Studies on seedling, nodulation, growth and yield parameters in promising genotypes of Soybean [*Glycine max* (L.) Merrill]

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By

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CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on seedling, nodulation, growth and yield parameters in promising genotypes of Soybean [*Glycine max* (L.) Merrill]"** submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in AGRICULTURE (Agronomy)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) is a record of the bonafied research work carried out by **Miss. Preeti Sisodia I/D No RA/SH/634/2008** 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 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 investigation has been acknowledged by her.

Place : **Sehore** **(Prof.Rohan Singh)**

Date : **Chairman of the Advisory Committee**

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CERTIFICATE – II

This is to certify that the thesis entitled **"Studies on seedling, nodulation, growth and yield parameters in promising genotypes of Soybean [*Glycine max* (L.) Merrill]"** submitted by **Miss. Preeti Sisodia I/D No RA/SH/634/2008** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURE (Agronomy)** in Department of Agronomy, RAK College of Agriculture, Sehore has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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Director of Instruction ……………………..

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbol		Legend
&		and
@		At the rate of
^{o}C		Degree Celsius
C.D.		Critical Difference
cm		Centimeter
C.V.		Coefficient of Variation
DAS		Days after sowing
D.F.		Degree of Freedom
et.al.		And others
etc		and the rest
Fig.		Figure (s)
g		Gram
ha		hectare
ha^{-1}		Per hectare
HI		Harvest Index
i.e.		That is
R.V.S.K.V.V.		Rajmata Vijyarajya Scindia Krishi Vishwa Vidhyalaya
R.A.K.		Rafi Ahmed Kidwai
kg		Kilogram (s)
l		Litre
m		Meter (s)
MSS		Mean sum square
No.		Number (s)
RH		Relative humidity
Rs.		Rupees
S.Em.±		Standard error of mean
S.S.		Sum of Square
Viz.		Namely
√		Square root
%		Per cent
±		Plus or Minus

CHAPTER I

INTRODUCTION

Soybean [*Glycine max* (L) Merrill] ranks first amongst oilseed crops of world and Soya oil is next to palm oil in the international trade market. It is legume crop mainly grown in *kharif* season. Soybean belongs to family leguminoseae and subfamily Papilonaceae. The edible products like oil (20%) and protein (40%) are relatively of recent origin. Soybean is commonly used as pulses, oil seeds, vegetarian meal & milk and it has been known as "wonder crop" of twentieth century. Soybean is compared with cow milk but at the same time rich with iron and vitamin C.

Soybean besides having a nutritive value is capable of fixing atmospheric nitrogen at the rate of 65-115 kg N/ha per year (Alaxander, 1977) with symbiosis of *Rhizobium japonicum*, micro-organism. After fulfillment of requirement soybean gives about 25-30 kg N to the soil. It improves the structure and fertility of soil by adding the leaves and straw having 9 per cent Nitrogen, 12 per cent phosphorus and 8-9 per cent potash.

Soybean is largely used for the extraction of oil and now considered as one of the most important oilseeds crop of the country. The credit for such a big boost in the production of soybean in the country goes to Madhya Pradesh popularly known as " Soya bowl" of the country. Among the different growth characters like early seedling vigour, nodulation, yield contributing traits, variety adaptability are the important factors which are mainly positively associated with higher productivity of crop.

The world soybean area, production and productivity are 97 million hectare, 231 million tonnes and 2.3 tonnes per ha, respectively (2008-09). The United State of America, Brazil, Argentina, China and India are the leading nations contributing for 90% of world production.

Looking to India scenario, soybean is first oilseed crop having 9.67 million hectare with production of 10.22 million tonnes and 1.11 tonnes/ha productivity, which is quite low than other countries because soybean is grown mainly as rainfed crop during rainy season under variety of soil type and topographic conditions.

India ranks 5th with respect to soybean acreage and production in state as 52.985 lakh hectares area with production of 55.084 lakh tones with the productivity of 1040 kg/ha during *kharif* 2009 SOPA (The Soybean Processars Association of India).

