Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols

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(AGRONOMY)

By

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2008

CERTIFICATE – I

This is to certify that the work entitled **"Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols"** *submitted in partial fulfillment of the requirement for the degree of* **MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* **Mr. MUKESH VERMA,** *I.D.No. AP/IN - 37/2002, under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee and the Director of Instruction.*

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

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CERTIFICATE – II

This is to certified that the thesis entitled "**Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols**" *submitted by* **Mr. MUKESH VERMA,** *I.D. No. AP / IN- 37/2002 to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of* **Master of Science in Agriculture** *in the Department of* **Agronomy** *has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination of the same.*

Place – Indore

Date 07/01/2009

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(MUKESH VERMA)

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ABBREVIATION

S.No.	Legends	Description
1	ANOVA	Analysis of variance
2	AICRP	All India Co-ordinated Research Project
3	Av	Average
4	BBF	Broad-bed and furrow
5	B:C	Benefit cost ratio
6	BBM	Broad bed maker
7	CD	Critical difference
8	CGR	Crop growth rate
9	CPE	Cumulative pan evaporation
10	Cm	Centimeter
11	Cv	Co variance
12	CSRP	Cropping system research project
13	^0C	Degree Celsius
14	df	Degree of freedom
15	DMA	Dry matter accumulation
16	DAS	Days after sowing
17	DSm^{-1}	Desi siemens per meter
18	Ec	Electrical conductivity
19	EMS	Error means sum of square
20	E-W	East-west
21	*et al.*	Alied (and other)
22	FBS	Flat bed system
23	FYM	Farmyard manure
24	g	Gram
25	GDP	Gross domestic product
26	ha^{-1}	Per hectare
27	HI	Harvest index
28	i.e.	That is (inference to)
29	IWD	Irrigation water depth
30	J.N.K.V.V.	Jawaharlal Nehru Krishi Vishwa Vidyalaya
31	Kg	Kilogram
32	LAI	Leaf area index
33	M.P.	Madhya Pradesh
34	Max.	Maximum
35	Min.	Minimum
36	mm	Millimeter
37	m	Meter
38	Mss	Mean sum of square
39	MSL	Mean sea level
40	Mt	Metric tones
41	ml	Mili litre
42	M.	Million
43	No.	Number

44	NPK	Nitrogen, Phosphorus, Potassium
45	NAR	Net assimilation rate
46	NS	Non significant
47	OST	Optimum sowing time
48	q	Quintal
49	RGR	Relative growth rate
50	RS	Row spacing
51	RSBS	Ridge sunken bed system
52	RFS	Ridge and furrow system
53	RDS	Recommended seed rate
54	RH.	Relative humidity
55	Rs.	Rupees
56	&	And
57	SPD	Split plot design
58	SEm±	Standard error of mean
59	SMW	Standard meterological week
60	Sq.m.	Square meter
61	SS	Sum of square
62	S.V.	Source of variance
63	S	Seed rate
64	$t\ ha^{-1}$	Tons per hectare
65	$(T \times S)_1$	Difference between any two seed rate means at the same land configurations.
66	$(T \times S)_2$	Difference between any two land configuration means at the same or different seed rates.
67	Viz	Wide list
68	wt	Weight
69	WU	Water use
70	WUE	Water use efficiency
71	@	At the rate of
72	%	Percentage
73	r	Replication
74	*	Significant at 5 % level

Chapter-1

Introduction

CHAPTER – 1

INTRODUCTION

Suitability of soil as a medium for plant growth depends upon the presence and quality of chemical nutrients and on the absence of toxicity along with state and mobility of water and air, mechanical attributes and thermal regime, known as physical edaphic factors. The physical edaphology provides us knowledge about the relationship between physical edaphic factors and plant growth. However, the practical aspects of physical edaphology involve the knowledge of the management practices to modify these factors for favourable plant growth. The soil must be sufficiently loose to permit the germination of seed, and shoot and root development of plants without obstruction. The pores of the soil should be of the volume and size distribution that will allow sufficient entry, movement and retention of both water and air to meet plant needs. All the physical parameters affecting seedling emergence, root growth and crop growth, *viz.*, soil wetness, aeration, temperature and penetration resistance are affected by land management.

Most of the cultivated area in Madhya Pradesh is considered as rainfed area therefore soybean grown mainly as rainfed crop (Garg,1985) and account 70 % of area and 55% of productivity in the country. The average productivity of soybean has been fluctuating around 1.0±0.1 t ha^{-1} (Tomar, 2000) for last few years against potential productivity of about 2 to 2.5 t ha^{-1} even under rainfed conditions.

Research evidences have indicated promise to maintain the productivity of different cropping system by modifying the tillage and planting systems (Parihar, 2004, Kumar *et al.*, 2004, Yadav *et al.,* 2005). The bed planting system has become very popular in Mexico (Sayre and Ramos, 1997).

Generally in flatter terrain Vertisols of Malwa region at present extensively flat-land cultivation system is more popular in cultivation of *Kharif* crop like soybean, which faces the problem of water logging and poor aeration thereby affecting crop productivity adversely. The small changes through land configuration in flat field conditions may help in improving the productivity of Vertisols of Malwa region. Using light machinery like bund former and *desi hal* with minor modifications may improve the physical conditions and drain ability. It is assumed that land treatments will help to improve the physical conditions, root development and over all productivity in Vertisols.

Madhya Pradesh is endowed with well distributed rains ranging from 700 to 1200 mm. Vertisols with good moisture holding capacity can be used to grow short-duration soybean by adopting sound land management practices such as broad bed and furrow system, Ridge and furrow system otherwise about 2.02 m ha accounting for 6.57% of the total area of the state were under fallow. The adoption of proper land configuration system will help increase income to the farmers besides preventing land degradation due to runoff erosion (Dwivedi *et al.,* 2002).

Apart from soil related properties, the seed rate also played a crucial roll in optimizing crop productivity. Shrinking seed size is resulting in over seed rate / plant population and is resulting into excessive plant growth, more biotic stresses and reduced crop productivity, therefore, it is hypothesized that reduced seed rate may help in improvement of crop productivity. With this background the study was carried out with the following objectives:

1. To study the effect of land configuration on growth, yield attributes and yield of soybean.
2. To find out suitable seed rate for proper growth and yield of soybean.
3. To workout the economics as influenced by different treatments.

Chapter-2
Review of Literature

CHAPTER – 2

REVIEW OF LITERATURE

Soil physical conditions in relation to plant growth and adequate seed rate / plant population are the two most important practices which affect crop growth and productivity tremendously. Number of workers have evaluated the effect of these factors on crop growth and productivity. The finding of the previous workers have been briefly reviewed and presented in this chapter under the following heads.

1. Land configurations and crop growth and productivity.
2. Seed rates in relation to crop growth and productivity.

2.1. Land configurations and crop growth and productivity:

Lochaiyukul and Ferraris (1970) reported that sowing on 75 cm ridges increased seed yield by 300-400 % compared with plants on flat or corrugated soil in sesame.

Khan and Agarwal (1985) reported that ridge-and-furrow sowing was significantly superior to conventional flat sowing in increasing plant height, number of branches plant^{-1}, dry weight of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight and seed yield of *Brassica juncea.*

Halepyati *et al.*, (1987) in a trial in the *kharif* (monsoon) season of 1984, evaluated the performance of pigeonpea as an intercrop with sorghum under ridge and furrow system and flat bed of planting. Pigeonpea sown on 22 June and 24 July under 2 systems of seedbed preparation gave average seed yields of 0.86 and 0.59 t ha^{-1} and had a 100-seed wt of 17.0 and 14.6 g, respectively. The yields on a flat seedbed and under the ridge/furrow system were 0.68 and 0.77 t^{-1} and the 100-seed wt was 14.85 and 16.75 g, respectively.

Patil *et al.,* (1991) reported that *in situ* soil moisture conservation agro-techniques (vertical mulch (trenches 30 cm wide and 30 cm deep filled with *jowar* stubbles and covered with soil, at 4 m horizontal intervals); live bunds (green gram in thick strips); broad bed and furrow system (150 cm ridge with tropiculator) and ridge and furrows) gave average sorghum grain yield of 2.03-2.31 t and pigeon pea seed yields of 0.24-0.29 t ha^{-1} compared with corresponding yield of 2.01 and 0.23 t on flat seed bed. The vertical mulch treatment was the most effective followed by broad bed and furrow treatment.

Gupta and Sharma (1993) reported that an array of raised (8m width) and sunken (4m width) beds with an elevation difference of 20 cm was the most effective configuration for providing surface drainage and arresting runoff. It also increased deep percolation and moisture availability during the dry season. Soybean seed yields were comparable with the traditional flat bed system.

Kumar *et al.*, (1993) reported that ridge and furrow + straw mulch was the most efficient moisture conservation treatment resulting in maximum increase in *bajra* productivity over flat bed sowing.

Lawand *et al.*, (1993) reported that cowpea yield was lowest with sowing in flat beds, was about 2.8 t in standard ridge-furrow method and was highest (5.01 t) when seeds were sown in the center of the furrows and the ridges modified after about a month such that the plant stems were placed in the center of the ridges.

Subbaraj *et al.*, (1993) conducted a field experiments in 1988 in Madurai on an Alfisol, maize *cv.* Co 1 was grown under broad bed furrow, compartmental bunding or ridge and furrow cultivation and given 40 kg N ha^{-1} in a single or 2 or 3 applications. Grain and stover yields were highest with sowing in ridges and furrows and 40 kg N ha^{-1} applied in 3 equal splits at sowing, 30 and 45 days after sowing.

Ugale *et al.*, (1995) reported that grain and fodder yield were higher in furrow and ridge method as compared to flat bed in pearl millet.

Jayapaul *et al.*, (1996) reported that seed yield of soybean was highest when sown in broad bed followed by ridges and least in flat bed.

Tomar *et al.*, (1996) reported that maximum average seed yield of soybean was recorded in 6 m wide raised bed followed by 9 m raised bed and minimum in flat plots. Beside providing adequate surface drainage to soybean crop, the land configurations were also useful during prolonged dry spell thereby, minimizing any adverse effect of soil moisture stress at flowering and seed development stages of rainy season crops.

Bejiga *et al.*, (1997) reported that there was no significant differences among the mean seed yields of chickpea under different seed bed types (ridge and furrow, broad bed furrow and flatbed).

Rajashekhar and Reddy (1997) reported that seed yield in sunflower was lowest with basin irrigation and highest with irrigation to broad beds and furrows.

Rao *et al.,* (1997) discussed various agronomic and engineering soil management measures used for soil and water conservation in the semiarid tropics including tillage, organic and inorganic amendments, cropping systems, land smoothing, land surface configuration and drainage systems.

Sayre and Ramos (1997) reported that following crops planted on raised bed gave higher grain yield: maize (37.4%), uradbean (33.6%), mungbean (21.8%), green peas (14.5%), wheat (6.4%), rice (6.2%), pigeon pea (46.7%) and gram (37.0%) as compared to flat planting.

Shivkumar *et al.,* (1997) reported that grain yield of greengram, wheat and soybean was higher when sown on broad beds with furrows compared to flat bed sowing.

Chavan *et al.,* (1999) reported that the sowing of groundnut and soybean on broad beds and furrows gave higher yield than ridges and furrows and flat bed sowing.

Ingle *et al.,* (1999) conducted a trial at Nagpur, Maharashtra, India in *kharif* (monsoon) 1997 with soybean *cv.* JS 80-21 and reported that the mean seed yields of 1.58, 1.70 and 1.84 t ha^{-1} were obtained when sown on flat beds, broad beds and furrows, and ridges and furrows, respectively.

Selvaraju *et al.,* (1999) investigated the land configuration effect on sorghum. The land configurations treatments were flat bed, open ridging and tied ridging. Tied ridges stored 14% more soil water and produced

14% and 11% higher grain and straw yields, respectively, than did flat beds.

Desai *et al.,* (2000) reported significant effect of different land configurations on grain yield of pigeon pea. Providing 1 furrow after 4 rows of pigeon pea recorded the highest grain yield (2.65 t ha^{-1}), which was significantly superior to the flat bed and ridge and furrow systems. Economic analysis showed that the highest net return (Rs 33780 ha^{-1}) and benefit:cost ratio (3.92) were recorded for the treatment involving 1 furrow after 4 rows.

Raut *et al.,* (2000) studied different sowing methods in soybean flat bed; raised beds (1, 2, 3 and 4 rows), and ridges (one row top, one and two rows)] and reported significant differences among the different sowing methods for the number of pods $plant^{-1}$ and seed yield. The differences for the plant height and 100 seed weight were not significant. A significantly higher number of pods $plant^{-1}$ was recorded from the raised bed sowing with one row. Pod numbers in the flat bed method, raised bed method with 3 and 4 rows and ridges with 2 rows on both sides were at par with each other and were lower than those in other methods. The highest seed yield average (3347 kg ha^{-1}) was recorded from ridges method with 2 rows on both sides.

Shivkumar and Mishra (2001) noticed no difference in grain yield due to broad bed and furrow sowing compared to flat bed sowing inspite of higher growth and yield attributes.

Bahale *et al.,* (2001) reported that different land configurations did not had any significant impact on grain yield of sesame. However, opening of furrow after every 12 rows produced higher seed yields (10.80 and 5.90%) and recorded the highest benefit:cost ratio (4.26) than the conventional flat bed method and opening of furrow after every 4 rows.

Dangore *et al.,*(2001) studied the effect of land configurations on growth and yield of rainfed cotton and reported that the land configurations treatments did not significantly affect growth and yield but had significant effect on dry matter accumulation at flowering and harvesting stages.

Sowing of cotton on ridges resulted in more dry matter accumulation over the other treatments.

Haque *et al.,* (2002) conducted a study to determine the effects of various land configurations on dry matter production, distribution and growth of garlic and found that ridge planting method significantly influenced total dry matter (TDM) production and its distribution into root, stem and leaf. It had higher total, stem, root and leaf dry matter, leaf area index (LAI) and crop growth rate (CGR) over furrow and flat methods of planting.

Dwivedi *et al.,* (2002) reported that adoption of proper land configuration systems will help in increacing income of the farmers besides preventing land degradation due to runoff and erosion in Madhya Pradesh.

Khatri *et al.,* (2002) reported that growth parameters such as number of tillers m^{-1} row length, leaf area index, crop growth rate and dry matter accumulation, as well as yield attributes such as number of grains $earhead^{-1}$, grain yield $earhead^{-1}$ and test weight were higher with sowing in raised beds as compared to flat beds in wheat.

Tumbare and Bhoite (2003) reported that ridging and furrow method of sowing recorded higher grain yield of pearl millet and chickpea which was 38.15 and 23.78 per cent higher than flat bed method of sowing.

Ralli and Dhingra (2003) reported higher nodule count and nodule dry weight under ridge sowing when compared with flat sowing. The number of branches per plant and dry matter accumulation were highest in ridge sowing. Growth and yield attributes were highest in ridge sowing followed by broad bed and furrow and flat sowing.

Thakur *et al.,* (2004a) reported that the ridge planting of onion, garlic and coriander gave 31.5%, 22% and 10.1% higher yield, than flat bed planting respectively Similar results were also reported by Gupta *et al.*, (1979) and Nema *et al.*, (1991).

Thakur *et al.,* (2004b) reported that the performance of pigeonpea and turmeric crops when grown under sole and intercropped condition was better on ridge and furrow system of cultivation than flat bed system of cultivation. There was a 38%, 20%, 33% and 20% increase in the yield of pigeonpea sole, turmeric sole and pigeonpea + turmeric intercropping, respectively, over flat bed system of cultivation.

Kumari *et al.,* (2005) found sowing of mustard with broad bed and furrow and ridge and furrow methods of land configurations for optimum growth and yield of Indian mustard in Tirupati.

Khichar and Ram-Niwas (2005) reported that the wheat in furrow-irrigated raised bed planting system intercepted less PAR compared to wheat in flat bed planting system.

Singh *et al.,* (2005) assessed in a 2-year (2001-02) field study under a subtropical environment in Ludhiana, Punjab, India, the pod productivity of summer-sown groundnut in relation to 3 land configurations (flat, furrow, and furrow followed by its earthing-up to a low raised bed before peg initiation) and 3 sowing rates (recommended rate of 95 kg kernel ha^{-1}, 85 and 70% of the recommended). The land configurations had a significant effect on the pod productivity. The average pod yield of flat, furrow, and furrow-earthing was 17.9, 17.3 and 20.5 q ha^{-1}, respectively. The better pod development culminating in the maximum pod yield under the furrow-earthing was attributable to a higher rooting density of 3.69 mg cm^{-3} (15-30 cm soil layer), a lower bulk density of 1.39 g/cc and a reduced soil strength of 0.38 MPa than the respective values of 3.45, 1.51 and 0.59 under flat, and 3.56, 1.52 and 0.59 in the furrow configurations. Moreover, furrow-earthing, a 2 pronged operation, apparently created the desired environment supportive of a better plant development. While the furrows caused an enhanced emergence and better plant establishment due to maintaining a higher level of moisture, the earthing-up of these furrows to a low raised bed created a physical environment conducive for peg penetration, pod production and development, sustaining a higher plant stand upto harvest time. The recommended sowing rate had significantly higher pod yield over 70% of the recommended rate and was at par with 85% of the recommended rate, indicating the possibility of reducing the sowing rate by 15%.

The higher grain yield (1546 kg ha^{-1}) was recorded in dead furrow after 9 rows which was found significantly superior than yield under flat sowing (1478 kg ha^{-1}) at 45 cm (Annual Report 2006).

Kantawa *et al.,* (2006) reported that broad bed and furrow system of planting recorded higher biomass and grain yield of pigeonpea, N and P uptake, net returns over flat bed planting.

Trials conducted on population management in mungbean under raised bed system at Srinagar, Ludhiana, Hissar and Imphal reported that raised bed system significantly increased the grain yield of mung bean over flat bed system (Annual Report, 2007).

Tomar *et al.*, (2007) suggested that the land configuration practices such as raised-shunken bed system for normal as well as problematic soils, broad bed and furrow and tied furrow for conserving rainwater, nutrient and soil resources are appropriate and cost effective.

On the basis of the results of trials conducted at Pantnagar, Dholi and Berhampur, raised bed sown urd bean resulted in significantly highest yield over flat bed sown urd bean (Annual Report 2008).

2.2. Seed rates in relation to crop growth and Productivity:

Niklyaev (1975) observed tat optimum yield were obtained at sowing rates of 200000 seeds ha^{-1} and the highest seed yield of 2.63 t ha^{-1}.

Sharma and Singh (1985) reported that number of branches, number of leaves, number of root nodules and dry weight plant^{-1} decreased with increasing plant density.

Moore (1991) reported that the test crop soybean *cv.* Hartz 5171 was sown at low, medium or high sowing rates and thinned to give final plant densities of 3, 26 and 48 plants m^{-1} of row in 1988 and 6, 19 and 28 plants m^{-1} in 1989 in rows 97 cm apart. The study concluded that the more densely sown plots were thinned to give equidistant or non-equidistant within-row spacing. Seed yields were slightly higher in both years with equidistant spacing. Yields were low due to stress in 1988 and plants in equidistant spacing produced only 157 kg ha^{-1} more than those in non-equidistant spacing. Yields were higher in 1989 than 1988, and plants in equidistant spacing increased yield by 257 kg ha^{-1}. There was no interaction between plant spacing and plant density on yield, indicating that the optimum density for soybean was not dependent on plant spacing.

Thompson (1991) conducted field experiments with soybean cv. Kirby, in Gainesville, Florida in 1987 and 1988 to identify crop parameters and physiological and ecological relationships which mediate the effect of plant population on yield. SOYGRO, a process-oriented crop growth simulator, was also used to investigate the effect of plant population on seed yield and to test hypotheses regarding the efficiency with which the crop uses PAR to produce seed yield. Plant density (11.1, 25.0 and 44.4 plants m^{-2}) did not affect plant DM, seed DW or number of seeds.

Jasani *et al.*,(1993) concluded through a field experiment conducted on clayey soil in 1989/90 at Navasari, Gujarat, soybean was sown on 23 June, 8 or 23 July or 7 Aug. produced seed yields of 1.93, 1.88, 1.48 and 1.18 t/ha, respectively. Sowing rates of 40, 50, 60 or 70 kg seeds ha^{-1} produced seed yields of 1.36, 1.57, 1.76 and 1.78 t ha^{-1}, respectively.

Song *et al.,* (1995) reported that each variety had its own suitable density. The best density for varieties setting their pods on the main stem was- 30 000 plants 0.1647 $acre^{-1}$, while for those setting pods also on branches the best was 10 000 to 15 000 plants 0.1647 $acre^{-1}$. The closer the RS and PS, the higher was the yield.

Desoky and Far (1996) reported that seed and straw yields of soybean plants grown on the two-ridge system were 10.7 and 12.9% higher, respectively, than those grown on the single ridge system, but the number of branches $plant^{-1}$, number of pods $plant^{-1}$, seed yield $plant^{-1}$ and 100-seed weight were significantly lower.

Jain *et al.*,(1996) reported that the growth parameters (leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR)) of soybean increased with age and decreased at ripening, whereas the net assimilation rate (NAR) decreased with an increase in crop age. The LAI, CGR, and NAR decreased significantly due to increased row spacing and a reduced seed rate, whereas RGR increased at a lower seed rate. All growth parameters registered higher values up to the age of 50 days when the herbicides fluchloralin and metribuzin were used, whereas growth parameters in plots treated with oxadiazon increased up to the 75th day. CGR was positively correlated with seed yield (r = 0.4568) and crop biomass (r = 0.4597), and was described by the regression equation (Y = 1281.04 + 48.761X). The seed rate and row spacing did not influence the density of the weed population, but weed biomass was reduced at the highest seed rate and when row spacing was closer. Oxadiazon, oxyfluorfen and metribuzin also effectively controlled weeds and increased crop yield.

Halvankar *et al.,* (1999) concluded from a study that the planting geometry of 45 cm x 5 cm recorded significantly more nodes $plant^{-1}$, branches $plant^{-1}$, pods $plant^{-1}$, seeds $plant^{-1}$ and 100-seed weight of soybean than rest of the planting geometries except planting geometry of 30 cm x 15 cm for branches $plant^{-1}$ and 100-seed weight. Planting geometry of 30 cm x 10 cm gave significantly highest seed and oil yields over rest of the planting geometries except 45 cm x 5 cm.

Yadav *et al.*, (1999) reported that higher seed rate of soybean (150 kg ha^{-1}) significantly reduced the weed population and dry weight of weeds compared with the lower seed rate of soybean (125 and 100 kg ha^{-1}) and enhanced the soybean yield.

Akunda (2001) conducted a field study during three seasons of sorghum and soybeans as test crops and concluded that in the first season, the sole crop yields of soybeans increased with increase in plant populations, contrary to the intercrops. Intercropping had significant influence on yields (p=0.05).

