⁻¹ which in turn was at par with K 6 at a seed rate of 150 kg ha⁻¹. Pod yield of all varieties except K 6 at seed rate of 125 and 150 kg ha⁻¹ was at par with higher pod yield at 150 kg ha⁻¹ but JCG 88 recorded highest pod yield at 125 kg ha⁻¹ and was at par with 150 kg ha⁻¹. Lower yields were obtained with ICGV 91114 variety at a seed rate of 75 and 100 kg ha⁻¹ which in turn were at par. Kernel yield also followed similar trend as that of pod yield.

Haulm yield obtained with Narayani variety was significantly high followed by K 6 and JCG 88 varieties. Lower haulm yield was noticed with ICGV 91114 variety. Among seed rates, haulm yield obtained at seed rate of 150 kg ha⁻¹ and 125 kg ha⁻¹ was on par and significantly superior to 100 kg ha⁻¹ and 75 kg ha⁻¹. Lower haulm yield was obtained with a seed rate of 75 kg ha⁻¹. Haulm yield was not influenced by interaction between varieties and seed rates.

Maximum harvest index obtained with Narayani and was comparable with K 6 variety. Among the seed rates, higher harvest index was noticed with a seed rate of 150 kg ha⁻¹ and was comparable with seed rate of 125 kg ha⁻¹.

Oil content was higher in JCG 88 variety which was at par with K 6, Narayani which in turn were superior to ICGV 91114. The effect of seed rates on oil content was non significant.

Significantly higher oil yield was recorded by Narayani (653.01 kg ha⁻¹) followed by K 6 variety. Lower oil yield of 362.33 kg ha⁻¹ was recorded by ICGV 91114 variety. Maximum oil yield was obtained with seed rate of 150 kg ha⁻¹ which was at par with seed rate of 125 kg ha⁻¹.

Maximum Gross returns (Rs. 38535 ha⁻¹), Net returns (Rs.25632 ha⁻¹) and benefit-cost ratio (1.98) were obtained with Narayani variety. Among seed rates, maximum gross returns, net returns were with 150 kg ha⁻¹ but B: C ratio with 125 and 150 kg ha⁻¹ seed rates were comparable. The interaction between varieties and seed rates revealed that gross returns and B: C ratio were higher with Narayani variety at 150 kg ha⁻¹ seed rate and was on par with same variety at seed rate of 125 kg ha⁻¹ which in turn was on par with K 6 at seed rate of 150 kg ha⁻¹. In case of net returns maximum were obtained with Narayani variety at a seed rate of 150 kg ha⁻¹ and then by same variety at the seed rate of 125 kg ha⁻¹.

Pod yield, gross returns and net returns of groundnut varieties *i.e.* Narayani, ICGV 91114, K 6 and JCG 88 were significantly ($p=0.05$) and positively correlated to seed rate up to 150 kg ha^{-1} . However, economic optimum cannot be fixed within the tested level of seed rates.

The results suggest that for obtaining maximum pod yields and economic returns, cultivation of the variety Narayani with a seed rate of 125 kg ha^{-1} would be advisable under rainfed conditions of Southern Telangana zone, Andhra Pradesh.

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* Original not seen

The pattern of 'Literature cited' presented above is in accordance with the 'Guidelines' for thesis presentation for Acharya N.G. Ranga Agricultural University, Hyderabad.

Appendices

Appendix A

Schedule of cultural operations

Date	Operations
11-07-2010	Ploughing with disc plough
13-07-2010	Ploughing with disc harrow
14-07-2010	Levelling
15-07-2010	Latout of experiment
16-07-2010	Presowing irrigation
17-07-2010	Sowing and fertilizer application
31-07-2010	Weeding and hoeing
14-08-2010	Hand weeding
16-08-2010	Top dressing of nitrogen (10 kg N ha ⁻¹), gypsum application
20-08-2010	Spraying of Monocrotophos + Dithane M-45
30-09-2010	Hand weeding
5-09-2010	Spraying of Dithane M-45 for leaf spot control
20-10-2010	Harvesting of ICGV 91114 variety
21-10-2010	Stripping of ICGV 91114 variety
28-10-2010	Harvesting of Narayani and K 6 varieties
29-10-2010	Stipping of Narayani and K 6 varieties
5-11-2010	Harvesting of JCG 88 variety
6-11-2010	Stripping of JCG 88 variety

APPENDIX B

Cost of cultivation (Rs ha⁻¹) of groundnut at different seed rates

Operations	75	100	125	150
Land preparation	900	900	900	900
Fertilizer cost	800	800	800	800
Seed cost	1875	2500	3125	3750
Pre sowing irrigation	200	200	200	200
Sowing	1500	1500	1500	1500
Weeding	3625	3525	3225	3025
Plant protection	600	600	600	600
Harvesting	2740	2740	2740	2740
Total	12240	12765	13090	13515

*Cost of cultivation of groundnut did not varied due to varieties