Keeping in view, the above-mentioned facts, the present study entitled "Studies on seedling, nodulation, growth and yield parameters in promising genotypes of soybean [*Glycine max*. (L.) Merrill] under Vindhyan plateau of Madhya Pradesh " was carried out under All India Co-ordinated Research Project (AICRP) on soybean at R.A.K. College of Agriculture, Sehore (M.P.) during *kharif* season 2009 with the following objectives:

Objectives:

1. To study the extent of variation for seedling, nodulation, growth and yield traits in soybean genotypes.
2. To study the relationship of different traits on seed yield.
3. To identify better new soybean genotypes.
4. To work out economics of various treatments.

CHAPTER II

REVIEW OF LITERATURE

A lot of research work has been carried out to enhance the productivity of soybean crop in State but still per hectare yields are far below the world average. There are so many factors responsible for low yield of soybean. The major ones are erratic behavior of rain, dry spell and use of the cultivars with low productivity.

A brief resume of research work done in India on quantitative and qualitative aspects of different cultivars of soybean and their effect on growth and yield of soybean has been presented here under the following heads:

2.1 Growth parameters.

2.2 Yield attributing parameters.

2.3 Grain yield and Straw yield.

2.4 Correlation coefficient with yield

2.5 Correlation coefficient between other characters

2.6 Effect of environment on soybean

2.1 Growth Parameters -

Soni and Vyas (1984) inferred that plant height, branches per plant, leaves per plant, dry weight per plant and dry weight of nodules per plant varied significantly among different varieties.

Singh and Sharma (1985) reported that variety DS 76-1-29 produced significantly higher branches, trifoliates, pods per plant and grain yield per plant.

Dubey and Billore (1993) observed at Sehore that soybean genotypes viz. JS 81-335 and JS 81-1619 recorded higher nodules number per plant.

Kim *et al.* (1993) observed that number of branches per m^2 were more in determinate cultivars with compare to indeterminate cultivars.

Kumari *et al.* (1993) found that all tested varieties recorded maximum plant height at 90 days after sowing. Maximum plant height (70.72 cm) was observed in Davis and JN 2750 cultivars. They further include that LAI is highest in JN 2750 (8.09) at 90 DAS.

Mohammad Abbas *et al*. (1994) concluded that erect type variety (JS 75-46) was superior in plant height (57.8 cm), dry weight (17.5 g), root nodules per plant (32.5), while spreading type (JS 72-44) was superior in producing higher trifoliates and branches per plant.

Paul and Guha (1994) reeported that number of branches per plant and height (57.8) more in JS-2 than Bragg.

Sharma and Soni (1994) found that variety JS 87-28 produced higher number of branches, trifoliates, root nodules per plant, dry weight per plant and variety JS (SH) -1310 recorded highest plant height than remaining varieties.

Choubey and Nema (1996) found that variety JS 89-27 produced taller plant with more number of branches and trifoliates, dry weight of root nodules per plant and dry weight per plant than remaining varieties.

Dubey and Nema (1997) concluded that variety JS-335 produced higher number of root nodules per plant, dry weight per plant and variety MAUS 53-2 superior in plant height while maximum number of trifoliate recorded in MACS-431 than remaining varieties.

Panchariya (2000) noticed that variety JS 90-41 produced higher number of root nodules per plant and dry weight of root nodules per plant. They further concluded that variety NRC 37 recorded maximum height and branches than the remaining varieties.

Akbari and Peat (2001) reported that number of branches and pods per plant, number of seeds per pod, seed index , seed dry weight and plant height were found significant.

Parmar and Nema (2002) found that variety JS-335 produced higher LAI and variety RAUS-5 had higher number of branches, while variety MAUS 61-2 recorded highest plant height and variety JS 93-06 gave higher number of leaves. They further concluded that variety JS 93-07 produced higher dry weight per plant.

Mandloi *et al.* (2003) inferred that JS-335 gave significantly higher plant height (43.68), leaves per plant (10.02), root nodules per plant (124.16) and dry weight per plant (14.21).

Veni and Murthy (2003) reported that variety JS 335 produced higher plant height (42.55 cm) and higher number of branches (3.33).

Islam *et al.* (2004) reported that variety Shohag (Pb-1) produced greater plant height and number of branches per plant than BS-60 and BS-16.