Ball *et al.,* (2001) assessed the direct and indirect contributions of population density for short-season soybean *(Glycine max)* cultivars Asgrow 4922, Manokin and Hartz 4994) yield and its components over a wide range of population densities (6-134 plants m^{-2}) using path-coefficient analysis. Data were from field tests conducted in 1997, 1998, and 1999, at Keiser, Arkansas, USA. Although population density had a large inverse association with pods $plant^{-1}$, the large direct effect of population density on yield was greater than its negative indirect effect via pods $plant^{-1}$. The direct effects of pod number $plant^{-1}$ and seeds pod^{-1} on yield were positive, whereas mass seed^{-1} had a negligible effect. Pods per fertile node differed between cultivars, and it was reduced by increasing population density. For early sowing, the contribution of population density to yield was less because pods m^{-2} could be achieved at low population densities by a large number of fertile nodes plant^{-1} and pods fertile^{-1} node. In contrast, at late sowing, the decreased potential for fertile nodes plant^{-1} was compensated by increasing plant population density.

Kleinschmidt (2001) conducted a field study in Ohio, USA, to evaluate the effect of sowing rates on soybean *cv.* Pioneer 92B61 yields in a 10-inch row width system. The different sowing rates were 144 000, 180 000 and 212 000 seeds acre^{-1}. Harvest density was highest for the sowing rate 212 000 seeds acre^{-1} (162, 847 plants acre^{-1}). No significant differences in yield were observed due to different sowing rates.

Graterol and Montilla (2003) reported that row spacing, plant populations and genotypes are three factors of great importance in crops since they determine the efficiency in transforming solar energy into chemical energy. Although soybean (*Glycine max* L. Merrill) have usually been planted in rows 60-80 cm apart using plant population between 30,0 000 and 40,0000 plants ha^{-1}, the trend in the main producing countries is to use shorter distances and higher plant populations. The objective of this study was to determine the effect of two row spacings and three plant populations on grain yield, yield components, plant height, and pod height of two soybean cultivars of indeterminate growth habit.

Rambo *et al.*, (2003) conducted an experiment in Rio Grande do Sul, Brazil, in 2000-01 to investigate how soybean arrangement modified the interplant competition and the effect of arrangement on grain yield and yield components. The treatments were 2 water availability levels (with and without irrigation), 2 row spacings (20 and 40 cm) and 3 population levels (20, 30 and 40 plants m^{-1}). Grain yield was affected by the interaction between irrigation and plant spacing. Irrigation resulted in a higher grain yield (5015 kg ha^{-1}) compared to the non-irrigated treatment. Higher grain filling rate and larger seed weight caused higher yield in the irrigated treatment. Row spacing at 20 cm with the population 20 plants m-^{2} resulted in higher yield (5014 kg ha^{-1}) compared to 40 plants m^{-2} (4322 kg ha^{-1}).

Chapter-3
Material & Methods

CHAPTER – 3

MATERIAL AND METHODS

A field experiment was carried out to study the "Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols" in *Kharif* season, 2007. The present chapter deals with a brief description of methods employed and materials used during the course of investigation.

3.1 Experimental Site

An experiment was conducted under "All India Co-ordinated Research Project" (AICRP) for Dryland Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Farm, College of Agriculture, Indore, M.P. during *Kharif*-2007-08. The topography of field was uniform with gentle slope.

3.2 Location and Climate

Indore is situated in Malwa plateau in the Western M.P. at an altitude of 555.5 meters above mean sea level (MSL). It is located at latitude 22.43°N and longitude of 75.66°E. It has subtropical climate having a temperature range of 21°C to 45°C and 6°C to 31°C in summer and winter season, respectively. The rainfall in the region is mostly inadequate and erratic. Late commencement, early withdrawal and two to three dry spells are the main features. The average rainfall is 864 mm. The meteorological data during crop growth period from month of June to October 2007 is been given in Table 3.1. The data show that the total rainfall was 819.6 mm it was higher than normal with 45 rainy days in almost all the SMW. However, at 36 SMW the rainfall received was very high (135.4 mm). The Maximum and Minimum temperature varied from 26.5^0 C and 35.64^0 C and from 17.21^0C to 25.9^0C, respectively. The relative humidity, wind velocity and evaporation ranges in between 81.57 to 95.6 %, 0.21 to 3.5km/hr and 1.1 to 4.2 mm day^{-1}.

Table 3.1 Meteorological data observed during crop growth period 25 smw to 41 smw (June to October, 2007) recorded at Indore.

SMW	Month and date		RH (%)	Temp (°C)		Rain fall (mm)	No. of rainy days	Wind Velocity (km hr^{-1})	Evapo-Ration (mm day^{-1})
				Max.	Min.				
25	June	18-24	85.0	35.6	25.9	53.6	2	2.0	4.1
26		25-1	98.0	32.4	24.8	89.0	3	2.5	3.3
27	July	2-8	93.0	26.5	23.1	104.2	7	3.5	1.1
28		9-15	93.0	27.3	23.1	126.0	4	3.0	2.4
29		16-22	89.0	31.6	23.4	14.2	2	2.1	3.7
30		23-29	92.0	31.4	23.9	34.6	2	0.9	3.0
31		30-5	93.0	30.3	23.6	53.6	4	1.0	2.0
32	Aug	6-12	91.6	27.4	22.5	86.0	4	1.4	1.4
33		13-19	91.8	27.6	23.0	4.8	3	2.3	2.2
34		20-26	91.7	29.0	22.8	16.0	2	1.1	2.5
35		27-2	92.0	30.2	23.1	36.8	3	0.2	2.7
36	Sept	3-9	91.8	29.0	23.2	135.4	4	1.0	2.3
37		10-16	91.1	30.5	22.4	Nil	Nil	0.9	3.5
38		17-23	92.6	30.8	22.9	51.6	3	0.6	3.4
39		24-30	95.6	30.3	21.6	13.8	2	0.4	2.9
40	Oct	1-7	81.6	32.6	20.3	Nil	Nil	0.7	4.2
41		8-14	83.1	32.3	17.2	Nil	Nil	0.7	3.7
Total						819.6	45		

Source: Observatory,All India Co-ordinated Research Project for Dryland Agriculture; College of Agriculture, Indore (M.P.)

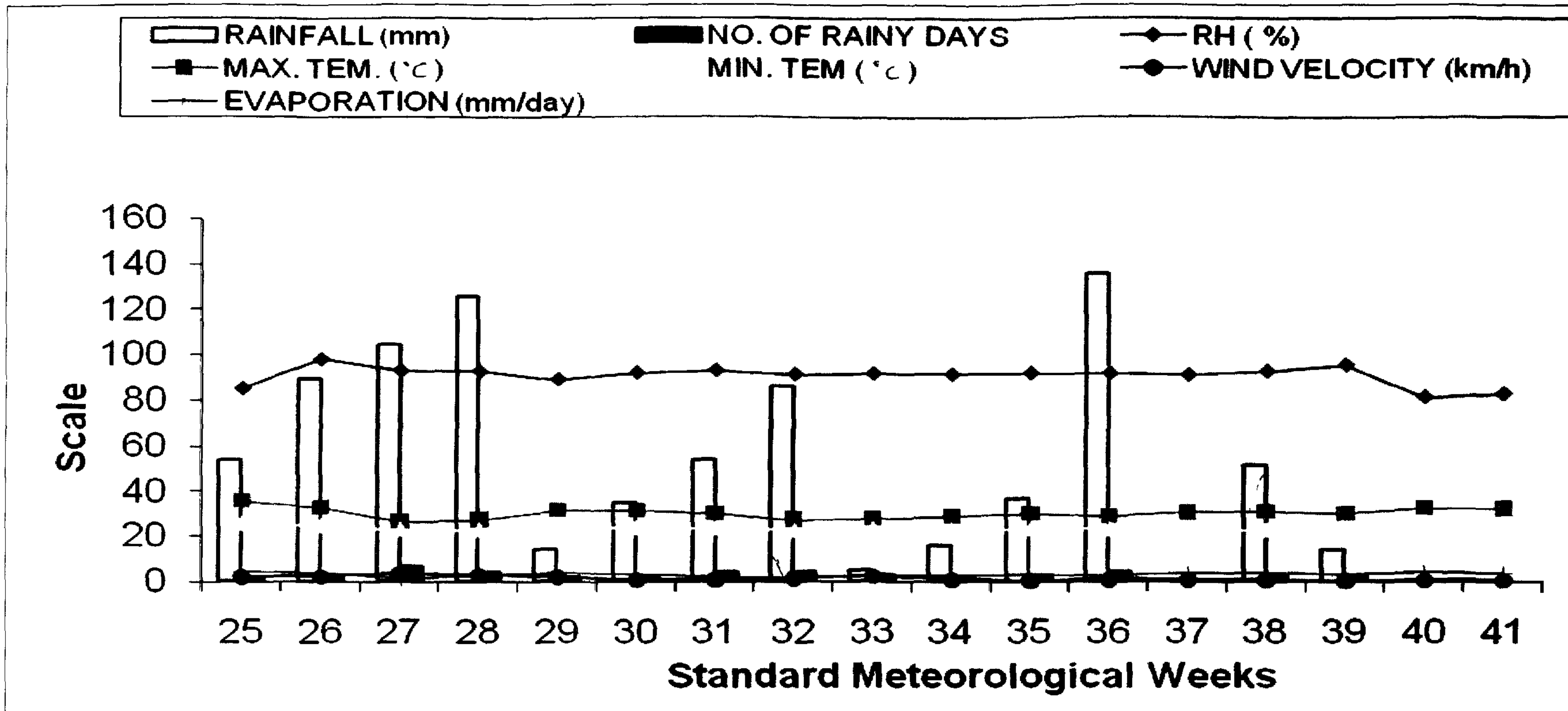


Figure 3.1 Meteorological data observed during crop growth period 25 smw to 41 smw (June to October, 2007) recorded at Indore (M.P.)

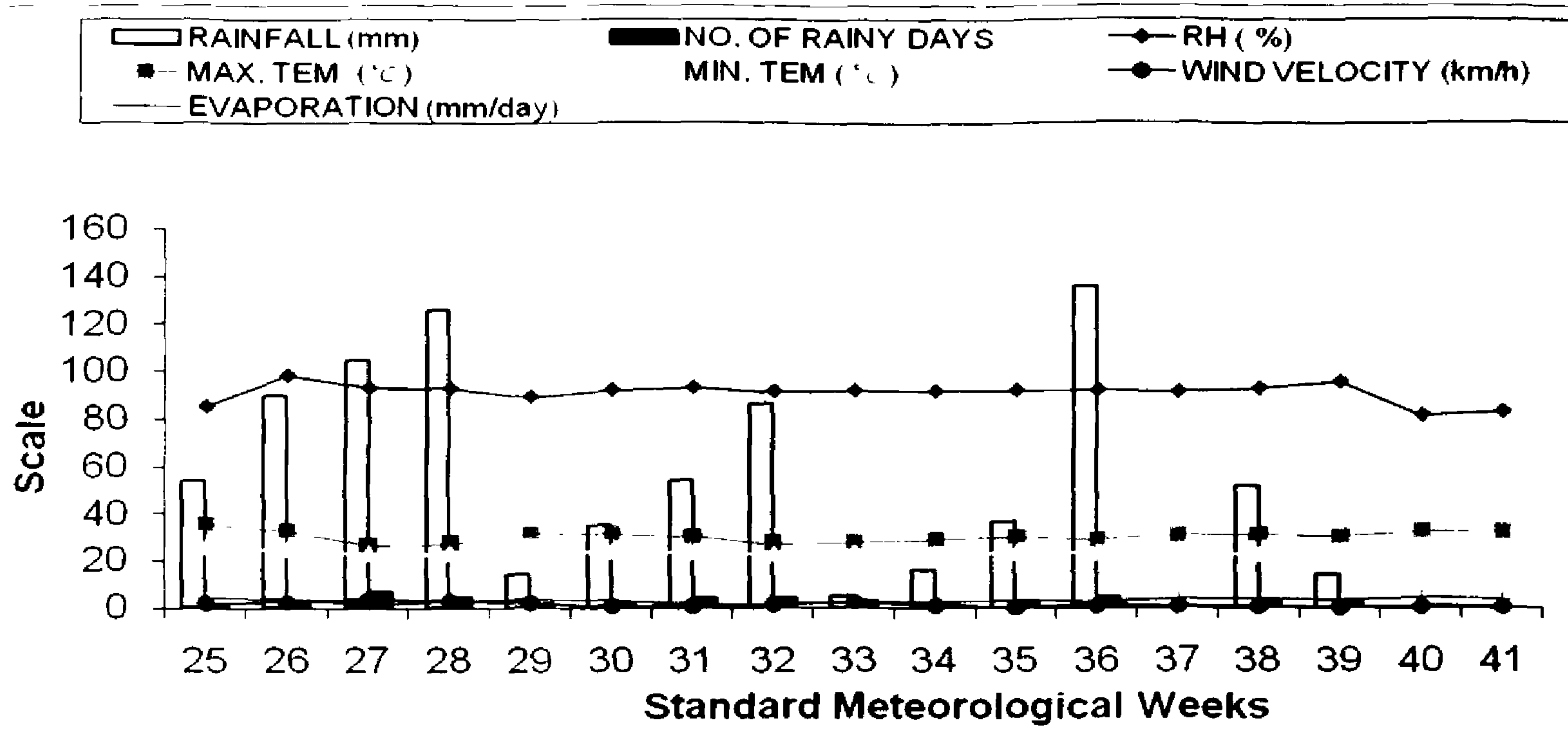


Figure 3.1 Meteorological data observed during crop growth period 25 smw to 41 smw (June to October, 2007) recorded at Indore (M.P.)

3.3 Soil

The soil of the experimental field has been grouped under medium black (*Vertisols*) belonging to fine montmorillonite hypothermic family of typical chromosterts predominantly clay in texture. In order to determine the textural class and fertility status of the experimental area the soil samples were collected randomly with the help of soil auger before sowing from the experimental field.

Table 3.2 physico-chemical properties of the experimental soil

Mechanical analysis

S.N	Component	Quantity (%)	Method of analysis
1.	Sand	18	Bouyoucos hydrometer method (Piper, 1950)
2.	Silt	37	
3.	Clay	45	
4.	Textural class	Clay	

Chemical analysis of the experimental soil

S.N	Analysis	Values	Category	Method adopted
1.	Soil pH	7.79	Slightly alkaline	Glass electrode method (pH meter) (Jackson, 1967)
2.	Electrical conductivity (dS m^{-1})	0.33	Normal	Conductivity meter at 25°C (Jackson, 1967)
3.	Organic carbon (%)	0.41	Low	Wakley and Black's rapid titration method,1934
4.	Available Nitrogen (kg ha^{-1})	180.75	Low	Alkaline permanganate method (Jackson,1967)
5.	Available phosphorus (kg ha^{-1})	11.3	Medium	Olsen's method (Jackson, 1967)
6.	Available potash (kg ha^{-1})	395.20	High	Flame photometer (Jackson, 1967)

The physico-chemical analysis of soil showed that the soil of experimental site was predominantly clayey in nature. The organic carbon content (o.41%) and available nitrogen (180 kg ha^{-1}) were low. The available phosphorus (11.30 kg ha^{-1}) and potash (395.20 kg ha^{-1}) were medium and high respectively. The soil pH was (7.79) slightly alkaline. Electrical conductivity (.33dSm^{-1}) of soil is normal (Table 3.2).

3.4 History of experimental field:

The history of crops sequence followed during the last five years is shown in the Table 3.3.

Table 3.3 History of experimental field

Year	Kharif	Rabi
2003-04	Soybean	wheat
2004-05	soybean	wheat
2005-06	soybean	fallow
2006-07	soybean	fallow
Kharif, 2007	soybean	-

Source: Dry land Agriculture Research Project, College of Agriculture, Indore (M.P.)

3.5 Experimental details

The present experiment consisting of 04 main treatments and 03 sub treatments. The details layout plan are follows:

Experimental design	: Split plot design
Number of replications	: 04
Number of treatments	: (a) Main treatments – 04
	(b) Sub treatments -03
Total number of plots	: 48
Gross sub plot size	: 3.6 m X 10.0 m
Net sub plot size	: 3.6 m x 9.0 m
Row spacing	: 45 cm & 60 cm as per treatment
Distance between Replication	: 1.5 m
Distance between plots	: 1 m
Total experimental area	: 2411.9 m^2
Crop and Variety	: Soybean (JS-335)
Seed rate	: 80 kg, 60 kg & 40 kg ha^{-1}
Seed source	: College Farm, College of Agriculture, Indore (M.P.)

3.6 Treatments

Main Treatment: Land configurations

T_1. Control (sowing on flat bed at 45 cm spacing)

T_2. Broad bed and furrow system at 45 cm spacing

T_3. Ridge and furrow system at 45 cm spacing

T_4. Ridge and furrow system at 60 cm Spacing

Sub Treatment: Seed rate

S_1 – 80 kg ha^{-1} seed rate of soybean

S_2 – 60 kg ha^{-1} seed rate of soybean

S_3 – 40 kg ha^{-1} seed rate of soybean

Treatment combinations

T_1 S_1 - Control (sowing on FBS at 45 cm spacing) + 80 kg ha^{-1} seed rate

T_1 S_2 - Control (sowing on FBS at 45 cm spacing) + kg ha^{-1} seed rate

T_1 S_3 - Control (sowing on FBS at 45 cm spacing) + kg ha^{-1} seed rate

T_2 S_1 – BBFS at 45 cm spacing + 80 kg ha^{-1} seed rate

T_2 S_2 – BBFS at 45 cm spacing + 60 kg ha^{-1} seed rate

T_2 S_3 – BBFS at 45 cm spacing + kg ha^{-1} seed rate

T_3 S_1 – RFS at 45 cm spacing + 80 kg ha^{-1} seed rate

T_3 S_2 – RFS at 45 cm spacing + 60 kg ha^{-1} seed rate

T_3 S_3 – RFS at 45 cm spacing + 40 kg ha^{-1} seed rate

T_4 S_1 - RFS at 60 cm spacing + 80 kg ha^{-1} seed rate

T_4 S_2 - RFS at 60 cm spacing + 60 kg ha^{-1} seed rate

T_4 S_3 - RFS at 60 cm spacing + 40 kg ha^{-1} seed rate

Where as FBS - Flat bed system
BBFS- Broad bed and furrow system
RFS- Ridge and furrow system

Fig. 3.2 Layout plan of the experimental field N ⇔ S

	T2- BBFS at 45 cm			T3 - RFS at 45 cm			T1 - FBS at 45 cm			T4- RFS at 60 cm		
	80 kg	60 kg	40 kg	60 kg	80 kg	40 kg	80 kg	40 kg	60 kg	60 kg	40 kg	80 kg
REP I	T2S1	T2S2	T2S3	T3S2	T3S1	T3S3	T1S1	T1S3	T1S2	T4S2	T4S3	T4S1
REP II	T2S1R2	T2S2	T2S3	T3S2	T3S1	T3S3	T1S1	T1S3	T1S2	T4S2	T4S3	T4S1
REP III	T2S1	T2S2	T2S3	T3S2	T3S1	T3S3	T1S1	T1S3	T1S2	T4S2	T4S3	T4S1
REP IV	T2S1	T2S2	T2S3	T3S3	T3S1	T3S3	T1S1	T1S3	T1S3	T4S2	T4S3	T4S1

.3.6m. 1m .3.6 m 1m. . 3.6m .1m ..3.6m.. ..1m.....3.6m ..1m....3.6m.....1m....3.6m...1m ...3.6m. ..1m....3.6m ..1m. ..3.6m....1m.....3.6m ..1m...3.6m ....

|------ 54.2 m ------|

Rows: 10m --- 1.5m --- 10m --- 1.5m --- 10m --- 1.5m --- 10m; ---44.5 m---

Treatments: a). Main plot treatment

T1: Flat bed system at 45cm
T2: Broad-bed & furrow system at 45cm
T3: Ridge & furrow system at 45cm
T4: Ridge & furrow system at 60cm

b). Sub plot treatment

S1: 80 kg ha^{-1} seed rate
S2: 60 kg ha^{-1} seed rate
S3: 40 kg ha^{-1} seed rate

Gross plot size: 3.6 m x 10.0 m
Net plot size : 3.6 m x 9.0 m
Total experimental area: 2411.9 m^{-2}

3.7 Varietal Characteristics

Soybean variety, Jawahar soybean (JS-335) is a cross between JS-78-77 & JS –71-75 it matures in about 95-100 days. It has purple flowers, yellow seed coat and higher germination percentage (85-90%). It exhibits wider adaptability for cultivation. The weight of 100 seeds is 10-15 g and yield potential is 25-30 q ha^{-1}. It has resistance for bacterial pustules, bacterial blight and *Alternaria* leaf spot.

3.8 Field operation

3.8.1 Field preparation

The experimental field was prepared by two cross harrowing followed by planking to level the field and then made Broad bed furrow and ridge furrow with the help of *desi hal.* Previous crop stubbles were removed from the field. The layout of experiment was done as given in fig.3.2 in Split plot design as per the specification need.

3.8.2 Fertilizer application

The recommended dose of nutrient for Soybean was used i.e. 40 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1}. The fertilizers were applied to soybean crop as basal as per the treatment requirements. The sources of N, P_2O_5 and K_2O were urea, single superphosphate and muriate of potash respectively.

3.8.3 Seed and seed treatment

For ensuring perfect germination, healthy and good quality seeds were used. For seed treatment of soybean crop seeds were treated by carbandazim @ 3 g kg^{-1} seeds and after that inoculated with *Rhizobium* culture of suitable strength @ 10 g kg^{-1} seed at the time of sowing.

3.8.4 Sowing

Sowing of the crop was done on 25th June 2007, Seed rates of soybean used 80 kg, 60 kg and 40 kg ha^{-1} as per the treatments requirement.

3.8.5 Weeding

A hand weeding was done to keep the crop weed free.

3.8.6 Plant protection operations

To protect the crop from insects pests like girdle beetle, stem fly caterpillars, blue beetle etc. in soybean at early stage one spray of cyper methrin 10 Ec. @ 60 ml/15 litre water/pump was sprayed on 21th July at 26 DAS.

3.8.7 Harvesting

The crop was harvested on 13th October. Before harvesting, five randomly tagged plants plot^{-1} of the crop were taken out for post harvest studies. After harvesting, the produce of each plot was tied in bundle properly labelled and it was allowed to dry in the field for 4-5 days. The produce of individual plot was threshed separately and winnowed. Yield of the crop in kilograms obtained from each net plot was recorded.