Kaul and Vyas (2004) found that JS-335 produced significantly higher branches per plant, leaves per plant, number of root nodules per plant, dry weight of root nodules and dry weight per plant.,

Khan *et al.* (2004) observed that variety Epps (Epps, MGV) produced tallest plants as compared with Williams 82 (Williams 82, MG 111).

Hakim *et al.* (2005) observed that cultivar spark produced the maximum plant height (92.67 cm) than other tested varieties.

Kumar *et al.* (2005) reported that cultivars PK-472 produced the higher plant height (84.91cm), while cultivars SL-231 produced significantly higher number of branches per plant (6.47) as compared to other cultivars.

Thakur and Vyas (2005) concluded that variety JS-335 produced significantly higher plant height, number of branches, leaves per plant, dry weight per plant and leaf area index.

Patidar and Vyas (2006) reported that genotype JS 97-51 produced significantly tallest plant (78.83cm) followed by genotype RKS-18, RKS-15 and NRC-64.

Abayomi (2008) reported that branching, plant height, dry matter production crop growth rate and relative growth rate were higher in late than in the early maturity group.

Patel (2008) reported that plant height, number of branches, dry weight per plant, number of nodules per plant, dry weight of nodule were found significant. The JS 335 performed best for the majority of the characters followed by JS 2002-14.

Baghel (2009) found that plant height, number of branches, number of leaves, dry weight per plant, nodule number, dry weight of nodule were found significant and JS (SH) 2004-3, JS (SH) 2004-8 and JS (SH) 2004-1 are found promising ones.

2.2 Yield attributing parameters :

Soni and Vyas (1984) inferred that number of pods, seed index and grain yield per plant varied significantly among different varieties.

Singh and Sharma (1985) found that variety DS 76-1-29 produced significantly higher grain yield, harvest index and grain production efficiency than other varieties PK-472 and Bragg.

Nigam *et al.* (1989) found that average number of pods per plant were higher in Bragg. (28.50), while the seed index (18g) and harvest index (59.41) were significantly higher in JS 71-05.

Sharma and Sharma (1991) inferred that JS 81-335 produced significantly higher number of pods per plant (43.56), grain yield per plant (12.01g), grain yield (2600 kg/ha) and grain production efficiency (23.70 kg/ha/day) than other varieties JS 80-21, JS 81-220 and JS 81-714.

Dubey (1993) observed at Sehore that soybean genotypes viz. JS 81-335 and JS 81-1619 recorded higher nodules number per plant.

Kim *et al.* (1993) found that harvest index was found in interdeterminate types of plants whereas seed index was higher in indeterminate types.

Choubey and Nema (1996) observed that variety Pb-1 produced higher number of grains per pod than the other varieties, while JS 89-27 produced higher number of pods per plant and grain yield per plant, accordingly. They also noted the greater grain production efficiency for variety JS 89-27 than other varieties.

Billore *et al.* (2000) observed at NRCS, Indore (M.P.) that the harvest index was higher in Ahilya 3 (85-51) and seed per pod (1.87) was higher in JS 335 while seed index (12.7) was better in JS 71-05 and pods per plant were highest in Ahilya 1 (39.03).

Dubey and Tomar (2000) reported increase in dry weight per plant and seed yield ranged from 26.0 to 41.0% and 7.8 to 15.4%, respectively. The highest seed yield (19.45 q/ha) was recorded with Sehore.

Panchariya (2000) reported that variety JS 90-41 was produced higher seed index, pods per plant and grain per pod than other tested varieties.

Weilenmann *et al.* (2000) results revealed that at the rainfed site, a difference between cultivars for biological yield was not significant.

Akbari and Peat (2001) reported that number of branches and pods per plant, number of seeds per pod, seed index, and stem leaf and seed dry weight and plant height were found significant.

Parmar and Nema (2002) observed that seed index was higher in MAUS 61-2. They further reported that seeds per pod was higher in JS 93-05 and pods per plant was higher in RAUS-5, while NRC-41 gave higher seed yield per plant.

Mandloi *et al.* (2003) found that JS-335 produced significantly more pods per plant (17.13), seeds per pod (2.83), seed index (6.8), grain yield per plant (2.74g), grain yield (731.26 kg/ha) and harvest index (34.26).

Islam *et al.* (2004) reported that variety Shohag produced higher number of seeds per pod and pods per plant over BS-60 and BS-16.

Kaul and Vyas (2004) found that JS-335 produced significantly higher pods per plant (40.51) and seed index (11.69).

Hakim *et al. (*2005) observed that cultivar kharif-93 produced the highest number of pods per plant (45.67) and 100 seed weight (19.90 g) than other tested cultivars.

Khan *et al.* (2005) observed that cultivars kharif 93 as produced the highest number of pods per plant (45.67) and seed index (19.90g) than other tested cultivars.

Kumar *et al*. (2005) recorded significantly higher number of pods per plant (82.40) with SL-231 as compared to other cultivars.

Thakur and Vyas (2005) observed that variety JS-335 produced higher number of pods per plant than other varieties, while variety JS 95-60 produced higher number of seeds per pod, seed index, grain yield per plant and harvest index.

Patidar *et al.* (2006) found genotypes RKS-18 produced significantly higher grain yield per plant (8.66g) and genotype NRC-64 gave significantly higher harvest index (50.60).

Samaiya et al. (2007) revealed that pod number, seed per pod and seed weight are the major parameters of productivity. The maximum node and effective nodes per plant were highest in cultivar JS 75-46. Cultivar JS 72-280 and JS 80-21had higher number of branches per plant. Cultivars, which had highest biomass and higher yield JS 80-21 and JS 75-46, recorded maximum biological yield.

2.3 Grain yield and Straw yield :

Sarathe and Singh (1983) observed that grain yield varied significantly among the different varieties of soybean.

Sharma *et al*. (1984) reported that Bragg and UPSM 19 gave the highest seed yield of Soybean.

Soni (1984) inferred that number of pods. Seed index and grain yield per plant varied significantly among different varieties.

Singh and Sharma (1985) found that variety DS 76-1-29 produced significantly higher grain yield, harvest index and grain production efficiency than other varieties PK-472 and Bragg.

Dheer singh and Sharma (1990) concluded that determinate variety PK 262 gave higher grain Yield (23.86 q/ha) than indeterminate variety T-49.

Sharma and Sharma (1991) inferred that JS 81-335 produced significantly higher number of pods per plant (43.56), grain yield per plant (12.01g), grain yield (2600 kg/ha) and grain production efficiency (23.70 kg/ha/day) than other varieties JS 80-21, JS 81-220 and JS 81-714.

Dahtonde and Shava (1992) found that genotype MACS-13 was significantly superior in producing more number of pods and grain yield per plant than PK-472.

Mohammad Abbas *et al.* (1994) observed that erect plant type (JS 75-46) was superior in producing higher pods per plant (33.9): grain per pod (1.75), grain yield per plant (6.22g) seed index (11.89 g) and harvest index (42.28 %) than spreading types variety JS 72-44.

The variety PK-1068 recorded significantly higher grain yield (23.8q/ha) that check variety Pk-472 (19.14 q/ha) it was at par with other two check varieties *i.e* JS-335 (22.27 q/ha) and JS-8021 (20.21 q/ha) (AICRPS, 1995)

The variety PK-1068 recorded significantly higher grain yield (23.8q/ha) that check variety PK-472 (19.14q/hq) it was at par with other two check varieties like JS-335 (22.27q/ha) and JS-8021 (20.21q/ha). (Anonymous, 1995)

Choubey (1996) observed that variety Pb-1 produced higher number of grains per pod than the other varieties, while JS 89-27 produced higher number of pods per plant and grain yield per plant, accordingly. They also noted the greater grain production efficiency for variety JS 89-27 than other varieties.

Karmakar and Bhatnagar (1996) found that genotypes PK-262, PK-564, Pk-416, and NRC-2 PK-427 gave higher seed yield in rainy season.

Taware *et.al.* (1997) observed that MACS-63 cultivars gave the highest yield (20.32 q/ha) followed by MACS-124 (19.59 q/ha) and MACS-13 (19.24q/ha).