3.9 Methodology adopted for recording observations

3.9.1 Pre-harvest observations

3.9.1.1 Plant population

The plant population was taken initially at 15 DAS and at harvest. Plant population was counted meter^{-2} at five randomly selected spot within each net plot and the mean thus obtained was used to estimate average plant population meter^{-2}.

3.9.1.2 Height (cm) of the plant

In each net plot five plants were selected randomly and tagged for periodic observation. The height (cm) was recorded at 30, 45, 75 DAS and harvest stage of the crop in all the plots. It was measured from the ground surface to the main stem apex.

3.9.1.3 Number of branches plant^{-1}

Number of branches was recorded at 30, 45, 75 DAS and harvest stage of the crop in all the plots. It was measured on five plants which were selected randomly and tagged.

3.9.1.4 Root growth

Root is a major part of the plant which provides base and active participation in nutrient, moisture uptake and play effective role in fixation of atmospheric nitrogen. In each net plot five plants were selected randomly and tagged for observation. The number of nodules was recorded at flowering stage of the crop.

3.9.1.5 Leaf area index

Leaf area index was recorded at 30, 45 and 75 DAS. LAI of the crops. It expressed the total leaf area in relation with the total ground area over in which the crop was grown as calculated by the following equation:

Leaf area index = Leaf area / Ground area

3.9.1.6 Dry matter accumulation g plant^{-1}

The dry matter of five plants was recorded after 30, 45, 75 DAS and at harvest. The five selected plants were uprooted and they were kept in oven at 65^{0} C for 48 hours then weighed. The data is converted on plant basis and analyzed.

3.9.2 Post- harvest observation recorded as follows

3.9.2.1 Yield and its attributes

Post harvest studies *viz.* mean No. of pods plant^{-1}, No. of seeds pod^{-1} etc. were recorded on sample of five randomly tagged plants in each treatment.

The following observations were recorded:

Post harvest Observations

No. of pods plant^{-1}

No. of seeds pod^{-1}

Grain weight plant^{-1} g

Seed Index, g

Grain & Straw yield kg ha^{-1} and Harvest Index (%)

3.9.2.2 Harvest index (%)

Harvest index is the ratio of economic yield (kg ha^{-1}) to biological yield (kg ha^{-1}) and multiplied by 100 to obtain its value in percentage. The harvest index is calculated by the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)} \times 100}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

3.10 Chemical analysis of soil sample

3.10.1 Collection and preparation of soil sample

Composite soil samples were collected randomly with the help of soil sampling tube before sowing and after harvesting of crop from each plot. The samples were mixed thoroughly and dried in air, crushed, sieved through 2 mm sieve. The samples so prepared were analyzed for fertility status.

3.10.2.1 Soil pH

Soil pH was determined by using Beckman glass electrode pH meter in 1:2, soil: water suspension. (Piper,1950).

3.10.2.2 Electrical conductivity

Electrical conductivity was determined by electrical conductivity meter in 1:2 soil water suspensions at 25°C and it is expressed in dSm^{-1} (Desi seimens per meter).

3.10.2.3 Organic carbon

Organic carbon was determined by Walkley and Black (1934) wet digestion method. Organic carbon is expressed in percentage (%).

3.10.2.4 Available nitrogen (kg ha^{-1}.)

Determination of available nitrogen was done by alkaline permanganate method suggested by Subbiah and Asija (1956).

3.10.2.5 Available phosphorus (kg ha^{-1}.)

The estimation of available P was done by using Olsen's extract (0.5 N sodium bicarbonates solution of pH 8.5) as referenced by Olsen *et al.*, (1954).

3.10.2.6 Available potassium (kg ha^{-1}.)

The available amount of potassium was determined by using N-neutral ammonium acetate as mentioned by Jackson (1967).

3.11 Economic calculations

The economic calculations were done by method suggested by Yang and Dhondyal (1971).

3.11.1 Benefit: cost ratio

It is the ratio of gross return to cost of cultivation. It is expressed as returns per rupee invested.

Benefit cost ratio = Gross return (Rs ha^{-1})/Cost of cultivation (Rs ha^{-1})

3.11.2 Net Monetary Returns (Rs ha^{-1})

It is obtained by subtracting cost of cultivation from gross returns. It is good indicator of suitability of a cropping system since this represents the actual income of the farmer.

Monetary returns for different treatments were calculated with the help of prevailing market rates of output and inputs.

Net Monetary Returns (Rs ha^{-1}) =

Gross return (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

3.12 Statistical Analysis:

The data was analyzed by method of analysis of variance as described by Fisher (1950). The structure of analysis of variance is given below. The design of experiment was Split plot design with four main treatments, three sub treatments and four replications.

The yield and growth attributes of soybean crop were studied separately, in this case the no. of plots were 12 x 04 = 48 and degree of freedom 47. For overall study of economics of all the treatments, the no. of treatments 12 and degree of freedom was 11.

Table 3.4 Skeleton of analysis of variance for yield and growth attributes of soybean

Source of variation	**df**	**SS**	**MSS**	F_{cal}	F_{tab}	
					5 %	**1%**
Replications	3				3.86	6.99
Main Treatments	3				3.86	6.99
Error (a)	9		**EMS (a)**		-	-
Sub Treatments	2				3.40	5.61
Interaction (Main X Sub)	6				2.51	3.67
Error (b)	24		**EMS (b)**		-	
Total	47				-	

The null hypothesis was tested by the 'F' test, which revealed the significance of treatment effect. The critical difference (CD) of 5% was worked out to judge the difference between the two treatment means.

The standard error between the treatments and CD (5%) were calculated as below:

(i) Standard error for the difference between two land configuration means

$$SEm(d_1) = \pm \sqrt{\frac{2E(a)}{12}}$$

C.D. (at 5%) = SEm (d_1) x t_{9df}(5%)

(ii) Standard error for the difference between two seed rate means

$$SEm(d_2) = \pm \sqrt{\frac{2E(b)}{16}}$$

C.D. (at 5%) = SEm (d_2) x t_{24df}(5%)

(iii) Standard error for the difference between two seed rate means at the same land configuration

SEm (d_3) $= \pm \sqrt{\frac{2E(b)}{4}}$

C.D. (at 5%) = SEm (d_3) x t_{24df}(5%)

(IV) Standard error for the difference between two land configuration means at the same or different seed rate

SEm (d_4) $= \pm \sqrt{\frac{2[2E(b) + E(a)]}{12}}$

C.D. (at 5%) = SEm (d_4) x t^*

$$t^* = \frac{2E(b)t_{24df}(5\%) + E(a)t_{9df}(5\%)}{2E(b) + E(a)}$$

Where: E(a) = M.S. due to error (a)

E(b) = M.S. due to error (b)

t_{9df}(5%) = tabulated 't' value at 9 df (t_{9df} =2.262)

t_{24df}(5%) = tabulated 't' value at 24 df (t_{24df} = 2.064)

Note:

Standard error of the mean i.e. $SE_{(m)}$ for each pairs was calculated by dividing their corresponding SEm(d) by 2.

Observations recorded

(A). Growth parameters

(1).	Plant population m^{-1} row	- at 15 DAS & harvest
(2).	Plant height	- at 30, 45, 75 DAS & harvest
(3).	No. of branches $plant^{-1}$	- at 30, 45, 75 DAS & harvest
(5).	No of nodules $plant^{-1}$	- at flowering stage
(6).	Leaf area	- at 30, 45 & 75 DAS
(7).	Dry weight $plant^{-1}$	- at 30, 45, 75 DAS & harvest

(B). Post harvest Observations

(1). No. of pods $plant^{-1}$

(2). No. of seeds pod^{-1}

(3). Grain weight $plant^{-1}$

(4). Grain & Straw yield $plot^{-1}$

(C). Data to be calculated

(1). Plant population m^{-2}

(2). LAI - at 30, 45 & 75 DAS

(3). Seed & Straw yield kg ha^{-1}

(D). Economic analysis of different treatments:

(1). Cost of cultivation (Rs ha^{-1})

(2). Gross monetary returns (Rs ha^{-1})

(3). Net monetary returns (Rs ha^{-1})

(4). B: C ratio

Chapter-4
Results

CHAPTER – 4

RESULTS

The present chapter deals with the experimental result obtained during the course of investigation on "Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols" during *kharif* season, 2007. The results were statistically analyzed by using the analysis of variance technique in order to find out the significance of different treatments. The experimental findings are presented and interpreted in following paragraphs. The analysis of variance Tables are given in Appendices.

4.1 Pre Harvest Studies

Different growth characters were recorded to characterize the growth performance and development of soybean crop at various growth stages.

4.1.1 Plant population

The plant stand in all the treatments was recorded at 15 DAS and at harvest stage and the data are presented in Table 4.1.1. Mean population under different treatments (m^{-2}) has been depicted in Fig. 4.1.1A and 4.1.1B. The analysis of variance is presented in Appendix-I. The table 4.1.1 reveals that plant population was affected significantly due to different treatments. In case of land configurations, significantly higher plant population was recorded (48.1) in T_4:RFS-60 cm as compared to other treatments under study. Lowest plant population was recorded in case of flat bed sowing i.e. control (40.26). As the seed rate decreased, the plant population was also decreased significantly. Interactive effect of seed rate and land configuration also influenced the plant population significantly. The highest plant population was recorded due to S_1:80 kg ha^{-1} seed rate under T_4: RFS-60 cm (63.78) and the lowest in case of flat bed sowing with S_3:40 kg ha^{-1} seed rate (26.6). Similar trend was observed when plant population was recorded at harvest of soybean.

Table 4.1.1 Effect of land configurations (T), seed rates (S) and their interaction on plant population at 15 DAS & at harvest

Land configurations	Seed rates							
	S_1 -80 kg ha^{-1}		S_2 -60 kg ha^{-1}		S_3 -40 kg ha^{-1}		Mean	
	15 DAS	At harvest	15 DAS	At harvest	15 DAS	At harvest	15 DAS	At harvest
T_1 FBS-45cm	53.58	52.69	40.61	39.86	26.60	26.00	40.26	39.52
T_2 BBF-45cm	54.51	53.86	40.97	40.43	27.30	26.26	40.93	40.18
T_3 RFS-45cm	54.88	54.18	41.13	39.93	27.48	26.57	41.16	40.23
T_4 RFS-60cm	63.78	52.56	48.13	47.25	32.43	30.91	48.11	46.91
Mean	56.68	55.82	42.71	41.87	28.45	27.44		
	T		S		$(TxS)_1$		$(TxS)_2$	
	15 DAS	At harvest	15 DAS	At harvest	15 DAS	At harvest	15 DAS	At harvest
SE(m) ±	0.13	0.20	0.15	0.17	0.31	0.35	0.29	0.35
C.D.(at 5%)	0.43	0.65	0.46	0.52	0.93	1.04	0.87	1.06

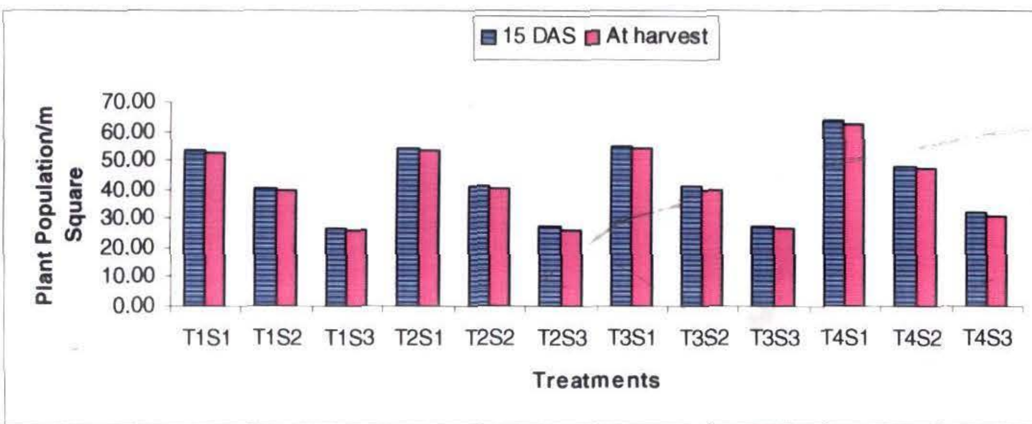


Fig. 4.1.1A Mean plant population under different treatments at 15 DAS and at harvest

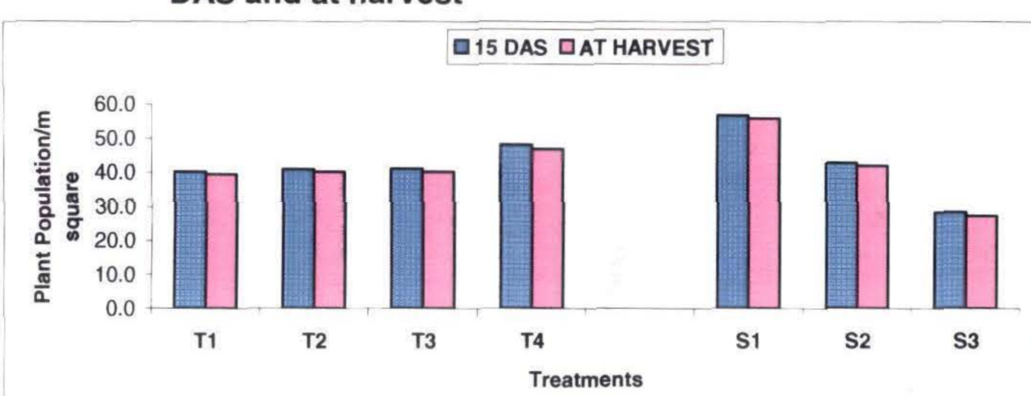


Fig. 4.1.1B Mean plant population under land configurations and seed rates at 15 DAS and at harvest

4.1.2 Plant Height (cm)

Plant height is an important index of plant growth, which differs due to different treatments and agronomic conditions. Plant height recorded at 30, 45, 75 DAS and at harvest are presented in the table 4.1.2A and 4.1.2B and depicted in Fig. 4.1.2 A and 4.1.2 B. the analysis of variance is presented in Appendix –II.

Table 4.1.2.A Effect of land configurations (T), seed rates (S) and their Interaction on plant height at 30 DAS and 45 DAS

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 -40 kg ha^{-1}		Mean	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1 FBS-45cm	24.78	39.23	25.19	39.34	24.20	38.10	24.72	38.89
T_2 BBF-45cm	26.00	41.33	26.58	44.18	26.13	41.38	26.23	42.29
T_3 RFS-45cm	26.38	41.58	27.03	45.66	24.70	38.30	26.04	41.84
T_4 RFS-60cm	25.60	40.25	26.25	41.50	25.19	39.78	25.68	40.51
Mean	25.69	40.60	26.26	42.67	25.05	39.39		
	T		S		$(TxS)_1$		$(TxS)_2$	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
SE(m) ±	0.97	1.78	0.66	1.55	1.32	3.103	1.45	3.09
C.D.(at 5%)	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.1.2.B Effect of land configurations (T), seed rates (S) and their interaction on plant height at 75 DAS and at harvest stage

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
T_1 FBS-45cm	65.25	63.75	65.37	63.87	65.25	63.75	65.29	63.79
T_2 BBF-45cm	69.06	67.16	70.44	68.44	69.43	67.43	69.64	67.64
T_3 RFS-45cm	70.04	68.04	72.95	70.75	66.01	63.81	69.66	67.53
T_4 RFS-60cm	66.73	64.53	69.63	68.13	60.28	58.78	65.54	63.81
Mean	67.77	65.84	69.60	67.80	65.24	63.44		
	T		S		$(TxS)_1$		$(TxS)_2$	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
SE(m) ±	1.28	1.28	0.89	0.89	1.78	1.78	1.94	1.94
C.D.(at 5%)	NS	NS	2.60	2.60	NS	NS	NS	NS

The perusal of the data revealed that the seed rate affected the plant height significantly at 75 DAS and at harvest stage. The higher plant height was recorded at S_1:80 kg ha^{-1}seed rate and S_2:60 kg ha^{-1} seed rate as compared to lower seed rate i.e. S_3:40 kg ha^{-1}. The differences in plant height at S_1:80 kg ha^{-1}seed rate and S_2:60 kg ha^{-1} seed rate were non significant. Effect of land configuration treatments and its interaction with seed rate was non significant at all the growth stages (Table 4.1.2A and 4.1.2B).

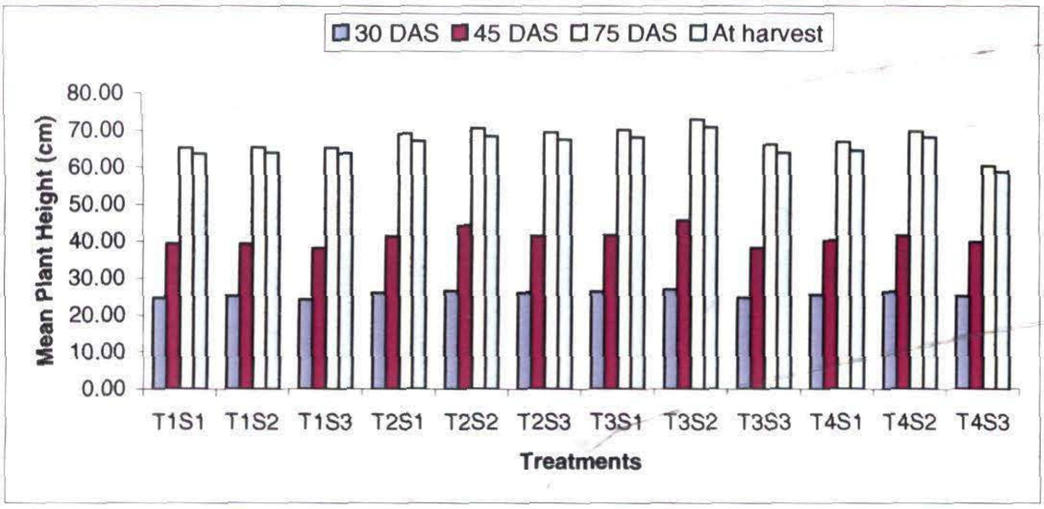


Fig. 4.1.2.A Mean plant height (cm) under different treatments at various growth stage of the crop

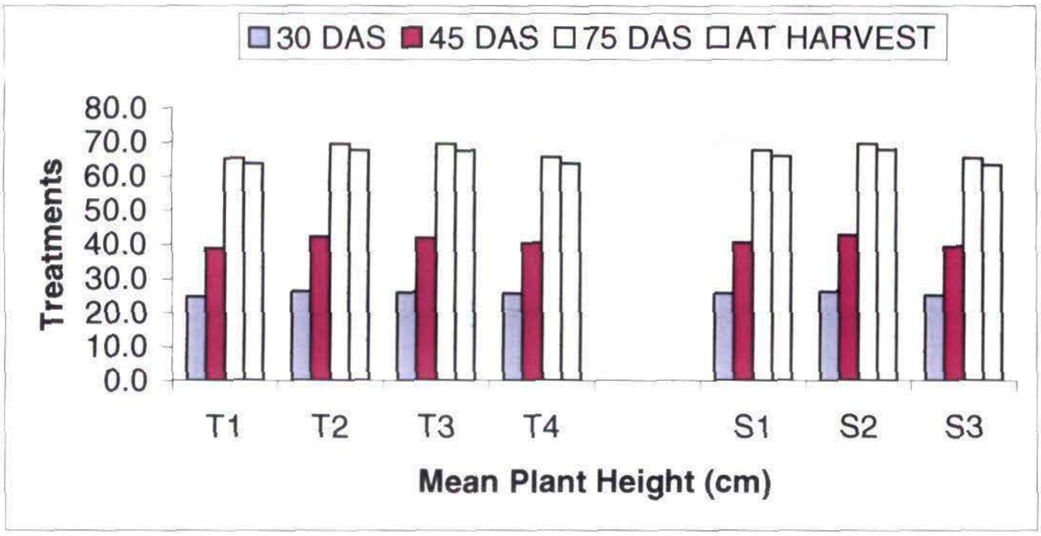


Fig. 4.1.2B Mean plant height (cm) under land configurations and seed rates at various growth stage of the crop

4.1.3 Number of branches plant^{-1}

The number of branches plant^{-1} recorded at 30, 45, 75 DAS and at harvest and the data are presented in Table 4.1.3A and 4.1.3B, and depicted in Fig. 4.1.3A and Fig. 4.1.3B.The analysis of variance is presented in Appendix –III.

Table 4.1.3.A Effect of land configurations (T), seed rates (S) and their interaction on number of branches plant^{-1} at 30 and 45 DAS

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1 FBS-45cm	2.05	2.78	2.10	2.78	1.81	2.65	1.99	2.73
T_2 BBF-45cm	2.40	3.24	2.75	4.18	2.45	3.73	2.53	3.71
T_3 RFS-45cm	2.68	4.05	2.97	4.30	2.01	2.71	2.55	3.69
T_4 RFS-60cm	2.15	3.21	2.56	4.00	2.10	2.98	2.27	3.40
Mean	2.32	3.32	2.60	3.81	2.09	3.01		
	T		S		(TxS)$_1$		(TxS)$_2$	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
SE(m) ±	0.085	0.073	0.067	0.054	0.13	0.109	0.13	0.11
C.D.(at 5%)	0.27	0.23	0.20	0.16	NS	0.32	NS	0.34

Table 4.1.3.B Effect of land configurations (T), seed rates (S) and their interaction on number of branches plant^{-1} at 75 DAS and at harvest stage

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
T_1 FBS-45cm	4.08	5.18	4.55	5.90	4.30	4.80	4.31	5.29
T_2 BBF-45cm	4.85	6.20	5.23	6.50	5.08	6.25	5.05	6.32
T_3 RFS-45cm	5.30	6.45	5.90	6.85	5.40	5.65	5.53	6.32
T_4 RFS-60cm	4.01	5.53	4.38	6.25	4.15	5.00	4.18	5.59
Mean	4.56	5.84	5.01	6.37	4.73	5.43		
	T		S		(TxS)$_1$		(TxS)$_2$	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
SE(m) ±	0.097	0.148	0.113	0.090	0.225	0.18	0.20	0.20
C.D.(at 5%)	0.31	0.47	0.33	0.26	NS	NS	NS	NS

It is evident from the data that the number of branches plant^{-1} was influenced significantly by different treatments.

In case of land configuration the lowest number of branches plant^{-1} was recorded in case of flat bed planting as compared to the treatments T_2 : BBFS-45 cm, T_3:RFS-45 cm and T_4 RFS-60 cm This trend was maintained at all the growth stages under study

Among land configuration treatments T_3 : ridge and furrow -45 cm distance produced the highest number of branches plant^{-1} at all the growth stages (Table 4.1 3A and 4 1.3B), followed by T_2·BBFS-45 cm and T_4:RFS- 60 cm. The differences among their interaction were non significant

In case of seed rate the differences in number of branches plant^{-1} were significant. Maximum numbers of branches plant^{-1} were recorded in S_2 :60 kg ha^{-1} seed rate which gave significantly higher number of branches plant^{-1} as compared to S_1 :80 kg ha^{-1} and S_3.40 kg ha^{-1} This trend was maintained at all the growth stages.