Results reported from Indore showed that JS 71-05 recorded significantly higher seed yield (905 kg/ha) but was at par with JS-335 and DSb-1. (Anonymous, 1999)

Rajput and Shrivastava (1999) found at Morena that variety. JS 71-05 was at par with JS 335 and significantly superior to Pk 472 in respect of seed yield of soybean.

Rahman *et al.* (2000) reported that cultivar hasting produced the highest seed yield (average 365 g/m^2), while the lowest yields (204-210 g/m^2) come from Nuhaka and Dorie cultivars.

Panchariya (2000) found that variety JS 90-41 Produced highest grain yield, grain production efficiency and harvest index compared to remaining varieties.

At Delhi the variety Pusa 9702, yielded highest 19.44 q/ha than PK-1225, SL-459, Bragg, PK-416, PK-1042 and Pusa-16 while, at Puna the genotypes JS (SH) 93-37 recorded highest grain yield (33.12 q/ha) than rest of the varieties and Bragg yielded lowest (19.3 q/ha). (Anonymous ,2001)

Parmar and Nema (2002) observed that NRC-41 produced highest grain yield (1746 kg/ha), while JS 93-05 produced highest straw yield with low yield potential.

At Dharwad the JS-335 recorded significantly higher yield (2766 kg/ha) than other varieties but was at par with NRC-51. (Anonymous, 2002-2003)

Rahman *et al.* (2002-2003) reported that cultivars hastings produced highest seed yield (average 365 g/m^2), while the lowest yields (204-210 g/m^2) come from Nuhaka and Dorie cultivars.

Neupane *et al*. (2003) observed that genotype PK-416 gave higher yield with medium bold seeds.

Veni and Murthy (2003) reported that variety JS 335 produced significantly maximum yield (1850 kg/ha) and straw yield (2410 kg/ha) than the other tested varieties.

Mandloi *et al*.(2003) found that JS-335 produced significantly more pods per plant (17.13), seeds per pod (2.83), Seed index (6.8), grain yield per plant (2.74g) grain yield (731.26 kg/ha) and harvest index (34.26).

Islam *et al.* (2004) reported that Shohag produced significantly higher grain yield (2.298 t/ha) than BS-60 and BS-16.

Khan *et al.* (2005) observed that cultivars kharif –93 produced highest seed yield (2562 kg/ha) than other tested varieties.

Kumar and Badiyala (2005) recorded that PK-416 produced the highest seed and straw yield (2015 and 2653 kg/ha), respectively, which was at par with PK-564 (1940 and 2583 kg/ha), respectively.

Thakur and Vyas (2005) reported that variety JS 95-60 produced highest grain yield (1012kg/ha) and straw yield (1370 kg/ha) than the other tested varieties. They also reported that variety JS 335 produced higher number of pods per plant than other varieties, while variety JS 95-60 produced higher number of seed per pod, seed index, grain yield per plant and harvest index.

Patidar *et al.* (2006) inferred that genotype RKS-18 produced significantly higher grain yield (2012 kg/ha) and straw yield (2673 kg/ha) among JS 97-51, JS-335, RKS-15 and NRC-64.

2.4 Correlation coefficient with yield :

Plant height :

Narolia (1990), Yaduvanshi (1992), Shinde *et al.* (1996) and Taware *et al.* (1997) reported significant and positive correlation coefficient between grain yield and plant height. Grain yield was significant correlated with plant height as reported by Rajarathinam *et al.* (1996) and Sridhara *et al.* (1998). Whereas, negative correlation between these two attributes were reported by Gwal (1990),Singh *et al.* (2000) and Jain *et al.* (2002).

Number of primary branches per plant :

Highly significant and positive correlation of grain yield with number of primary branches per plant was reported by Jadhav *et al.* (1995) and Mehetre *et al.* (1997) and, significant and positive correlation was observed by Narolia (1990), Rajarathinam *et al.* (1996), Singh *et al.* (1996) , Taware *et al.* (1997) Patware *et al.* (2001) and Deka and Talukdar (1994) observed positive association ; while, Shinde *et al.* (1996) and Kumar *et al.* (1997) observed negative correlation between primary branches per plant and grain yield in soybean.

Number of pods per plant :

Gwal (1990), Narolia (1990), Yaduvanshi (1992), Jadhav *et al.* (1995), Shinde *et al.* (1996) and Rajana *et al.* (2000) observed positive and highly significant association between yield and number of pods per plant. Whereas, significant and positive correlation was reported by Singh *et al.* (1996) and Taware *et al.* (1997) while, significant correlation found by Rajarathinam *et al.* (1996), Taware *et al.* (1997) and Shukla *et al.* (1998), positive association between yield and this character was observed by Lakhani (1993), Singh *et al.* (1994) and Taware *et al.* (1995) while Patware *et al.* (2001) and Chamundeswari (2003) reported significant and negative correlation with seed index.

Number of seeds per pod :

Gwal (1990), Narolia (1990), Soni *et al.* (1990) and Yaduvanshi (1992) observed that seed yield was positively correlated with number of seeds per pod. While, Shinde *et al.* (1996), Patware *et al.* (2001) and Uchikawa *et al.* (2003) reported highly significant and positive association between grain yield and seeds per pod.

Seed index (100 seed weight) (g):

Highly significant and positive association was observed by Yaduvanshi (1992), Kumar *et al.* (1997) and Mahetre *et al.* (1997) whereas, Singh *et al.* (1996) Dogney *et al.* (1998), Rajana *et al.* (2000) and Uchikawa *et al.* (2003) observed significant and positive correlation. Negative association was reported by Narolia (1990), Jagtap and Choudhary (1993) and Shinde *et al.* (1996) between seed index and grain yield.

Biological yield per plant :

Narolia (1990) and Yaduvanshi (1992) recorded positively and highly significant correlation between seed yield and biological yield per plant. Singh et al. (1996) reported positive association ; while Shukla *et al.* (1998) reported significant correlation between seed yield and biological yield per plant and negative association showed with harvest index reported by Patware *et al.* (2001).

Harvest index (%) :

Seed yield was positively and highly significant association with harvest index was reported by Narolia (1990), Yaduvanshi (1992), Mehetre *et al.* (1997) and Patware et al. (2001). While, Frederick and Hesketh (1996) observed positive significant correlation between these two traits. Singh *et al.* (1994) reported high positive association with grain yield per plant. Singh et al. (2000) reported negative correlation with almost all the characters under study except grains per pod.

2.5 Correlation coefficient between other characters :

Woodstock (1969) reported that seedling length could be used to estimate the final field emergence and seedling vigor index correlated significantly with final field emergence

Amarnath *et al.* (1990) reported that number of nodules showed significant and positive correlation with number of pods per plant, seed index, plant height and number of branches per plant.

Gwal (1990) recorded strong positive correlation for number of pods per plant with number of nodules and primary branches per plant ; While, significant but negative association found between pods per plant and number of seeds per pod. Number of seeds per pod showed highly significant and negative association with harvest index and seed index as reported by Jain (1996). He also found high positive association between harvest index and biological yield per plant.

Narolia (1990) found that nodule number exhibited positive correlation with biological yield per plant, number of pods per plant was positively correlated with biological yield per plant while, it exhibited negative correlation with seed index.

Yaduvanshi (1992) recorded that plant height exhibited positive association with biological yield per plant.

Jagtap and Choudhary (1993) found that seed index had the positive weak association with number of primary branches per plant while, significant and negative association of biological yield with plant height.

Singh *et al.* (1996) reported that nodule number showed high positive correlation with plant height, seed index and biological yield per plant whereas, number of pods per plant showed strong positive correlation with biological yield per plant, harvest index and plant height.

Shukla *et al.* (1998) reported that significant and positive correlation, between plant height and pods per plant and biological yield per plant.

Jagtap and Choudhary (1993) found negative correlation of biological yield with plant height and pods per plant exhibited strong positive correlation with biological yield per plant.

Jain (1996) observed positive and highly significant association for the trait number of pods per plant and biological yield per plant.