Interactive effect of land configuration treatments and seed rates was found non significant at all the growth stages except at 45 DAS, where, the interactive effect of T_3 ridge and furrow- 45 cm and S_2 : 60 kg ha^{-1} seed rate gave maximum number of branches plant^{-1} (4.3) which was significantly superior to the rest of the treatment except T_3 ridge and furrow system-45 cm and S_1.80 kg ha^{-1}, T_2 BBF at 45 cm and S_2. 60 kg ha^{-1} seed rate and T_1 ridge and furrow- 60 cm and S_2 60 kg ha^{-1} seed rate at 45 DAS, the differences among these treatments were non significant.

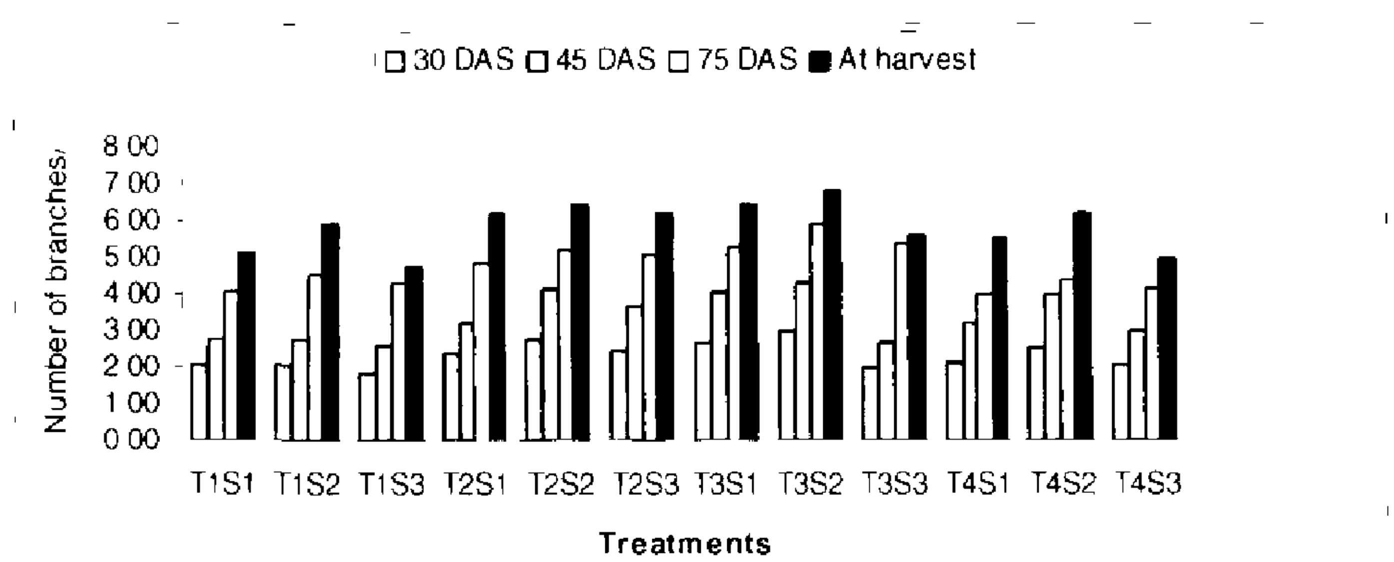


Fig. 4.1.3.A Mean number of branches plant^{-1} under different treatments at various growth stage of the crop

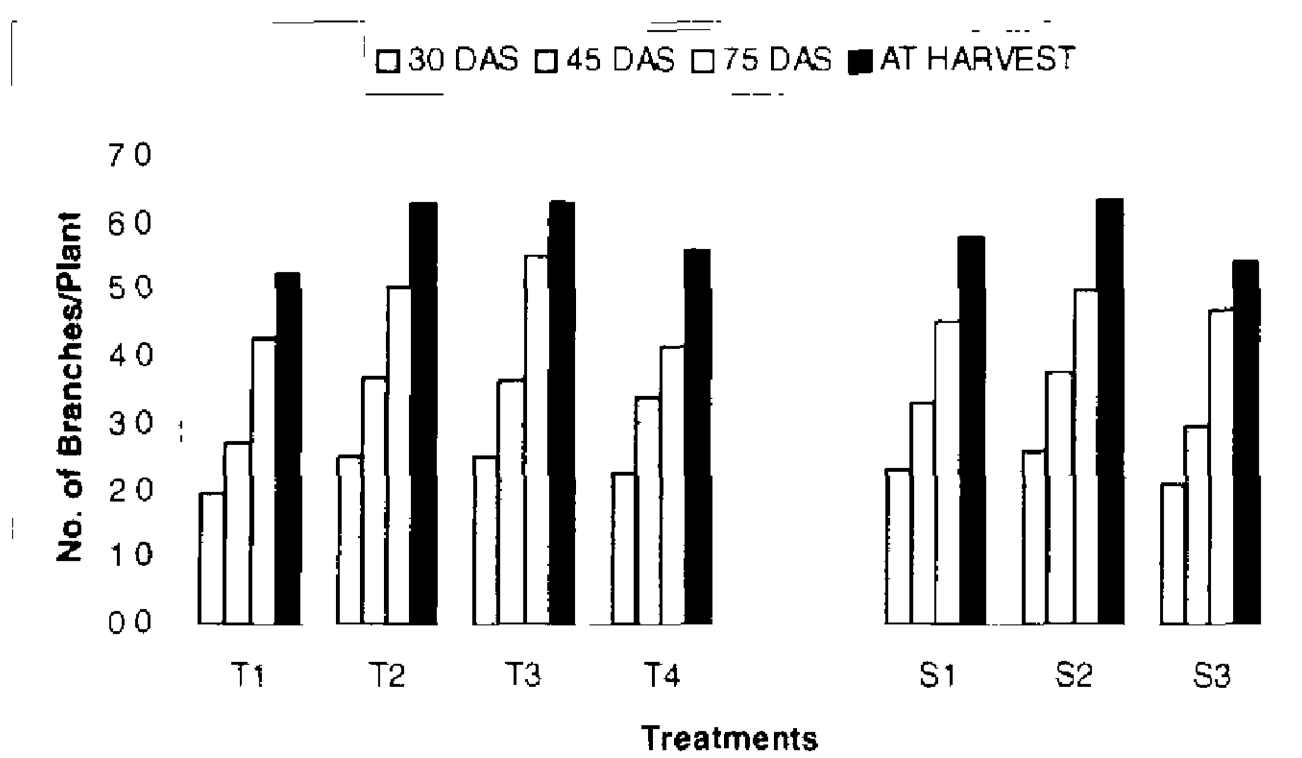


Fig. 4.1.3B Mean number of branches plant^{-1} under land configurations and seed rates at various growth stage of the crop

4.1.4a: Root growth (Number of root nodules plant^{-1})

The root nodules are responsible for the fixation of atmospheric nitrogen in the soil and their number may differ due to various treatments. The number of root nodules plant^{-1} was recorded at flowering stage of the crop under different treatments; the data are presented in Table 4.1.4a and depicted in Fig 4 1.4a A and 4.1.4a.B, the analysis of variance is presented in Appendix –V It is clear from the data that the number of root nodules plant^{-1} was influenced significantly by different treatments

In case of land configuration the lowest number of root nodules plant^{-1} was recorded in case of flat bed planting as compared to the treatment T_2.BBFS-45 cm, T_3 RFS -45 cm and T_4:RFS -60 cm

Among land configuration treatments T_2 BBFS-45 cm distance produced the highest number of root nodules plant^{-1} (Table 4 1 4), followed by T_3 ridge and furrow-45 cm (64 88) and T_4·RFS-60 cm (62 05) Treatment T_2 BBF-45 cm, T_3 :RFS-45 cm and T_4:RFS-60 cm were statistically at par with each other

In case of seed rate the differences in number of root nodules plant^{-1} were significant Maximum number of root nodules plant^{-1} (66 99) was recorded in S_2:60 kg ha^{-1} seed rate which gave significantly higher number of root nodules plant^{-1} as compared to S_1 :80 kg ha^{-1} (63.04) and S_3 : 40 kg ha^{-1} (55.67). Lowest seed rate i.e. S_3:40 kg ha^{-1} recorded significantly lower no. of nodules plant^{-1} as compared to S_1:80 kg ha^{-1} and S_2:60 kg ha^{-1}.

Table 4.1.4a Effect of land configurations (T), seed rates (S) and their interaction on number of root nodules plant^{-1} at flowering stage

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	57.19	60.50	48.43	55.37
T2 BBF-45cm	62.20	70.90	62.78	65.29
T3 RFS-45cm	70.98	73.34	50.33	64.88
T4 RFS-60cm	61.81	63.23	61.64	62.05
Mean	63.04	66.99	55.67	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	0.89	0.51	1.02	1.22
C.D.(at 5%)	2.87	1.49	2.99	3.76

Interactive effect of land configuration treatments and seed rates was found significant T_3: ridge and furrow- 45 cm and S_2 :60 kg ha^{-1} seed rate gave maximum number of root nodules plant^{-1} (73.34) which was significantly superior than the rest of the treatments and the lowest number of root nodules plant^{-1} (48.43) in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate which was found significantly inferior to the rest of the treatments.

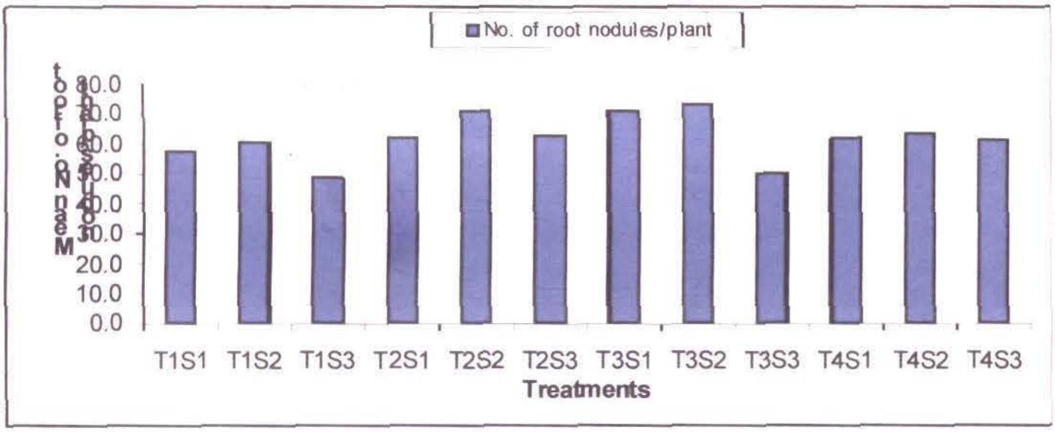


Fig. 4.1.4a.A Mean number of root nodules plant^{-1} under different treatments at flowering growth stage of the crop

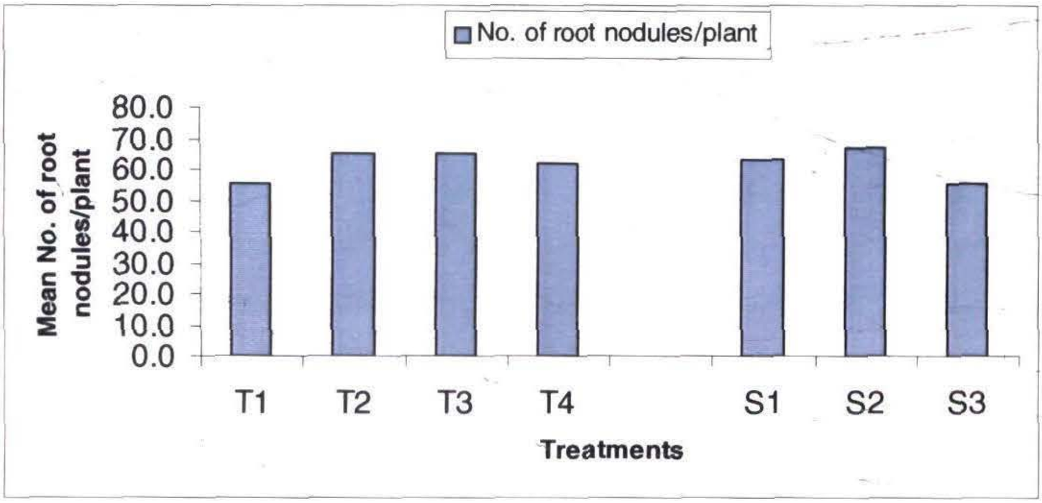


Fig. 4.1.4a.B Mean number of root nodules plant^{-1} under land configurations and seed rates at flowering growth stage of the crop

4.1.4b: Root length:

Data presented in Fig. 4.1.4 revealed that the higher root length was recorded in the treatments T_2 :BBF-45 cm and S_1: 80 kg ha^{-1}, T_3 :RFS-45 cm and S_1:80 kg ha^{-1} and T_4 : RFS-60 cm and S_1: 80 kg ha^{-1} seed rate as compared to T_1 :FBS-45 cm and S_1: 80 kg ha^{-1} that is flat bed planting. The percent increase in the root length due to land configuration treatments was more than 50%. The maximum root length was observed in T_3 :RFS-45 cm and S_1:80 kg ha^{-1} (61% more) followed by T_2 :BBF-45 cm and S_1: 80 kg ha^{-1} (57%more), T_3 :RFS-45 cm and S_1:80 kg ha^{-1} (50%more) as compared to T_1 :FBS-45 cm and S_1: 80 kg ha^{-1}, which gave minimum root length of 28 m.

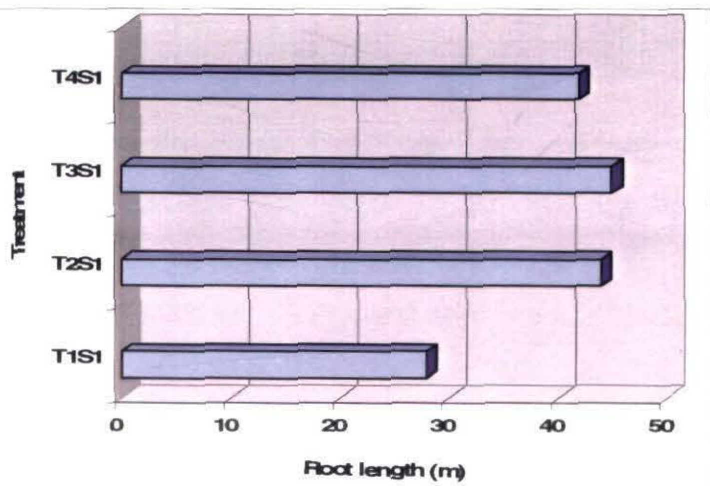


Fig. Effect of land configuration on the root length of soybean

4.1.5. Leaf Area Index (LAI)

Leaf area is important for photosynthesis. Its estimation indicates both assimilating area and growth. For crop, leaf area per unit land area is more important than leaf area of individual plants. The observation on leaf area index recorded at 30, 45 and 75 DAS and the data are presented in Table 4.1.5 and depicted in Fig. 4.1.5A and 4.1.5B, the analysis of variance is presented in Appendix –IV.

Table 4.1.5 Effect of land configurations (T), seed rates (S) and their interaction on leaf area index at various growth stagė of the crop

d ations	Seed rates											
	S_1 - 80 kg ha^{-1}			S_2 - 60 kg ha^{-1}			S_3 - 40 kg ha^{-1}			Mean		
	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS
l5cm	3.47	4.90	10.6	3.53	4.95	10.80	3.39	4.75	10.48	3.46	4.87	10.63
l5cm	3.96	5.38	11.03	4.16	5.20	11.20	4.01	5.20	10.95	4.04	5.26	11.06
l5cm	4.22	5.35	11.13	4.46	5.55	11.25	3.45	4.75	10.63	4.04	5.22	11.00
i0cm	3.68	5.20	10.75	4.03	5.33	11.05	3.46	5.10	10.80	3.72	5.21	10.87
	3.83	5.21	10.88	4.04	5.26	11.08	3.57	4.95	10.71			
	T			S			$(TxS)_1$			$(TxS)_2$		
	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS	30 DAS	45 DAS	75 DAS
	0.06	0.04	0.05	0.07	0.03	0.03	0.14	0.07	0.07	0.13	0.07	0.09
%)	0.20	0.14	0.18	0.20	0.10	0.11	0.41	0.21	0.22	0.39	0.21	0.27

It is evident from the table that there was a significant effect of different treatments on the leaf area index. At 30 DAS the maximum leaf area index was recorded in T_2 :BBF-45 cm (4.04) and T_3 :RFS-45 cm (4.04) followed by T_4:RFS-60 cm (3.72) and minimum in case of T_1: FBS-45 cm (3.46), which was found statistically inferior to the rest of the treatments. Almost similar trend was observed in case of 45 and 75 DAS. AT 45 DAS the leaf area recorded in T_2 :BBF-45 cm, T_3 :RFS-45 cm and T_4:RFS-60 cm treatment did not differ significantly from each other, while at 30 and 75 DAS the leaf area recorded in T_2 :BBF-45 cm and T_3 :RFS-45 cm treatment was found significantly higher than the treatment T_4:RFS-60 cm. Seed rate also influenced the LAI significantly at all the three stages i.e. 30, 45 and 75 DAS. At 30 DAS the maximum LAI (4.04) was recorded in the treatment S_2: 60 kg ha^{-1} seed rate followed by S_1: 80 kg ha^{-1} seed rate and minimum in case of S_3: 40 kg ha^{-1} seed rate. All the three treatments differ significantly from each other. Almost similar trend was observed in LAI recorded at 45 and 75 DAS. Interactive effect of land configuration and seed rate was also affected LAI significantly at all the three stages significant.

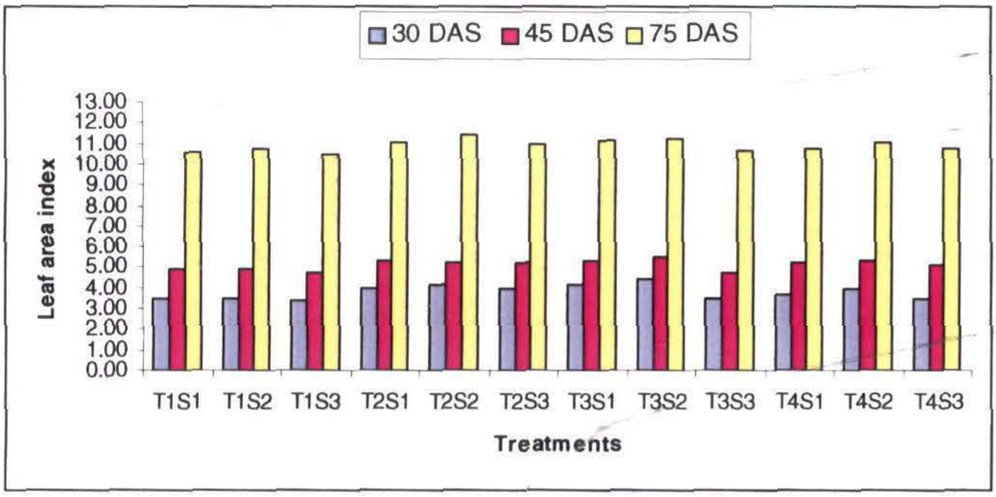


Fig. 4.1.5.A Mean leaf area index under different treatments at various growth stage of the crop

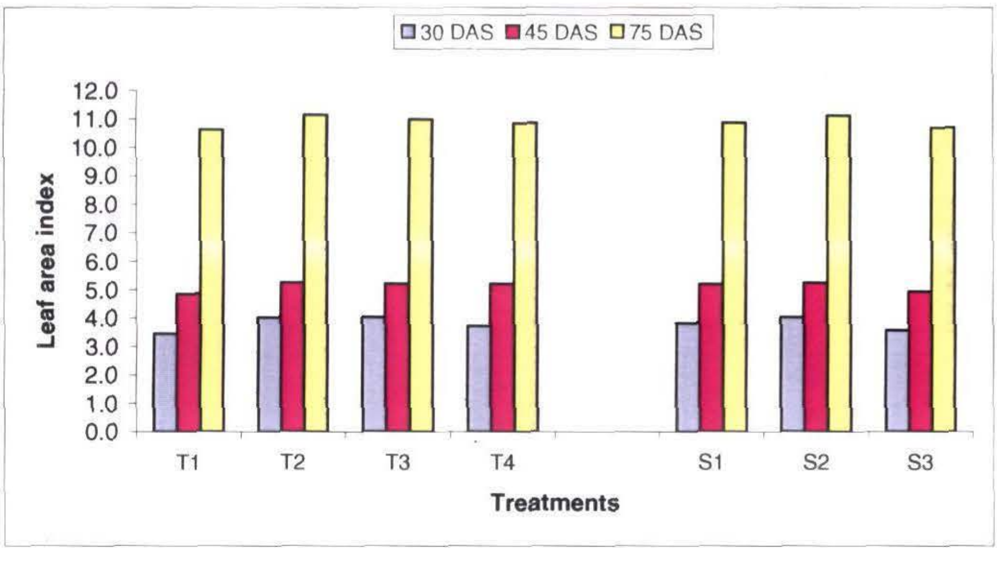


Fig. 4.1.5.B Mean leaf area index under land configurations and seed rates at various growth stage of the crop

4.1.6. Dry matter accumulation plant^{-1} (g)

The dry weight plant^{-1} was recorded at various growth stages. The periodical increase in dry weight plant^{-1} due to different treatments is presented in Appendix – VI and depicted in Fig. – 4.1.6 A and 4.1.6B.

(a) Periodical dry weight plant^{-1} (g)

It is clear from Table 4.1.6.A that the dry matter per plant was gradually increased with advancement in the age of the crop. The accumulation was maximum between 30 and 75 days in almost all the treatments. Later on rate of increase in dry weight accumulation reduced.

(b) Final dry weight plant^{-1} (g)

Final dry weight plant^{-1} recorded at harvest was analyzed statistically and presented in Appendix – VI, which showed significant effect of land configurations and seed rates interaction T x S on dry weight plant^{-1}.

Table 4.1.6.A Effect of land configurations (T), seed rates (S) and their interaction on dry matter accumulation (g) at 30 DAS and 45 DAS

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1 FBS-45cm	2.25	10.40	2.29	10.35	2.15	10.16	2.23	10.30
T_2 BBF-45cm	2.60	11.20	2.40	10.74	2.40	10.83	2.47	10.92
T_3 RFS-45cm	2.53	11.10	2.60	11.40	2.15	10.30	2.43	10.93
T_4 RFS-60cm	2.38	10.65	2.50	11.00	2.35	10.45	2.41	10.70
Mean	2.44	10.84	2.45	10.87	2.26	10.43		
	T		S		$(TxS)_1$		$(TxS)_2$	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
SE(m) ±	0.03	0.12	0.08	0.087	0.173	0.175	0.144	0.18
C.D.(at 5%)	0.11	0.39	NS	0.25	NS	0.51	NS	0.56

Table 4.1.6.B Effect of land configurations (T), seed rates (S) and their interaction on dry matter accumulation (g) at 75 DAS and at harvest stage

Land configurations	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
T_1 FBS-45cm	20.23	21.18	19.93	20.31	15.57	17.91	18.57	19.80
T_2 BBF-45cm	24.42	26.10	22.56	24.95	22.33	25.10	23.10	25.38
T_3 RFS-45cm	23.70	25.37	25.31	27.68	20.30	20.10	23.10	24.38
T_4 RFS-60cm	21.15	24.10	22.05	25.18	18.97	23.70	20.72	24.33
Mean	22.37	24.19	22.46	24.53	19.29	21.70		
	T		S		$(TxS)_1$		$(TxS)_2$	
	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest	75 DAS	At harvest
SE(m) ±	0.69	0.157	0.53	0.171	1.06	0.341	1.11	0.31
C.D.(at 5%)	2.23	0.50	1.55	0.50	NS	0.99	NS	0.95

Among land configuration treatments the maximum dry matter accumulation (DMA) at 30 DAS was recorded in the treatment T_2:BBF-45cm (2.47 g), which was closely followed by the treatments T_3:RFS-45 cm (2.43 g) and T_4 :RFS-60 cm (2.41 g) these treatments were found statistically at par with each other but were found statistically superior to the treatments T_1:FBS-45 cm (2.23 g).Similar trend of DMA was observed at 45 DAS. At 75 DAS the values of DMA recorded in the treatment T_2-BBF-45 cm and T_3:RFS-45 cm were 23.10 g, which was found statistically superior to the DMA values recorded in T_1:FBS-45 cm and T_4:RFS-60 cm treatments. At harvest the maximum DMA (25.38 g) was recorded in T_2:BBF-45 cm which was found significantly higher than rest of the treatments. Treatment T_3:RFS-45 cm and T_4:RFS-60 cm were found statistically at par with each other but superior to T_1:FBS-45 cm treatment. The perusal of the data further revealed that at 30 DAS the influence of seed rate on DMA was non significant. But at later growth stages DMA has been affected significantly due to seed rate. AT 45 DAS the treatment S_1:80 kg seed rate and S_2:60 kg seed rate were found at par with each other but the treatment S_3:40 kg seed rate produced significantly lower

DMA than S_1:80 kg seed rate and S_2:60 kg ha^{-1} seed rate. Interactive effect of land configuration and seed rate was also found non significant at 30 and 75 DAS but affected significantly at 45 and at harvest stage.

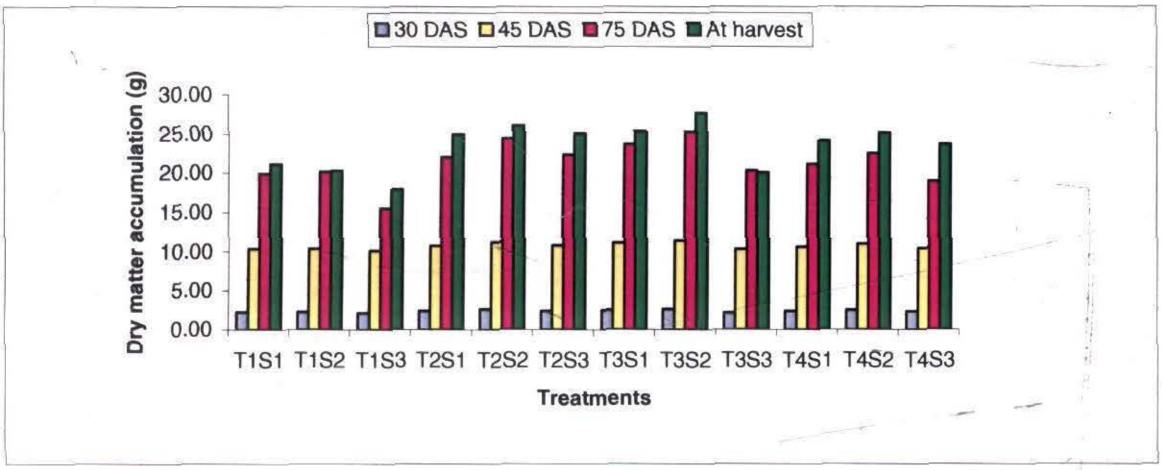


Fig. 4.1.6.A Mean dry matter accumulation $plant^{-1}$ (g) under different treatments at various growth stage of the crop

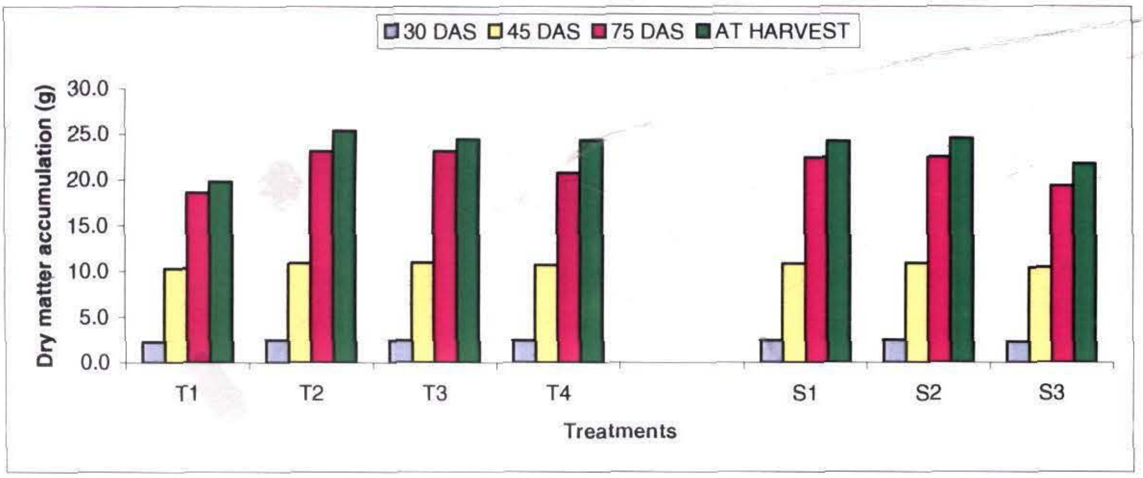


Fig. 4.1.6.B Mean dry matter accumulation $plant^{-1}$ (g) under land configurations and seed rates at various growth stage of the crop

4.1.7. Chlorophyll content

It is an important physiological character, which was recorded at flowering stage of the crop under different treatments; the data are presented in Table 4.1.7 and depicted in Fig. 4.1.7A and 4.1.7B, the analysis of variance is presented in Appendix –V. It is clear from the data that the chlorophyll content in leaves at flowering stage of the crop was non significantly influenced by different treatments. In general the chlorophyll content was highest in the treatment T_2: BBF-45 cm (42.45) followed by T_3: RFS-45 cm (42.22), T_4: RFS-60 cm (41.88) and lowest in T_1: FBS-45 cm (39.98).

Table 4.1.7 Effect of land configurations (T), seed rates (S) and their interaction on chlorophyll content at flowering stage

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	40.00	40.35	39.60	39.98
T2 BBF-45cm	42.20	43.00	42.15	42.45
T3 RFS-45cm	42.35	44.53	39.78	42.22
T4 RFS-60cm	41.85	42.35	41.45	41.88
Mean	41.60	42.56	40.74	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	1.083	0.906	1.813	1.83
C.D.(at 5%)	NS	NS	NS	NS

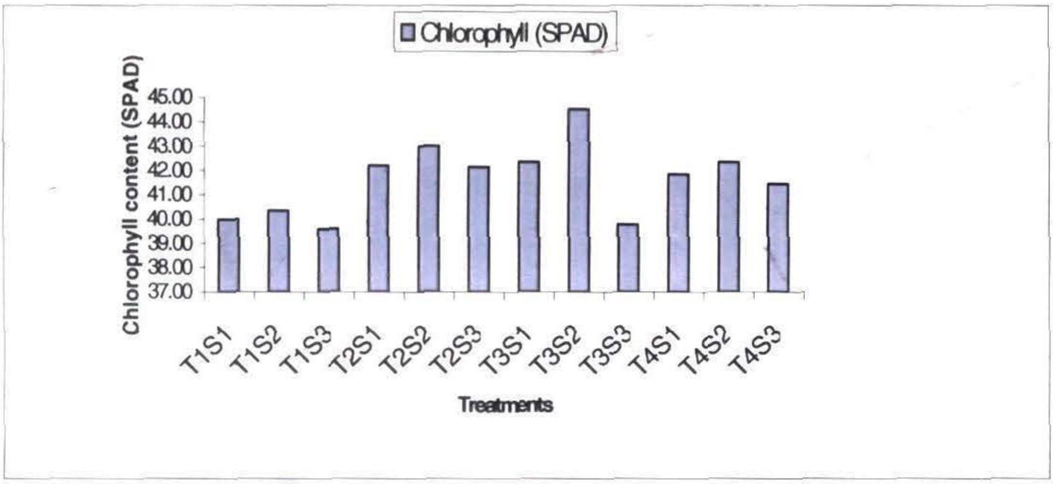


Fig. 4.1.7 Mean chlorophyll content (SPAD) under different treatments at flowering growth stage of the crop

4.2. Post Harvest Studies

Different yield attributing characters and yield were recorded to characterize the different treatment performances of soybean crop production.

4.2.1 Number of pods plant^{-1}

The number of pods plant^{-1} is one of the most important yield attributing characters, which determines the seed yield of crop under different treatments; the data are presented in Table 4.2.1 and depicted in Fig. 4.2.1A and 4.2.1B, the analysis of variance is presented in Appendix – VII.

Table 4.2.1 Effect of land configurations (T), seed rates (S) and their interaction on number of pods plant^{-1}

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	45.08	45.08	40.11	43.42
T2 BBF-45cm	51.40	56.36	51.93	53.23
T3 RFS-45cm	55.88	58.30	43.30	52.49
T4 RFS-60cm	49.25	52.11	47.52	49.63
Mean	50.40	52.96	45.71	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	0.351	0.296	0.592	0.59
C.D.(at 5%)	1.12	0.86	1.73	1.80

Among land configuration treatments, the maximum number of pods plant^{-1} were recorded in the treatment T_2:BBF-45 cm (53.23), which was closely followed by the treatments T_3:RFS-45 cm (52.49); these treatments were found statistically at par with each other but were found statistically superior to the treatments T_1:RFS-45 cm (43.23) and T_4:RFS-60 cm (49.63) . The lowest no. of pods plant^{-1} was recorded in case of T_1: FBS-45 cm which gave significantly lower no. of pods plant^{-1}. The perusal of the data further revealed that the influence of seed rate on number of pods plant^{-1} was significant. The treatment S_2: 60 kg ha^{-1} gave significantly higher no. of pods plant^{-1} as compared to S_1: 80 kg ha^{-1} (50.40) and S_3: 40 kg ha^{-1} (45.71). Data further revealed that the treatment S_2: 60 kg seed rate gave significantly lower no. of pods plant^{-1} as compared to S_1:80 kg seed rate. Interactive effect of land configuration and seed rate also influenced the no. of pods per plant significantly being highest in T_3 :RFS-45 cm and S_2: 60 kg ha^{-1} (58.30) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} (40.11).

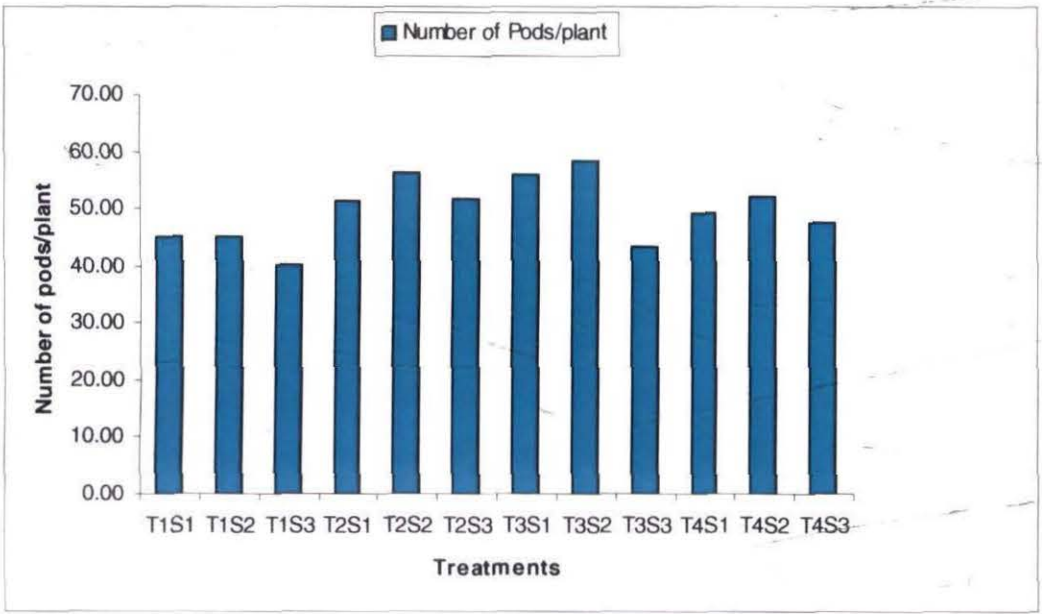


Fig. 4.2.1.A Mean number of pods plant^{-1} under different treatments

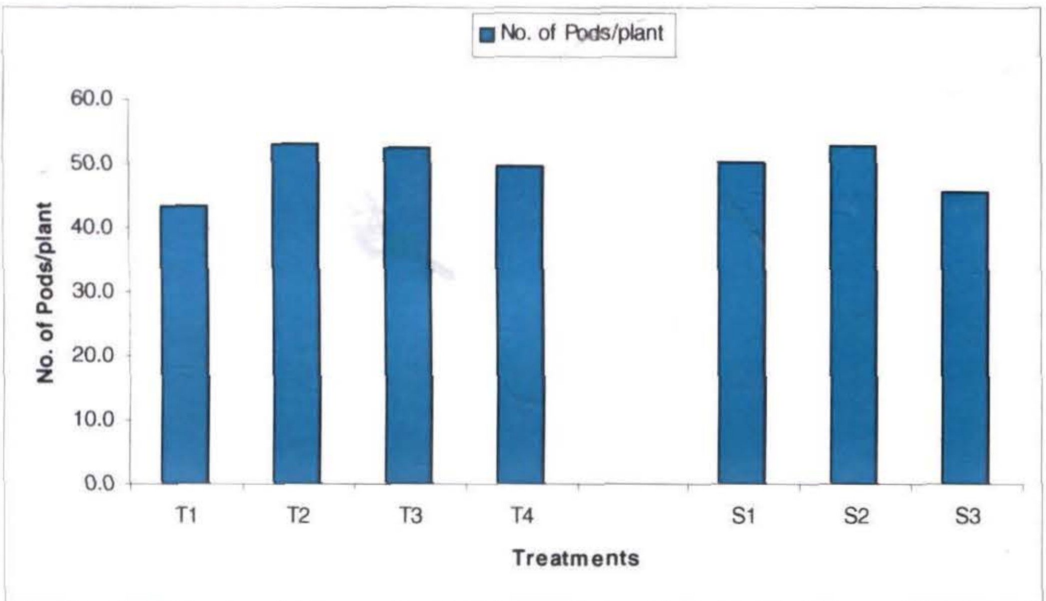


Fig. 4.2.1.B Mean number of pods plant^{-1} under land configurations and seed rates

4.2.2 Number of seeds pod^{-1}

It is also important yield attributing character having direct impact on the seed yield of crops. The data on seeds per pod were analyzed statistically. The data are presented in Table 4.2.2 and depicted in Fig. 4.2.; the analysis of variance is presented in Appendix –VII.

Table 4.2.2 Effect of land configurations (T), seed rates (S) and their interaction on number of seeds pod^{-1}

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	2.65	2.80	2.60	2.68
T2 BBF-45cm	2.80	2.85	2.80	2.82
T3 RFS-45cm	2.80	2.95	2.65	2.80
T4 RFS-60cm	2.70	2.80	2.70	2.73
Mean	2.74	2.85	2.69	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	0.083	0.049	0.098	0.11
C.D.(at 5%)	NS	NS	NS	NS

Among land configuration treatments the maximum no. of seeds pod^{-1} was recorded in the treatment T_2:BBF-45 cm (2.82), which was closely followed by the treatments T_3: RFS-45 cm (2.80), T_4: RFS-60 cm (2.73) and minimum in case of T_1: FBS-45 cm (2.68); these treatments were found statistically at par with each other. The perusal of the data further revealed that the influence of seed rate on no. of seeds pod^{-1} was also found non significant. The treatment S_2: 60 kg ha^{-1} gave highest no. of seeds pod^{-1} followed by S_1: 80 kg ha^{-1} (2.74) and lowest in S_3: 40 kg ha^{-1} (2.69). Interactive effect of land configuration and seed rate did not influence the no. of seeds pod^{-1} significantly

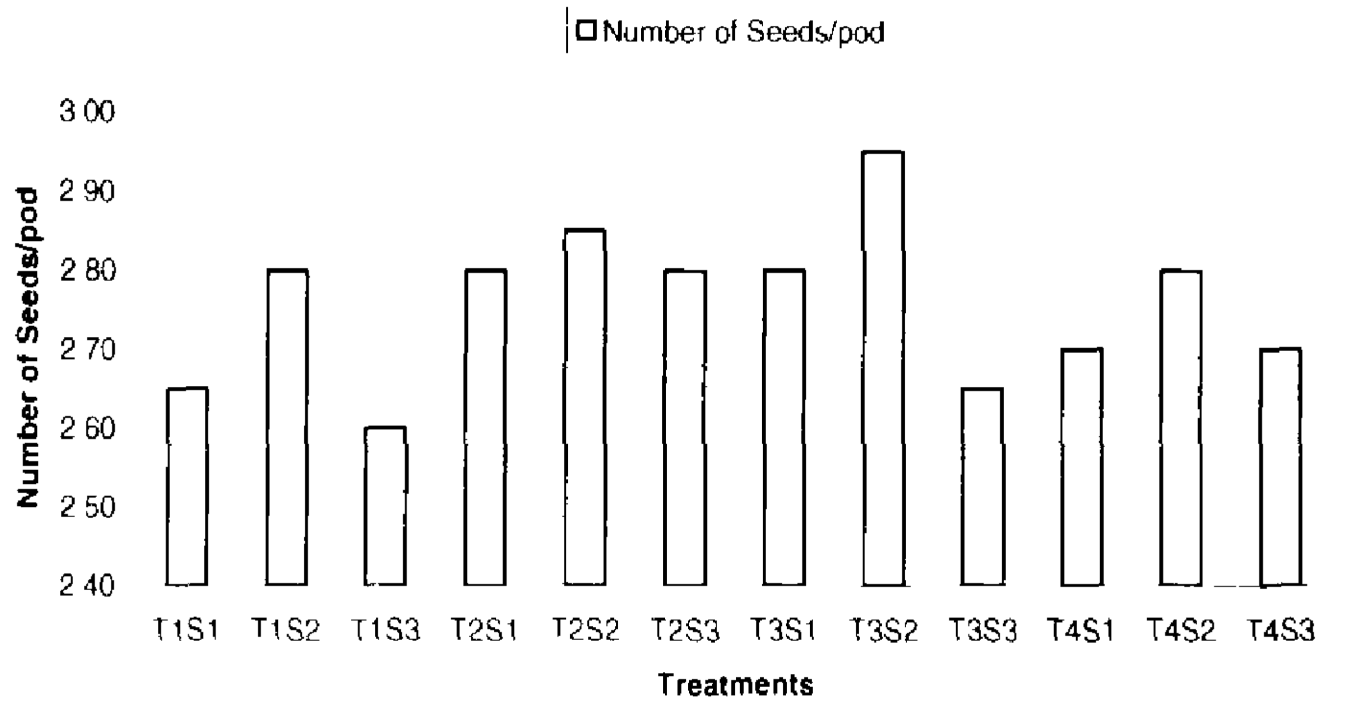


Fig. 4.2.2 Mean number of seeds pod^{-1} under different treatments

4.2.3 Grain weight plant^{-1} (g)

Grain weight is important indication of yield of any crop. The data are presented in Table 4 2.3 and depicted in Fig 4 2.3A and 4.2.3B, the analysis of variance is presented in Appendix –VIII.

Table 4.2.3 Effect of land configurations (T), seed rates (S) and their interaction on grain weight plant^{-1} (g)

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	9.36	9.70	8.63	9.23
T2 BBF-45cm	11 71	12.31	11 67	11.90
T3 RFS-45cm	11.93	12.47	8 73	11.04
T4 RFS-60cm	10.55	11.85	10.30	10.90
Mean	10.89	11 58	9 83	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	0.148	0 111	0 221	0.23
C.D (at 5%)	0 47	0 32	0 64	0.70

Among land configuration treatments the highest seed weight plant^{-1} was recorded in the treatment T_2: BBF-45 cm (11.90 g), which was found significantly superior to the rest of the treatments. The treatments T_3: RFS-45 cm recorded (11.04 g) seed weight plant^{-1} which was closely followed by the treatment T_4:RFS-60 cm (10.90 g) these treatments were found statistically at par with each other but were found statistically superior to the treatments T_1 :FBS-45 cm (9.32 g), which recorded lowest seed weight plant^{-1}. The perusal of the data further revealed that the influence of seed rate on seed weight plant^{-1} was significant. The treatment S_2: 60 kg ha^{-1} gave significantly higher seed weight plant^{-1} (11.58 g) as compared to S_1: 80 kg ha^{-1} (10.89 g) and S_3: 40 kg ha^{-1} (9.83 g). Data further revealed that the treatment S_3: 40 kg ha^{-1} gave significantly lower seed weight per plant as compared to S_2: 60 kg and S_1: 80 kg ha^{-1}. Interactive effect of land configuration and seed rate also influenced significantly being highest in T_3 : RFS-45 cm and S_2: 60 kg ha^{-1} (12.47 g) and the lowest in T_1 : FBS-45 cm and S_3 : 40 kg ha^{-1} (8.63 g).

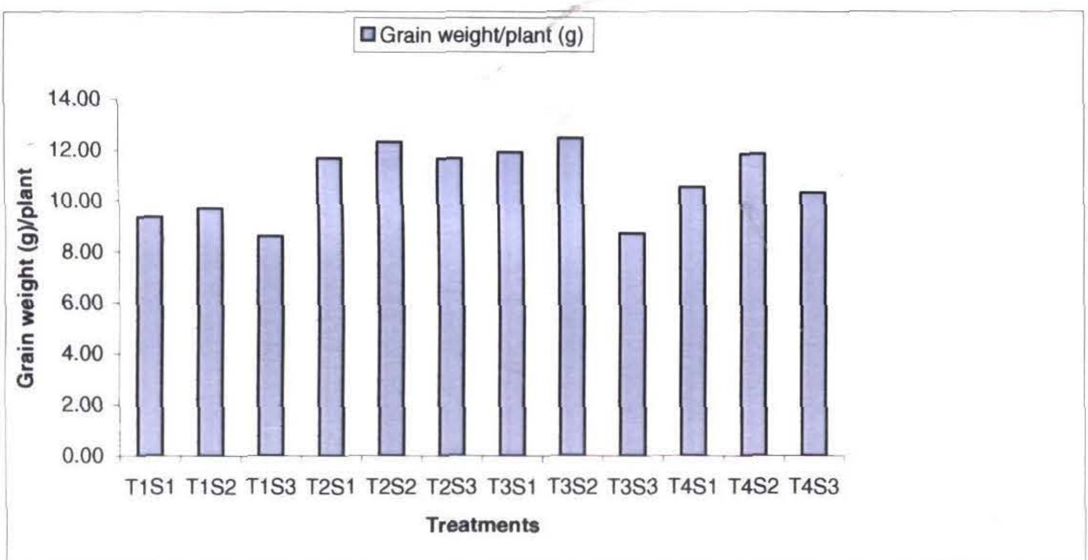


Fig. 4.2.3.A Mean grain weight plant^{-1} (g) under different treatments

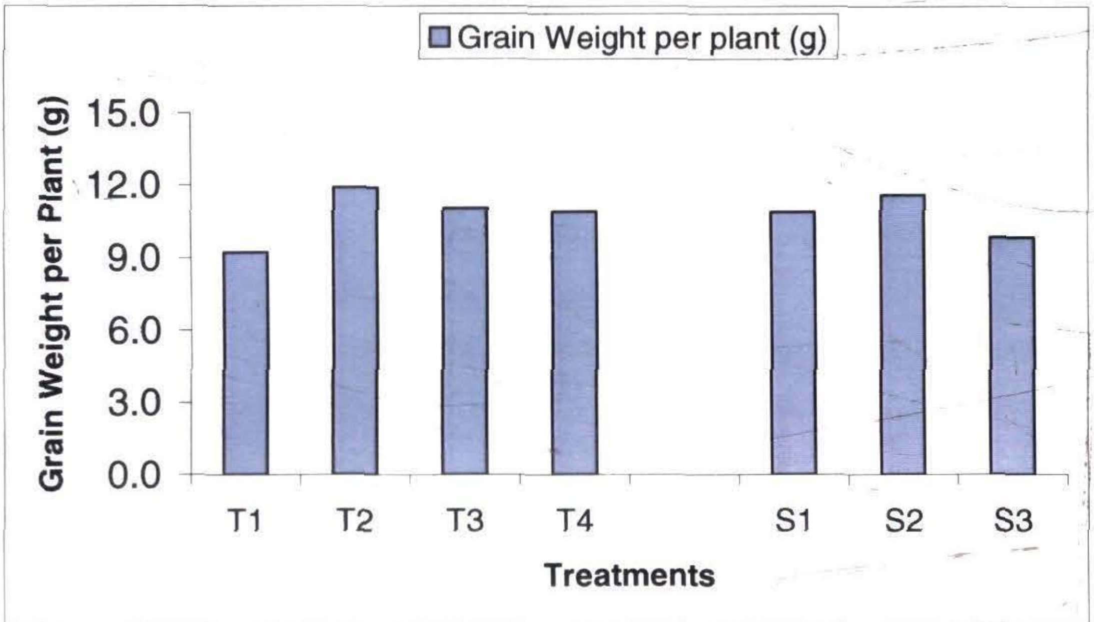


Fig. 4.2.3.B Mean grain weight plant^{-1} (g) under land configurations and seed rates

4.2.4 Seed Index (g)

Seed index is also an indication of yield of any crop. Therefore, it was recorded and subjected to statistical analysis. The data are presented in Table 4.2.4 and depicted in Fig. 4.2.4A and 4.2.4B; the analysis of variance is presented in Appendix –VIII.

Table 4.2.4 Effect of land configurations (T), seed rates (S) and their interaction on seed index (g)

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	8.75	8.85	7.35	8.32
T2 BBF-45cm	9.18	10.05	9.28	9.50
T3 RFS-45cm	9.83	10.60	8.58	9.67
T4 RFS-60cm	9.00	9.38	8.88	9.08
Mean	9.19	9.72	8.52	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	0.20	0.13	0.27	0.30
C.D.(at 5%)	0.65	0.40	0.80	0.92

Among land configuration treatments the highest seed index was recorded in the treatment T_3 :RFS-45 cm (9 67 g), which was closely followed by the treatments T_2·BBFS-45 cm (9.50 g) and T_4:RFS-60 cm (9.08 g); these treatments were found statistically at par with each other but were found statistically superior to the treatments T_1:FBS-45 cm (8.32 g) . The perusal of the data further revealed that the influence of seed rate on seed index was significant. The treatment S_2: 60 kg ha^{-1} gave significantly higher seed index (9 72 g) as compared to S_1: 80 kg ha^{-1} (9 19 g) and S_3: 40 kg ha^{-1} (8.52 g) Data further revealed that the treatment S_1 80 kg ha^{-1} gave significantly lower seed index as compared to S_2: 60 kg ha^{-1} and S_3· 40 kg ha^{-1}. Interactive effect of land configuration and seed rate also influenced significantly being highest seed index in T_3 : RFS-45 cm and S_2: 60 kg ha^{-1} (10.60 g) and the lowest in T_1 : FBS-45 cm and S_3 : 40 kg ha^{-1} (7.35 g).

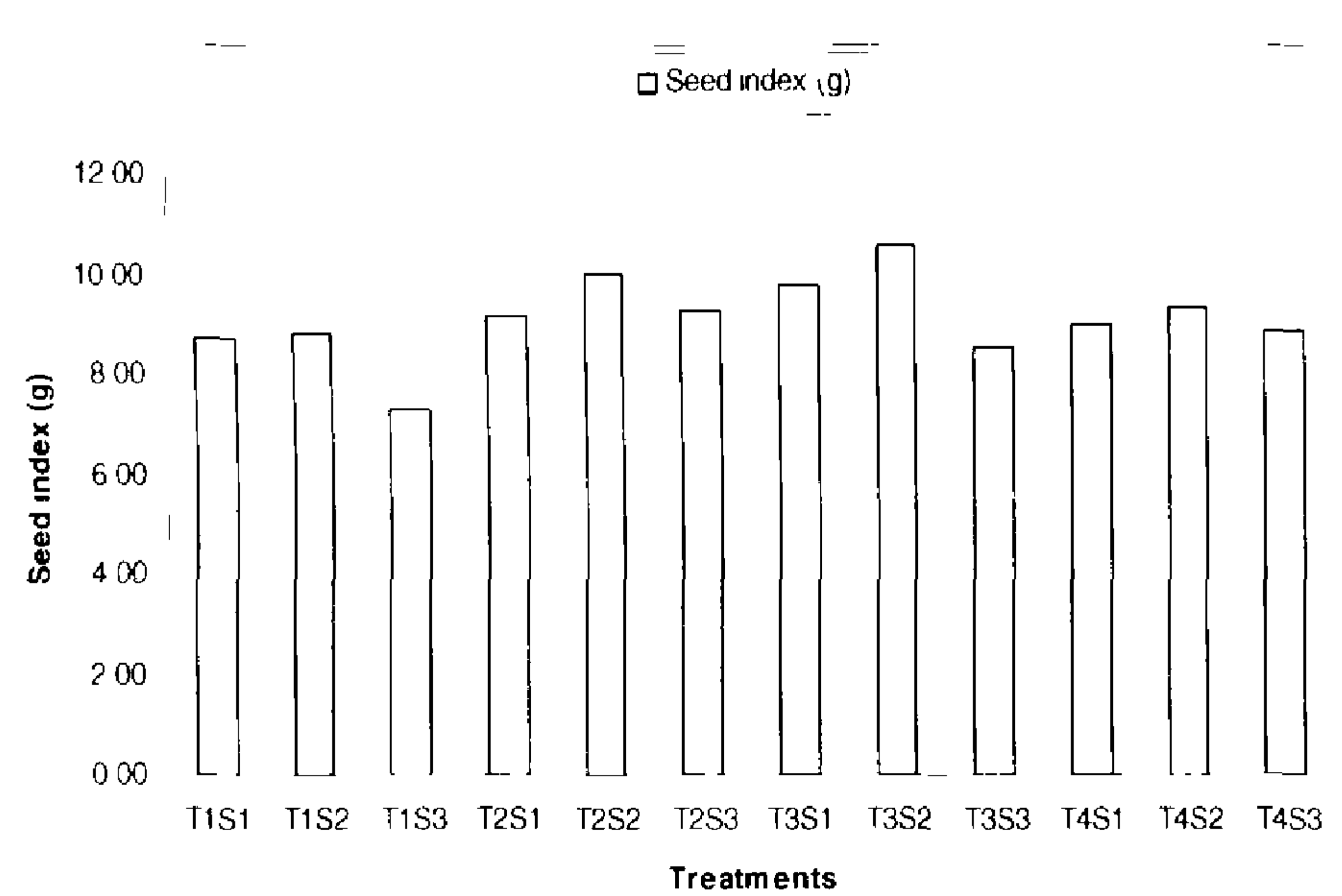


Fig. 4.2.4.A Mean seed index (g) under different treatments

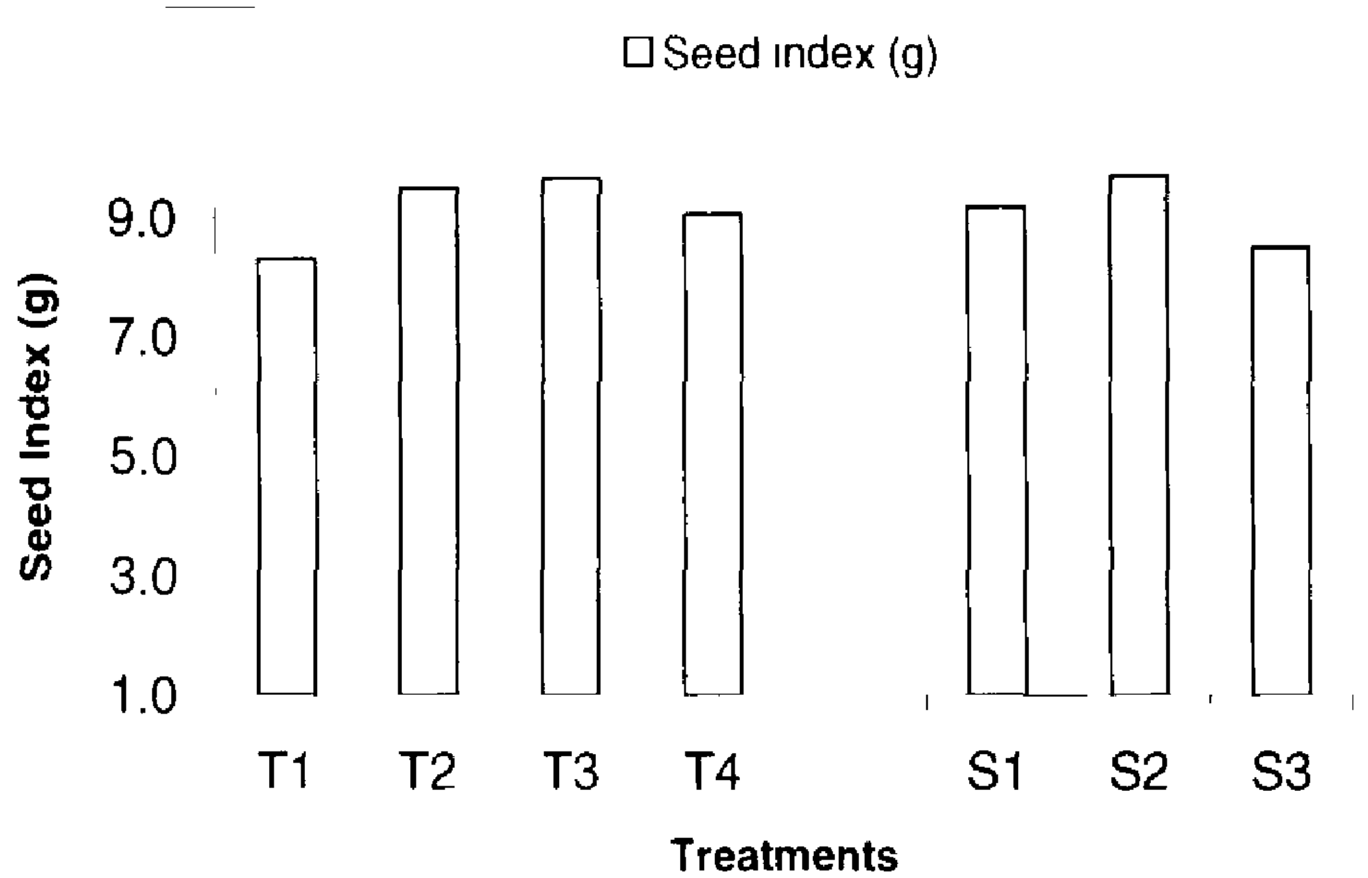


Fig. 4.2.4.B Mean seed index (g) under land configurations and seed rates

4.2.5 Grain yield (kg ha^{-1})

Grain yield of the crop is the consequence of the various biotic and abiotic factors, which are responsible for changes brought about in the productivity. Grain yield is the ultimate character responsible for judging the suitability or superiority of one treatment over the other The effectiveness of any treatment could be judged by the magnitude of changes in the productivity potential of a crop responded to different treatment in the experiment.

Table 4.2.5 Effect of land configurations (T), seed rates (S) and their interaction on grain yield (kg ha^{-1})

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	1799	1883	1657	1780
T2 BBF-45cm	2277	2472	2293	2347
T3 RFS-45cm	2324	2657	1733	2238
T4 RFS-60cm	2249	2296	1925	2157
Mean	2162	2327	1902	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	82.22	73.89	147 7	146 02
C.D (at 5%)	262 80	215 29	430 57	439 2

The perusal of the data presented in Table 4.2.5 and depicted in Fig. 4.2.5A and 4.2.5B; the analysis of variance is presented in Appendix – IX on seed yield of soybean revealed that there was a significant effect of land configuration treatment on the seed yield. It was highest in T_2: BBF-45 cm (2347 kg ha^{-1}), followed by T_3: RFS-45 cm (2238 kg ha^{-1}), T_4: RFS-60 cm (2157 kg ha^{-1}); these three treatments were found statistically at par with each other but gave significantly higher seed yield as compared to T_1: FBS-45 cm (1780 kg ha^{-1}). Among seed rates the highest seed yield was recorded in case of S_2 :60 kg ha^{-1} (2327 kg ha^{-1}), S_1: 80 kg ha^{-1} (2162 kg ha^{-1}) and lowest in S_3 :40 kg ha^{-1} (1902 kg ha^{-1}). Treatments S_2 :60 kg ha^{-1} and S_1: 80 kg ha^{-1} were statistically at par with each other but were found statistically superior to S_3 :40 kg ha^{-1}. Interactive effect of land configuration and seed yield was also found significant being highest seed yield recorded in T_3 : RFS-45 cm and S_2: 60 kg ha^{-1} (2657 kg ha^{-1}) and the lowest in T_1 : FBS-45 cm and S_3 : 40 kg ha^{-1} (1657 kg ha^{-1}).

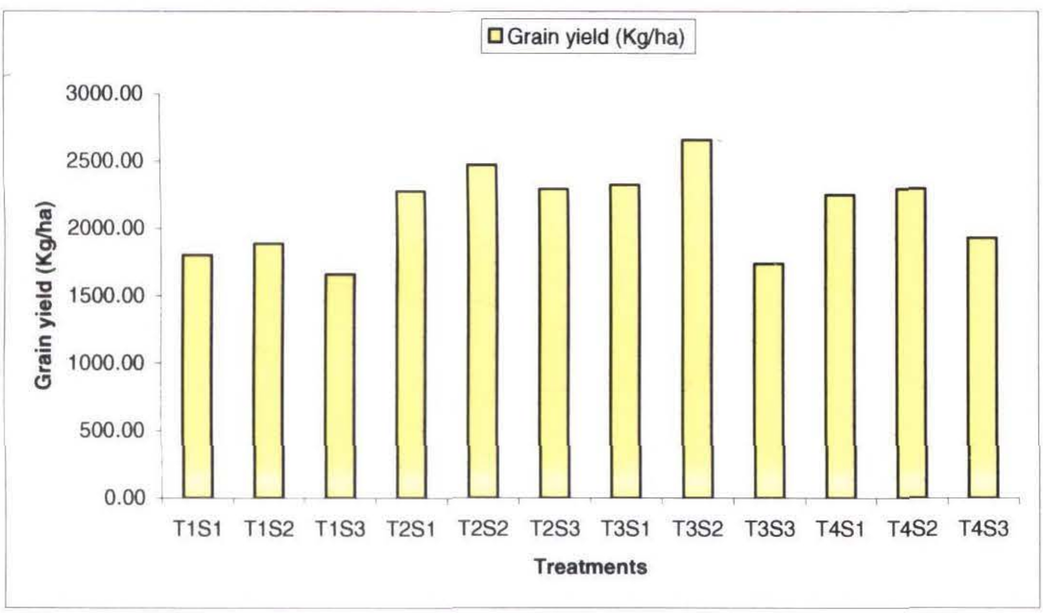


Fig. 4.2.5.A Mean Grain yield (kg ha^{-1}) under different treatments

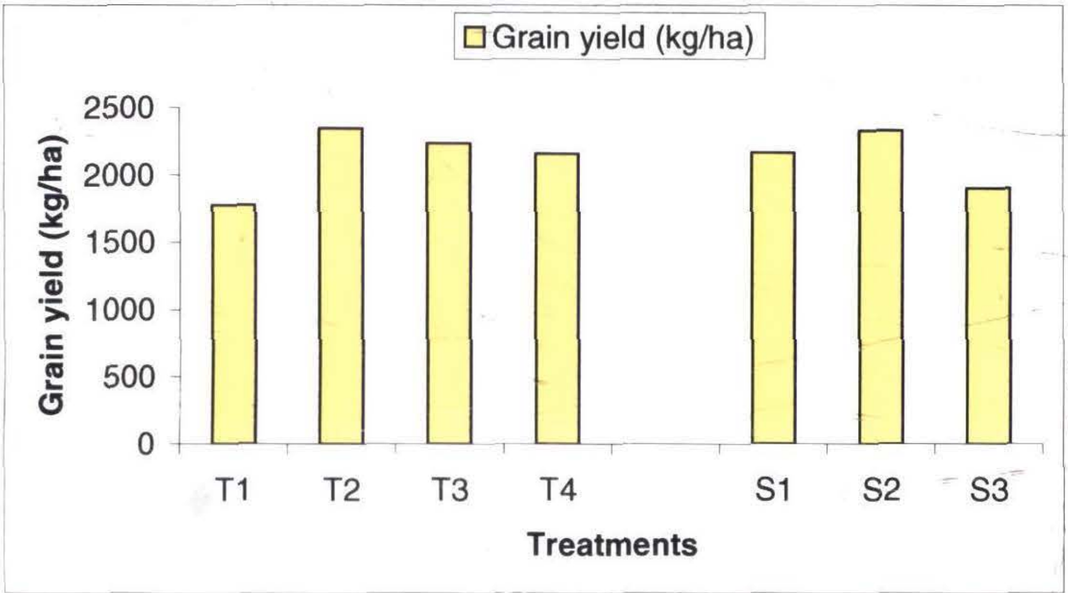


Fig. 4.2.5.B Mean Grain yield (kg ha^{-1}) under land configurations and Seed rates

4.2.6 Stover or Straw yield (kg ha^{-1})

The data are presented in Table 4.2.6 and depicted in Fig. 4.2.6 ; the analysis of variance is presented in Appendix –IX.

Table 4.2.6 Effect of land configurations (T), seed rates (S) and their interaction on stover yield (kg ha^{-1})

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	3215	3132	3589	3312
T2 BBF-45cm	3617	3515	3533	3555
T3 RFS-45cm	3478	3422	3032	3311
T4 RFS-60cm	3645	3691	3441	3592
Mean	3489	3440	3399	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) ±	98.58	85.52	171.04	170.95
C.D.(at 5%)	NS	NS	NS	NS

The stover yield recorded under different treatments show non significant effect of different treatments and their interaction on the stover yield of soybean .

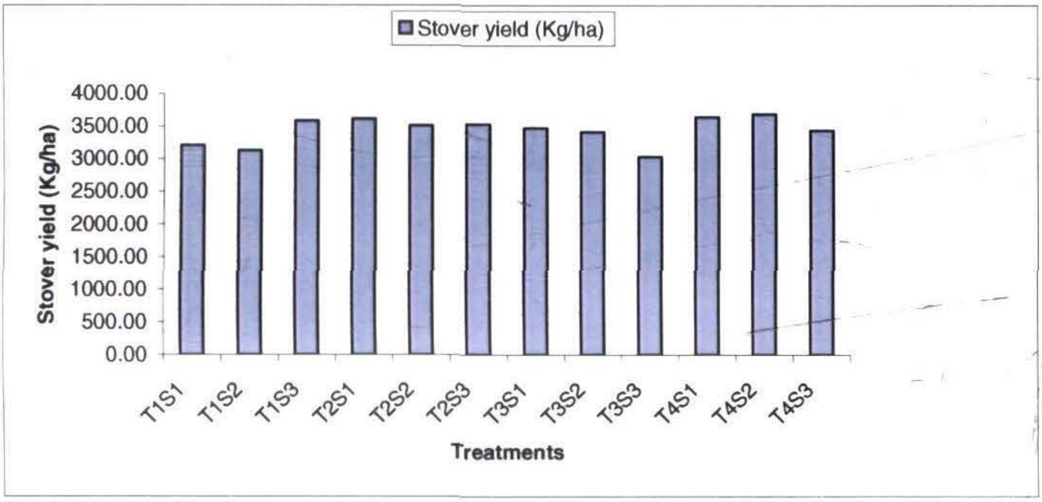


Fig. 4.2.6 Mean stover yield (kg ha^{-1}) under different treatments

Harvest Index (%)

Harvest index is the ratio of economic yield to biological yield, which is expressed in term of percentage. The data are presented in Table 4.2.7 and depicted in Fig. 4.2.7; the analysis of variance is presented in Appendix –IX.

Table 4.2.7 Effect of land configurations (T), seed rates (S) and their interaction on harvest index

Land configurations	Seed rates			
	S_1 - 80 kg ha^{-1}	S_2 - 60 kg ha^{-1}	S_3 - 40 kg ha^{-1}	Mean
T1 FBS-45cm	44.08	46.52	39.70	43.22
T2 BBF-45cm	47.34	50.90	4856	48.93
T3 RFS-45cm	49.29	54.12	44.78	49.40
T4 RFS-60cm	47.35	47.29	44.41	46.35
Mean	47.02	49.71	44.20	
	T	S	$(TxS)_1$	$(TxS)_2$
SE(m) $\pm$	.149	1.35	2.71	2.16
C.D.(at 5%)	NS	3.95	NS	NS

Perusal of the data revealed that the seed rate has influenced the harvest index significantly, while the effect of land configuration and its interaction with seed rate was found non significant on the harvest index. Among seed rate treatments the highest harvest index (49.11%) was recorded in S_2:60 kg ha^{-1} followed by S_1:80 kg ha^{-1}(47.02%); these two treatments were found at par with each other. The lowest HI was recorded due to S_3: 40 kg ha^{-1} which was found significantly inferior to S_1:80 kg ha^{-1} but was at par with S_2:60 kg ha^{-1}. Interactive effect was found absent.

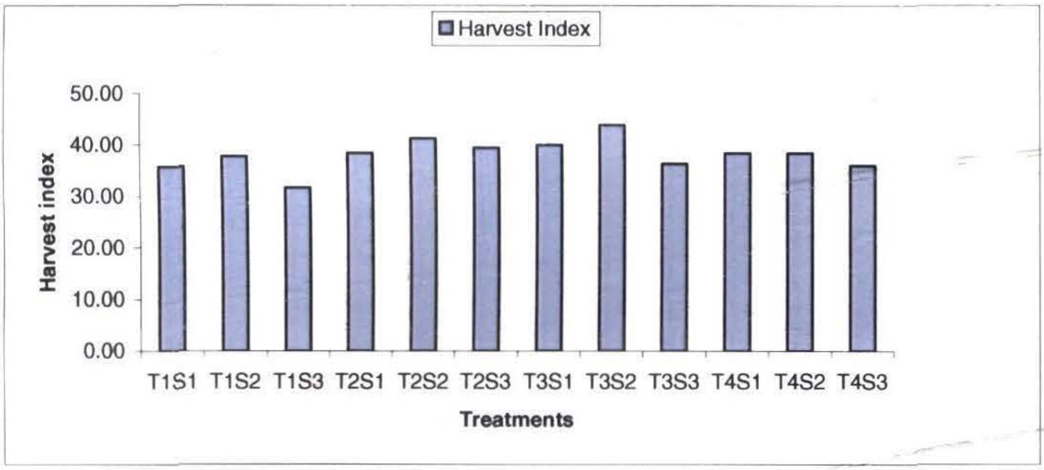


Fig. 4.2.7 Mean harvest index under different treatments

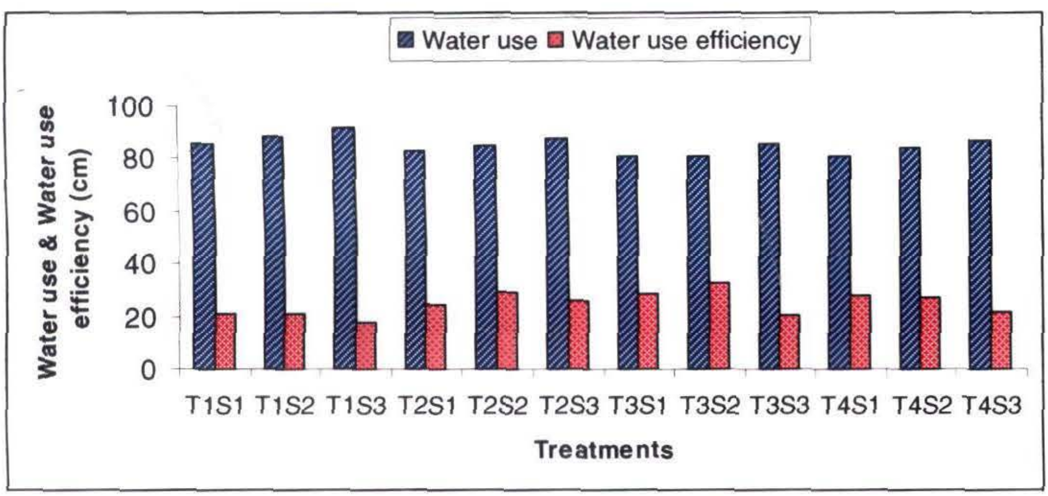
4.2.8 Water use and Water Use Efficiency

Using profile depletion method, water use and water use efficiency was calculated and data are presented in Table 4.2.7. From the data it is evident that there was not a very systematic trend was observed in case of water use. In case of land configuration water use was maximum in T_1 :FBS-45 cm (88.77 cm), followed by T_4:RFS-60 cm (84.11 cm) and minimum in case of T_3:RFS-45 cm (82.31 cm). In case of seed rate data, it revealed that the water use was more in case of lower seed rate treatment i.e. S_3: 40 kg ha^{-1} (88.06 cm), followed by S_2: 60 kg ha^{-1} (84.61 cm) and minimum in case of S_1: 80 kg ha^{-1} (82.65 cm). Water use efficiency data revealed that among land configuration treatment the highest WUE was recorded in T_2:BBF-45 cm (27.55, kg $ha^{-1}cm^{-1}$) which was closely followed by the treatment T_3:RFS-45 cm (27.32, kg $ha^{-1}cm^{-1}$), T_4: RFS-60 cm (25.71 , kg $ha^{-1}cm^{-1}$) and minimum in case of T_1: FBS-45cm (20.08 kg $ha^{-1}cm^{-1}$). In case of seed rate the highest WUE was recorded in S_2 : 60 kg ha^{-1}

(27.63 kg $ha^{-1}cm^{-1}$) and minimum in S_3: 40 kg ha^{-1} (21.64 kg $ha^{-1}cm^{-1}$). If we look at the interactive effects the data emphasized that the highest WUE i.e. 32.95 kg $ha^{-1}cm^{-1}$ was recorded in case of T_3:RFS-45cm and S_2: 60 kg ha^{-1} and minimum in case of T_1: FBS-45 cm and S_3: 40 kg ha^{-1} (17.99 kg $ha^{-1}cm^{-1}$).

Table 4.2.8 Effect of land configuration and seed rate on the water use (WU, cm) and Water Use Efficiency (WUE, kg $ha^{-1}cm^{-1}$).

Treatments	Seed rates							
	S_1 - 80 kg ha^{-1}		S_2 - 60 kg ha^{-1}		S_3 - 40 kg ha^{-1}		Mean	
Land configurations	WU,	WUE,	WU,	WUE,	WU,	WUE,	WU,	WUE,
T1 FBS-45cm	86.01	20.92	88.20	21.35	92.11	17.99	88.77	20.08
T2 BBF-45cm	82.90	27.47	85.23	29.00	87.60	26.18	85.24	27.55
T3 RFS-45cm	80.91	28.72	80.63	32.95	85.40	20.29	82.31	27.32
T4 RFS-60cm	80.80	27.83	84.40	27.20	87.13	22.09	84.11	25.71
Mean	82.65	26.24	84.61	27.63	88.06	21.64	85.11	25.17



4.2.8 Mean water use & water use efficiency under land configurations and seed rates treatment combination

4.3 Economics of treatments

The economics of various treatments was calculated and data on cost of cultivation, gross return, net return and B: C ratio are presented in Table 4.3.1 and depicted in Fig. 4.3.1. Perusal of data revealed that the cost of cultivation per hectare for different treatments ranged between Rs

10, 000 to 11400. It was maximum in the treatment combination T_3S_1 and T_4S_1 and minimum in case of T_1S_3. The highest gross return (Rs 44230 ha^{-1}), net return (Rs 33330 ha^{-1}) and B:C ratio (1:4.06) was recorded in the treatment T_3S_2 and the lowest in T_1S_3 i.e. Rs. 28313 ha^{-1} gross return, Rs 18313 ha^{-1} net return and 2.83 B:C ratio.

Table: 4.3.1 Economics of various treatments

Treatment	Cost of cultivation Rs ha^{-1}	Gross income Rs ha^{-1}	Net income Rs ha^{-1}	Benefit Cost ratio
T_1S_1	11000	30407	19407	2.76
T_1S_2	10500	31699	21199	3.02
T_1S_3	10000	28313	18313	2.83
T_2S_1	11200	38253	27053	3.42
T_2S_2	10700	41313	30613	3.86
T_2S_3	10200	38463	28263	3.77
T_3S_1	11400	38924	27524	3.41
T_3S_2	10900	44230	33330	4.06
T_3S_3	10400	29249	18849	2.81
T_4S_1	11400	37822	26422	3.32
T_4S_2	10900	38586	27686	3.54
T_4S_3	10400	32535	22135	3.13

Gross income : Market value of soybean grain @ Rs 1600 q^{-1} and straw @ Rs 50 q^{-1}

Benefit Cost ratio : It is the ratio of Gross return to cost of cultivation

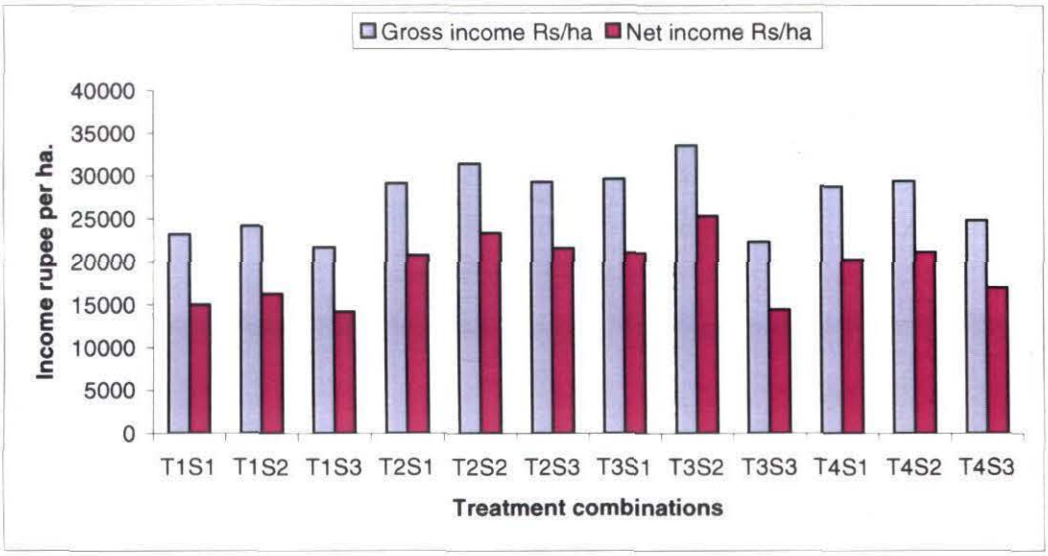


Fig: 4.3.1 Economics of various treatments

Chapter-5

Discussion

CHAPTER – 5

DISCUSSION

The experimental findings have been discussed with probable interpretation in the light of research work done in the past by various workers on the aspects relevant to the present experimental findings.

5.1 Pre harvest Studies

Perusal of findings reveal that different treatments showed significant variation in growth attributing characters i.e. plant height, number of branches, dry matter accumulation plant^{-1}, number of nodules plant^{-1} , leaf area index and number of root nodules plant^{-1}etc.

5.1.1 Plant population

Plant population was affected significantly due to different treatments. In case of land configurations significantly higher plant population was recorded (48.1) in T_4-RFS-60 cm as compared to other treatments under study. Lowest plant population was recorded in case of flat bed sowing i.e. control (40.26). As the seed rate decreased the plant population was also decreased significantly. Interactive effect of seed rate and land configuration also influenced the plant population significantly. Prevention of the occurrence of temporary water logging good aeration due to better soil porosity and low bulk density supported to better plant stand in Ridge and furrow system and BBF system than conventional method of soybean cultivation i.e. flat bed sowing. Similar results have been reported by Tomar *et al.*, (1996a). Similarly Verma *et al.*, (2004) also reported that the interactive effect of land configuration and FYM significantly increased the germination of linseed on farmers fields as compared to flat bed sowing.

5.1.2 Plant height

Land configuration did not affect the plant height significantly, while the seed rate has significant effect on plant height at 75 DAS and at harvest. As the seed rate increased the plant height also increased root growth. Similar results were also reported by Tomar *et.al.*, (1996a), Nema *et al.,* (1991) and Gupta *et al.,* (1997).

Maximum number of root nodules/plant was recorded in S_2:60 kg ha^{-1} seed rate which gave significantly higher number of root nodules $plant^{-1}$ as compared to S_1:80 kg ha^{-1} and S_3: 40 kg ha^{-1}. It signifies that over and reduced plant population adversely affected the root nodules $plant^{-1}$. The better plant growth in terms of plant height, number of branches, Leaf area index due to optimum plant population might have resulted into higher N fixation etc which might be responsible for better nodulation.

The maximum root length was observed in T_3 :RFS-45 cm and S_1 : 80 kg ha^{-1} (61% more) followed by T_2 : BBF-45 cm and S_1 :80 kg ha^{-1} (57%more), T_4 :RFS-60 cm and S_1 : 80 kg ha^{-1} (50%more) as compared to T_1 :FBS-45 cm and S_1 : 80 kg ha^{-1}. This might be due to better soil physical conditions on land configuration treatments in terms of porosity, bulk density, aeration etc.

Thakur *et al.,* (2004a) reported that ridge planting of onion, garlic, and coriander grown in Vertisols of central India is recommended as it improves crop performance and crop yields by providing better soil environment, which enhanced root growth and nutrient use.

5.1.5 Leaf area index

The data indicate that leaf area index was progressively increase with increase in the age of crop and found maximum between 45 to 75 DAS afterwards, its showed decline trend in almost all the treatments. This decline trend was because of the fact that the crop was progressing towards the maturity resulting into shedding of leaves.

There was a significant effect of different treatments on the leaf area index. The maximum leaf area index was recorded in T_2: BBF-45 cm (4.04) and T_3: RFS-45 cm (4.04) followed by T_4:RFS-60 cm (3.72) and minimum in case of T_1: FBS-45 cm (3.46), which was found statistically inferior to the rest of the treatments. Almost similar trend was observed in case of 45 and 75 DAS. Seed rate also influenced the LAI significantly at all the three stages i.e. 30, 45 and 75 DAS. At 30 DAS the maximum LAI (4.04) was recorded in the treatment S_2: 60 kg ha^{-1} seed rate followed by significantly. Many workers Verma *et al.,* (2004), Nikam and Firake (2002) have reported that higher plant population due to higher seed rate results in to more vegetative growth including plant height.

5.1.3 Number of branches plant^{-1}

In case of land configuration the lowest number of branches plant^{-1} was recorded in case of flat bed planting as compared to the treatments T_2 : BBFS 45 cm, T_3:RFS 45 cm and T_4:RFS 60 cm. This trend was maintained at all the growth stages under study. Ralli and Dhingra (2003) also reported that the number of branches and dry matter accumulation were higher in ridge sowing as compare to flat bed sowing of soybean in loamy sand soils of Ludhiana. In case of seed rate the differences in number of branches plant^{-1} were significant. Maximum numbers of branches plant^{-1} were recorded in S_2 :60 kg ha^{-1} seed rate which gave significantly higher number of branches plant^{-1} as compared to S_1 :80 kg ha^{-1} and S_3:40 kg ha^{-1}. This trend was maintained at all the growth stages. Jain *et al.*, (1996) reported that due to increased row spacing and a reduced seed rate the Crop Growth Rate and Net Assimilation Rate decreased significantly. Similar trend was also reported by Tomar *et al.*, (1996b).

5.1.4a Root growth (Number of root nodules plant^{-1})

The number of root nodules plant^{-1} was influenced significantly by different treatments. In case of land configuration the lowest number of root nodules plant^{-1} was recorded in case of flat bed planting as compared to the treatment T_2:BBFS-45 cm, T_3:RFS-45 cm and T_4:RFS-60 cm. Among land configuration treatments the differences were statistically at par with each other. Lupwayi *et al.,* (1997) reported that water logging adversely influenced the nodules dry matter it reduced the nodules dry matter by 33%, he recommended broad bed and furrow system to drain the water in the Vertisols. Thakur *et al.*, (2004b) also reported better growth of turmeric rhizomes when grown on Ridge and furrow system as compared to flat bed sowing. They explained that due to better soil plant water relationship and soil physical conditions on ridge planting enhanced

S_1: 80 kg ha^{-1} seed rate and minimum in case of S_3: 40 kg ha^{-1} seed rate. All the three treatments differ significantly from each other. Interactive effect of land configuration and seed rate was also affected LAI significantly at all the three stages significantly. Jayapaul *et al.,* (1995) reported that LAI, relative leaf water content, transpiration rate and stomatal conductance were highest and leaf temperature lowest with the broad bed and furrow treatment. Thus the better soil environment, water availability might have resulted in better plant physiological process and there by influenced the leaf area index positively. Khatri *et al.*, (2002) also reported that when wheat crop was grown on 3-row beds the growth parameters such as number of tillers m^{-1} row length, leaf area index, crop growth rate and dry matter accumulation, as well as yield attributes such as number of grains $earhead^{-1}$, grain yield $earhead^{-1}$and test weight were highest. Kumari and Rao (2005) reported that sowing of mustard with broad bed and furrow and ridge and furrow methods of land treatment during the first fortnight of October was found optimum for growth and yield of Indian mustard in Tirupati. Jain *et al.*, (1996) reported that the LAI, CGR, and NAR decreased significantly due to increased row spacing and a reduced seed rate, whereas RGR increased at a lower seed rate.

5.1.6 Dry matter accumulation $plant^{-1}$ (g)

Land configuration treatments were found statistically at par with each other but were found statistically superior to the treatments T_1:FBS-45 cm (2.23 g).Almost similar trend was observed at other growth stages. The better growth in land configuration treatments has resulted in higher DMA in case of bed planting as compared to flat bed sowing. Many workers Khichar and Ram-Niwas (2005), Khatri *et al.,* (2002), Kumari and Rao (2005) reported that the CGR and NAR were higher when crops are planted on ridge and furrow or bed planting system .The influence of seed rate on DMA was non significant at 30 DAS. But at later growth stages DMA has been affected significantly due to seed rate. Interactive effect of land configuration and seed rate was also found non significant at 30 and 75 DAS but affected significantly at 45 and at harvest stage. Jain *et al.*,

(1996) reported that the LAI, CGR, and NAR decreased significantly due to increased row spacing and a reduced seed rate.

5.1.7 Chlorophyll content

Chlorophyll content in leaves at flowering stage of the crop was non significantly influenced by different treatments. In general the chlorophyll content was highest in the treatment T_2: BBF-45cm (42.45) followed by T_3: RFS-45cm (42.22), T_4: RFS-60cm (41.88) and lowest in T_1: FBS-45cm (39.98).

5.2 Post harvest studies

Post harvest studies are made to find out the effectiveness of various treatments on the yield attributes, which directly related to the grain. The perusal of data revealed that all the treatments brought remarkable improvement in the yield attributing characters *viz.;* pods plant^{-1}, seeds pod^{-1} and seed index.

5.2.1 Number of pods plant^{-1}

Among land configuration treatments the more number of pods plant^{-1} were recorded when soybean was grown on BBF/ridge & furrow system than the treatment T_1: FBS-45 cm which gave significantly lower no. of pods plant^{-1}. Raut *et al.*, (2000) reported that a significantly higher number of pods plant^{-1} was recorded from the raised bed sowing with one row, while there were no significant differences observed in pod numbers in the flat bed method, raised bed method with 3 and 4 rows, and ridges with 2 rows on both sides. The influence of seed rate on number of pods plant^{-1} was significant. The treatment S_2: 60 kg ha^{-1} gave significantly higher no. of pods plant^{-1} as compared to S_1: 80 kg ha^{-1} (50.40) and S_3: 40 kg ha^{-1} (45.71). Data further revealed that the treatment S_2: 60 kg seed rate gave significantly lower no. of pods plant^{-1} as compared to S_1:80 kg seed rate. Interactive effect of land configuration and seed rate also influenced the no. of pods plant^{-1} significantly being highest in T_3 :RFS-45 cm and S_2 60 kg ha^{-1} (58.30) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} (40.11). Ball *et al.,* (2001) reported that the population density had a large inverse association with pods plant^{-1}. Pods fertile^{-1} node differed between cultivars, and it was reduced by increasing population density.

5.2.2 Number of seeds pod^{-1}

The maximum no. of seeds pod^{-1} were recorded in the treatment T_2: BBF-45 cm (2.82), which was closely followed by the treatments T_3:RFS-45 cm (2.80), T_4: RFS-60 cm (2.73) and minimum in case of T_1: FBS-45 cm (2.68); these treatments were found statistically at par with each other. The perusal of the data further revealed that the influence of seed rate on no. of seeds pod^{-1} was also found non significant. The treatment S_2: 60 kg ha^{-1} gave highest no. of seeds pod^{-1} followed by S_1: 80 kg ha^{-1} (2.74) and lowest in S_3: 40 kg ha^{-1} (2.69). Interactive effect of land configuration and seed rate did not influence the no. of seeds pod^{-1} significantly This yield attributing character is mainly governed by the genetically and environmental factor has little effect on it, therefore, this character was not affected significantly by various treatments.

5.2.3 Seed Index (g)

Land configuration treatments gave significantly higher seed index as compared to flat bed sowing. Khatri *et al.*, (2002) also found significantly higher test weight of wheat when grown on bed planting as compared to conventional method of sowing. The perusal of the data further revealed that the influence of seed rate on seed index was significant. The treatment S_2: 60 kg ha^{-1} gave significantly higher seed index (9.72 g) as compared to S_1: 80 kg ha^{-1} (9.19 g) and S_3: 40 kg ha^{-1} (8.52 g). Data further revealed that the treatment S_1: 80 kg ha^{-1} gave significantly lower seed index as compared to S_2: 60 kg ha^{-1} and S_3: 40 kg ha^{-1}. Interactive effect of land configuration and seed rate also influenced significantly being highest seed index in T_3 :RFS-45 cm and S_2 : 60 kg ha^{-1} (10.60 g) and the lowest in T_1 :FBS-45 cm and S_3: 40 kg ha^{-1} (7.35 g). Halvankar *et al.,* (1999) reported that plant geometry influenced the test weight significantly. Similar finding were also reported by Halepyati *et al.*,(1987).

5.2.4 Seed and Straw yield (kg ha^{-1})

Seed yield is the most important character and the superiority of one treatment over others is judged by its ultimate effect on the yield of the crop. The grain yield of soybean depends upon the basic components i.e. plant population and yield $plant^{-1}$, depending upon the growth of the plant and resultant grain productivity contributed by the number of pods $plant^{-1}$. Seed yield of soybean revealed that there was a significant effect of land configuration treatment on the seed yield. It was highest in T_2: BBF-45 cm (2347 kg ha^{-1}), followed by T_3 :RFS-45 cm (2238 kg ha^{-1}), T_4. RFS-60 cm (2157 kg ha^{-1}) these three treatments were found statistically at par with each other but gave significantly higher seed yield as compared to T_1: FBS-45 cm (1780 kg ha^{-1}). Chavan, *et al.*,(1999) reported that the sowing of ground nut on broad beds and furrows gave higher yield than ridges and furrows, or flat bed sowing. Similar results were also reported by Ingle *et al.,* (1999) for soybean yield. Desai *et al.*,(2000) reported the significant effect of different land configurations on grain yield of pigeon pea. Thakur *et al.* (2004a) reported that the ridge planting of onion, garlic and coriander gave 31.5%, 22% and 10.1% higher yield, than flat bed planting respectively Similar results were also reported by Gupta *et al.*, (1997) , Nema *et al.,* (1991) and Tomar *et al.,* (2007) for soybean and maize crops. Among seed rates the highest seed yield was recorded in case of S_2 - 60 kg ha^{-1} (2327 kg ha^{-1}), S_1 - 80 kg ha^{-1} (2162 kg ha^{-1}) and lowest in S_3 - 40 kg ha^{-1} (1902 kg ha^{-1}). Treatments S_2 - 60 kg ha^{-1} and S_1 - 80 kg ha^{-1} were statistically at par with each other but were found statistically superior to S_3 - 40 kg ha^{-1}. Interactive effect of land configuration and seed yield was also found significant being highest seed yield recorded in T_3 :RFS-45 cm and S_2 :60 kg ha^{-1} (2657 kg ha^{-1}) and the lowest in T_1 :FBS-45 cm and S_3 :40 kg ha^{-1} (1657 kg ha^{-1}). Jasani *et al.,* (1993) reported that the increasing seed rate from 40 kg ha^{-1} to 70 kg ha^{-1} increased the seed yield of soybean significantly. On the contrarily Kleinschmidt (2001) found no significant differences in yield due to different sowing rates. Similar, results were also reported for straw yield by Khichar and Ramniwas (2005).

5.2.5 Water use and Water Use Efficiency

Among land configuration treatments the highest WUE was recorded in T_2:BBF-45 cm (27.55, kgha^{-1}cm^{-1}) which was closely followed by the treatments T_3:RFS-45 cm (27.32, kgha^{-1}cm^{-1}), T_4: RFS-60 cm (25.71 , kg ha^{-1}cm^{-1}) and minimum in case of T_1: FBS-45 cm (20.08 kg ha^{-1}cm^{-1}). In case of seed rate the highest WUE was recorded in S_2 - 60 kg ha^{-1} (27.63 kg ha^{-1}cm^{-1}) and minimum in S_3 - 40 kg ha^{-1} (21.64 kg ha^{-1}cm^{-1}). If we look at the interactive effects the data emphasized that the highest WUE i.e. 32.95 kg ha^{-1}cm^{-1} was recorded in case of T_3:RFS-45 cm and S_2 - 60 kg ha^{-1} and minimum in case of T_1: FBS-45 cm and S_3 - 40 kg ha^{-1} (17.99 kg ha^{-1}cm^{-1}). In general the trend of water use efficiency commensurate the trend of seed yield as it is a function of grain yield and water use. Tomar *et al.*, (1996b) also reported the considerably higher production of soybean, maize and sorghum when planted on ridges. The land configuration system reduced runoff, soil loss, N and P loss by 13.5%, 30.1%, 16.1% and 13.5%, respectively over flat bed or conventional system of cultivation and enhanced soybean yield, water use and water use efficiency by 20.6%, 4.0% and 7.9%, respectively.

5.3 Economics of treatments

Perusal of the data on economics revealed that the cost of cultivation per hectare for different treatments ranged between Rs 10,000 to 11400. It was maximum in the treatment combination T_3:RFS-45 cm and S_1 - 80 kg ha^{-1} and T_4:RFS-60 cm and S_1 - 80 kg ha^{-1} and minimum in case of T_1:FBS-45 cm and S_3 - 40 kg ha^{-1}. The highest gross return (Rs 44230 ha^{-1}), net return (Rs 33330 ha^{-1}) and B:C ratio (4.06) was recorded in the treatment T_3:RFS-45 cm and S_2 - 60 kg ha^{-1} and the lowest in T_1:FBS-45 cm and S_3 - 40 kg ha^{-1} i.e. Rs. 28313 ha^{-1} gross return, Rs 18313 ha^{-1} net return and 2.83 B:C ratio. Higher economic return from land configuration treatment as compared to conventional system has been reported by Thakur *et al.*, (2004b), Tomar *et al.*, (1996a) and Jat and Singh (2003). Dwivedi *et al.,* (2002) reported that the adoption of proper land configuration system will help in increase the income to the farmers besides preventing land degradation due to runoff erosion.

Chapter-6
Summary, Conclusions & Suggestions

CHAPTER – 6

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

The present experiment **"Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols"** was conducted during *kharif* 2007 at "All India Co-ordinated Research Project" (AICRP) for Dryland Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Farm, College of Agriculture, Indore.

The soil of the experimental site was clay possesses pH 7.79, electrical conductivity 0.33 dSm^{-1} and organic carbon 0.41%. The quantities of available N, P_2O_5 and K_2O were 180.75, 11.3 and 395.20 Kg ha^{-1}, respectively. A field experiment was consisted of 4 main treatments (land configurations), 3 sub treatment (seed rates) and replicated four times in split plot design (SPD). As per treatment the seed of soybean *cv.* JS 335 were used. The sowing was done on 25th June 2007. the crop was harvested on 13th October 2007. The salient findings as elucidated in previous chapters are summarized below:

6.1 Summary

A. Growth parameters

1. The seed rate affected the plant height significantly at 75 DAS and at harvest stage Effect of land configuration treatments and its interaction with seed rate was non significant at all the growth stages.
2. The lowest number of branches $plant^{-1}$ was recorded in case of flat bed planting. This trend was maintained at all the growth stages under study. Among land configuration treatments T_3 : ridge and furrow at 45 cm distance produced the highest number of branches $plant^{-1}$ at all the growth stages. Maximum numbers of branches $plant^{-1}$ were recorded in S_2 :60 kg ha^{-1} seed rate which gave significantly higher number of branches $plant^{-1}$ as compared to S_1 :80 kg ha^{-1} and S_3:40 kg ha^{-1}.
3. In case of land configuration the lowest number of root nodules $plant^{-1}$ was recorded in case of flat bed planting Among land configuration

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3. In case of land configuration the lowest number of root nodules $plant^{-1}$ was recorded in case of flat bed planting Among land configuration

treatments T_2:BBFS-45 cm distance produced the highest number of root nodules $plant^{-1}$. Treatment T_2 :BBFS-45 cm, T_3 :RFS-45 cm and T_4 :RFS-60 cm were statistically at par with each other. The lowest seed rate i.e. 40 kg ha^{-1} recorded significantly lower no. of nodules $plant^{-1}$ as compared to S_1 : 80 kg and S_2 :60 kg ha^{-1}.

4. Interactive effect of land configuration treatments and seed rates was found significant T_3 :RFS-45 cm and S_2:60 kg ha^{-1} treatment combination gave maximum number of root nodules $plant^{-1}$ which was significantly superior to the rest of the treatments.
5. The maximum root length was observed in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} (61% more) followed by T_2 :BBFS-45 cm and S_1:80 kg ha^{-1} seed rate (57%more), T_3 :RFS-45 cm and S_1:80 kg ha^{-1} (50%more) as compared to T_1:FBS-45 cm and S_1:80 kg ha^{-1}, which gave minimum root length.
6. Minimum LAI was recorded in case of T_1: FBS-45 cm (3.46), which was found statistically inferior to the rest of the land configuration treatments. Seed rate also influenced the LAI significantly at all the three stages Interactive effect of land configuration and seed rate was affected LAI significantly at all the three stages.
7. DMA has been affected significantly due to seed rate except at 30 DAS. Land configuration treatments gave significantly higher DMA as compared to the treatments T_1:FBS-45 cm Interactive effect of land configuration and seed rate was also found non significant at 30 and 75 DAS but affected DMA significantly at 45 and at harvest stage.
8. The chlorophyll content in leaves at flowering stage of the crop was non significantly influenced by different treatments.

B. Yield attributing characters

1. All the treatment produced significantly more number of pods $plant^{-1}$ as compared to T_1:FBS-45 cm and S_1: 80 kg/ha seed rate treatment. The treatment S_2: 60 kg ha^{-1} gave significantly higher no. of pods $plant^{-1}$ as compared to S_1: 80 kg ha^{-1} (50.40) and S_3: 40 kg ha^{-1} (45.71). Interactive effect of land configuration and seed rate also influenced the no. of pods $plant^{-1}$ significantly being highest in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} (58.30) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate (40.11).

2. Seeds pod^{-1} were not affected significantly by the different treatments. Maximum seeds pod^{-1} were reached in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} treatment and minimum in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment.
3. Among land configuration treatments the highest seeds plant^{-1} were recorded in the treatment T_2:BBF-45 cm (11.90 g), which was found significantly superior to the rest of the treatments. The treatment S_2: 60 kg ha^{-1} gave significantly higher seed weight plant^{-1} (11.58 g) as compared to S_1: 80 kg ha^{-1} (10.89 g) and S_3: 40 kg ha^{-1} (9.83 g). Interactive effect of land configuration and seed rate also influenced significantly being highest in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} (12.47 g) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment.(8.63 g).
4. Land configuration treatment gave significantly higher seed index as compared to flat bed planting. The treatment S_2: 60 kg ha^{-1} seed rate gave significantly higher seed index (9.72 g) as compared to S_1: 80 kg ha^{-1} (9.19 g) and S_3: 40 kg ha^{-1} (8.52 g). Interactive effect of land configuration and seed rate also influenced significantly being highest seed index in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} (10.60 g) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment.(7.35 g).
5. Land configuration treatments gave significantly higher seed yield as compared to T_1: FBS-45 cm (1780 kg ha^{-1}). Treatments S_2:60 kg ha^{-1} and S_1 :80 kg ha^{-1} were statistically at par with each other but were found statistically superior to S_3:40 kg ha^{-1}. Interactive effect of land configuration and seed yield was also found significant being highest seed yield recorded in T_3 :RFS-45 cm and S_2:60 kg ha^{-1} (2657 kg ha^{-1}) and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment. (1657 kg ha^{-1}).
6. Seed rate has influenced the harvest index significantly, while the effect of land configuration and its interaction with seed rate was found non significant on the harvest index.
7. Among land configuration treatments the highest WUE was recorded in T_2 :BBF-45 cm (27.55, kg ha^{-1}cm^{-1}) which was closely followed by the treatment T_3: RFS-45 cm (27.32, kg ha^{-1}cm^{-1}), T_4: RFS-60 cm (25.71 , kg ha^{-1}cm^{-1}) and minimum in case of T_1: FBS-45 cm (20.08 kg ha^{-1}cm^{-1}).

8. In case of seed rate the highest WUE was recorded in S_2 : 60 kg ha^{-1} (27.63 kg $ha^{-1}cm^{-1}$) and minimum in S_3 :40 kg ha^{-1} (21.64 kg $ha^{-1}cm^{-1}$). If we look at the interactive effects the data emphasized that the highest WUE i.e. 32.95 kg $ha^{-1}cm^{-1}$ was recorded in case of T_3 :RFS-45 cm and S_2:60 kg ha^{-1} and minimum in case of T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment. (17.99 kg $ha^{-1}cm^{-1}$).
9. The highest gross return (Rs 44230 ha^{-1}), net return (Rs 33330 ha^{-1}) and B:C ratio (4.06) was recorded in the treatment T_3 :RFS-45 cm and S_2:60 kg ha^{-1} and the lowest in T_1:FBS-45 cm and S_3: 40 kg ha^{-1} seed rate treatment i.e. Rs. 28313 ha^{-1} gross return, Rs 18313 ha^{-1} net return and 2.83 B:C ratio.

6.2 Conclusions

Following conclusions are drawn from the findings of present experiment:

1. Seed yield of soybean was 32 and 26 percent higher when grown on broad-bed and furrow system and ridge and furrow system, respectively, as compared to conventional method of sowing that is flat bed sowing. Reduced seed rate i.e. 60 kg ha^{-1} in place of 80 kg ha^{-1} is recommended. Interactive effect of land configuration and seed yield was also found significant being highest seed yield recorded in ridge and furrow system with 60 kg ha^{-1}.The average water use efficiency due to land configuration treatment was enhanced by 34 % as compared to flat bed sowing.
2. Application of 60 kg ha^{-1} seed rate and sowing on ridge and furrow system at 45 cm spacing (T_3S_2) showed promising effect on growth parameters (i.e. plant height, number of branches $plant^{-1}$, number of root nodules $plant^{-1}$, leaf area index) of soybean JS – 335 over absolute control(Flat bed system). Ridge and furrow planting with reduced seed rate .proved most productive and economical than conventional method of sowing.
3. Thus over all conclusion can be drawn that for obtaining higher benefit cost ratio from soybean cultivation in rainfed conditions of Malwa region it is advised to grow soybean crop on ridge and furrow system at 45 cm spacing with 60 kg ha^{-1} seed rate.

Suggestions for further work

1 This study revealed that précised placement of seed on appropriate land configuration and optimum seed rate enhances crop productivity and water use efficiency. It suggested that in future studies on precision farming should be taken up so that resource use efficiency can be enhanced on sustainable basis.
2 Temporal and spatial distribution of root, nutrient and water should be studied under different land configuration treatments.
3 Runoff, soil and nutrient loss studies should be taken up.

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Appendices

APPENDICES

Appendix – I Analysis of variance table showing mean sum of square for plant population at different growth stages

Source of variation	df	Mean sum of square	
		15 DAS	At harvest
Replications	3	0.26	0.59
Main Treatments	3	162.80 *	145.45 *
Error (a)	9	0.21	0.49
Sub Treatments	2	3188.83 *	3223.27 *
Interaction (Main X Sub)	6	4.43 *	5.20 *
Error (b)	24	0.41	0.51
Total	47	* Significant	

Appendix – II Analysis of variance table showing mean sum of square for plant height at different growth stages

Source of variation	df	Mean sum of square			
		30 DAS	45 DAS	75 DAS	At harvest
Replications	3	30.53	121.38	20.26	20.45
Main Treatments	3	5.40	28.06	71.88	57.87
Error (a)	9	11.48	38.05	19.82	19.76
Sub Treatments	2	5.83	44.02	76.49 *	76.17 *
Interaction (Main X Sub)	6	0.81	8.66	21.94	21.20
Error (b)	24	7.02	38.51	12.73	12.72
Total	47	* Significant			

Appendix – III Analysis of variance table showing mean sum of square for number of branches plant^{-1} at different growth stages

Source of variation	df	Mean sum of square			
		30 DAS	45 DAS	75 DAS	At harvest
Replications	3	0.13	0.12	0.41	0.41
Main Treatments	3	0.85 *	2.49 *	4.89 *	3.24 *
Error (a)	9	0.09	0.06	0.11	0.26
Sub Treatments	2	1.02 *	2.61 *	0.83 *	3.62 *
Interaction (Main X Sub)	6	0.15	0.80 *	0.03	0.26
Error (b)	24	0.07	0.05	0.20	0.13
Total	47	* Significant			

Appendix – IV Analysis of variance table showing mean sum of square for leaf area index at different growth stages

Source of variation	df	Mean sum of square		
		30 DAS	45 DAS	75 DAS
Replications	3	0.04	0.03	0.01
Main Treatments	3	0.95 *	0.40 *	0.60 *
Error (a)	9	0.05	0.02	0.03
Sub Treatments	2	0.88 *	0.43 *	0.76 *
Interaction (Main X Sub)	6	0.21 *	0.13	0.07
Error (b)	24	0.08	0.02	0.03
Total	47	* Significant		

Appendix – V Analysis of variance table showing mean sum of square for number of root nodules plant^{-1} & chlorophyll content at flowering stage

Source of variation	df	Mean sum of square	
		No. of nodules plant^{-1}	Chlorophyll content
Replications	3	4.13	16.73
Main Treatments	3	252.08 *	15.17
Error (a)	9	9.67	14.07
Sub Treatments	2	528.53 *	13.15
Interaction (Main X Sub)	6	122.41 *	3.92
Error (b)	24	4.21	13.14
Total	47	* Significant	

Appendix – VI Analysis of variance table showing mean sum of square for dry matter accumulation plant^{-1} (g)

Source of variation	df	Mean sum of square			
		30 DAS	45 DAS	75 DAS	At harvest
Replications	3	0.07	0.12	15.66	0.92
Main Treatments	3	0.13 *	1.04 *	56.95 *	74.79 *
Error (a)	9	0.01	0.18	5.94	0.30
Sub Treatments	2	0.17	0.95 *	52.12 *	38.05 *
Interaction (Main X Sub)	6	0.05	0.32 *	4.49	12.53 *
Error (b)	24	0.12	0.12	4.54	0.47
Total	47	* Significant			

Appendix – VII Analysis of variance table showing mean sum of square for no. of pods $plant^{-1}$ and no. of seeds pod^{-1}

Source of variation	df	Mean sum of square	
		no. of pods $plant^{-1}$	no. of seeds pod^{-1}
Replications	3	0.35	0.07
Main Treatments	3	238.87 *	0.05
Error (a)	9	1.48	0.08
Sub Treatments	2	216.16 *	0.11
Interaction (Main X Sub)	6	42.44 *	0.01
Error (b)	24	1.40	0.04
Total	47	* Significant	

Appendix – VIII Analysis of variance table showing mean sum of square for grain weight $plant^{-1}$ and seed index

Source of variation	df	Mean sum of square	
		Grain weight $plant^{-1}$	Seed index
Replications	3	0.22	1.56
Main Treatments	3	14.93 *	4.35 *
Error (a)	9	0.26	0.50
Sub Treatments	2	12.44 *	5.79 *
Interaction (Main X Sub)	6	2.80 *	0.90
Error (b)	24	0.20	0.30
Total	47	* Significant	

Appendix – IX Analysis of variance table showing mean sum of square for grain yield, straw yield kg ha^{-1} & harvest index

Source of variation	df	Mean sum of square		
		grain yield (kg ha^{-1})	straw yield (kg ha^{-1})	harvest index
Replications	3	64572.68	81003.95	83731.62
Main Treatments	3	729026.17 *	277962.27	966922.32
Error (a)	9	81135.31	116629.20	266806.50
Sub Treatments	2	734020.73 *	32393.30	1212230.71 *
Interaction (Main X Sub)	6	134586.77	174737.79	160920.94
Error (b)	24	87376.58	117031.20	294221.98
Total	47	* Significant		

Appendix – X Cost of cultivation per hectare

Treatment: (T_1S_1) Flat bed system (45 cm spacing) + 100% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing,harrowing and planking	800
2.	Seed 80 kg @ Rs 25 per kg	2000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	11000

Treatment: (T_1S_2) Flat bed system (45 cm spacing) + 75% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing and planking	800
2.	Seed 60 kg @ Rs 25 per kg	1500
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting+ Transportation	1840
8.	Threshing and winnowing	1500
	Total	10500

Treatment: (T_1S_3) Flat bed system (45 cm spacing) + 50% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing and planking	800
2.	Seed 40 kg @ Rs 25per kg	1000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10000

Treatment: (T_2S_1) Broad bed & furrow system (45 cm spacing) + 100% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and BBF making	1000
2.	Seed 80 kg @ Rs 25 per kg	2000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	11200

Treatment: (T_2S_2) Broad bed & furrow system (45 cm spacing) + 75% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and BBF making	1000
2.	Seed 60 kg @ Rs 25 per kg	1500
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10700

Treatment: (T_2S_3) Broad bed & furrow system (45 cm spacing) + 50% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and BBF making	1000
2.	Seed 40 kg @ Rs 25 per kg	1000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10200

Treatment: (T_3S_1) Ridge & furrow system (45 cm spacing) + 100% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 80 kg @ Rs 25 per kg	2000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	11400

Treatment: (T_3S_2) Ridge & furrow system (45 cm spacing) + 75% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 60 kg @ Rs 25 per kg	1500
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10900

Treatment: (T_3S_3) Ridge & furrow system (45 cm spacing) + 50% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 40 kg @ Rs 25 per kg	1000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10400

Treatment: (T_4S_1) Ridge & furrow system (60 cm spacing) + 100% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 80 kg @ Rs 25 per kg	2000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	11400

Treatment: (T_4S_2) Ridge & furrow system (60 cm spacing) + 75% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 60 kg @ Rs 25per kg	1500
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection	700
6.	Weeding	1840
7.	Harvesting + Transportation	1840
8.	Threshing and winnowing	1500
	Total	10900

Treatment: (T_4S_3) Ridge & furrow system (60 cm spacing) + 50% seed rate

S.N.	Particulars	Cost (Rs)
1.	Ploughing, harrowing, planking and R & F making	1200
2.	Seed 40 kg @ Rs 18 per kg	1000
3.	Cost of fertilizers (40:60:30 kg NPK ha^{-1}) Urea @ Rs 506/100 kg (86.95 kg ha^{-1}) SSP @ 320/100 kg (375 kg ha^{-1}) MOP @ 466/100 kg (50 kg ha^{-1})	 440 1200.00 230.00
4.	Sowing	450
5.	Plant protection + Transportation	700
6.	Weeding	1840
7.	Harvesting	1840
8.	Threshing and winnowing	1500
	Total	10400

Vita

VITA

The author of this thesis **MUKESH VERMA** was born on 7th Oct, 1983, at Bhayawadi (Shiv Mohalla) , Teh – Shahpur District Betul (M.P). He completed primary & middle education at native place. He passed his High School and Higher Secondary Examination with 46.6 & 82.22 % from M.P.Board Bhopal in 1999 and 2001.

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Then he joined M.Sc.(Ag.) course in the 1st Semester ,2006-07 at College of Agriculture,Indore to specialize in "Agronomy" and partial fulfillment of the requirements for the award of the same. He allotted entitled "**Effect of Land Configurations and Seed Rates on the Growth and Productivity of Rainfed Soybean Grown in Vertisols**" for thesis work, which has been duly completed by him and presented in this thesis.

He is now submitting the thesis after completing the course with OGPA out of 10.00 Point scale.