Ramgiry and Raha (1997) results indicated that genotypic correlation coefficients were higher than phenotypic correlation coefficients. Seed yield per plant showed positive correlations with biological yield per plant followed by seeds per plant and pods per plant. At genotypic and phenotypic levels, biological yield per plant had the greatest positive relationship with seed yield and appeared to be the major yield contributing characters in soybean.

Rajput *et al.* (1998) reported that among yield components, pods per plant was most highly correlated with seed yield. The majority of growth and yield parameters exhibited positive and significant correlation among themselves.

Roy and Roquib (1998) found correlation values of the highest magnititude were observed for seed yield per plant with pods per plant. There exist an inherent positive association between the eight plant traits.

Choudhary and Singh (1999) found pods per plant exhibited significantly highly positive correlation with biological yield per plant and seed yield per plant but non-significant positive correlation with harvest index. Seed index showed significant highly positive association with harvest index whereas maximum positive correlation observed between biological yield and seed yield per plant (0.996).

.Pooranchand and Chand (1999) observed that the genotypic correlation for all characters studied were higher than the phenotypic correlation coefficients. Seed yield was positively correlated with branches, seeds per plant and pods per plant in terms of genotypic & phenotypic correlation coefficient. Plant height was negatively correlated with seed index.

Thorate *et al.* (1999) found genotypic and phenotypic coefficient of yield components were estimated using soybean cultivars. Seed yield was positively correlated with the number of pods per plant.

Dubey and Tomar (2000) reported significant correlation were observed between nodule number and nodule dry weight, pods number, total biomass and seed yield.

Nimbalkar and Gujar (2000) found grain yield highly significant and positive correlation with plant height, number of nodules per plant, number of pods per plant, number of seeds per plant and 100-seed weight. The greatest correlation ($r = 0.703$) was observed between grain yield per plant and number of seeds per plant.

Weilenmann *et al.* (2000) results revealed that correlation between biological yield and harvest index with economic were 0.59 ($P < 0.01$) at the irrigated site. Under irrigated conditions, there was a good positive correlation between biological, economic yield and harvest index

Agrawal *et al.* (2001) found that clusters per plant and pods per plant were the most important selection criteria for increasing seed yield..

Patware *et al.* (2001) found that seed yield per plant possessed highly significant and positive correlation with harvest index, pods per plant and branches per plant but pods per plant exhibited positive and significant association with harvest index and biological yield per plant.

Jain *et al.* (2002) found branches per plant (0.57), nodules per plant (0.54), pods per plant (0.66), seed per pod (0.64), seed yield per plant (0.80) and seed index (0.41) were positively and significantly correlated with seed yield.

Chamundeswari (2003) observed that seed yield showed positive correlation with pods per plant and biological yield per plant. The other characters did not show any correlation with yield at the genotypic and phenotypic levels.

Dwivedi (2003) found that grain yield was significantly and positively correlated with dry weight indicated an increase in production in acid soil.

Oneml (2003) found that the plant yield showed positive and significant correlations with the number of leaves, number of branches and number of seeds per pod.

Shrivastava et al. (2005) reported positive and significant correlation between seed yield with seed index days to 50% flowering with day to maturity and grain filling duration and days to maturity with grain filling duration

Mohammad Arshad *et al.* (2006) concluded that seed weight has positive correlation with pod per plant and grain yield had negative correlation with days to flowering, number of branches per plant, number of pods per plant and 100 seed weight.

Mohammad Faisal *et al.* (2007) reported that seed yield has positive correlation with days to flowering, days to maturity, plant height and number of branches per plant.

Patel (2008) reported that genotypic correlation was higher than phenotypic correlation seed yield per plant had significant positive correlation with pods per plant, biological yield per plant, seeds per plant, leaves per plant and harvest index and negative significant association with nodules per plant, plant height and seeds per pod.

Baghel (2009) reported that seed yield had positive correlation with dry weight per plant, pods per plant, straw yield per plant and harvest index.

2.7 Effect of environment on soybean :

Meng and Yang (1961) found in soybean cultivars that plant height, number of branches, number of pods per plant and internodal length were positively correlated with yield on alkaline fertile soils, but were negatively correlated to fertile soil.

Chandel and Saxena (1988) reported that the optimum soil condition for the soybean were light heavy textured soils having no water stagnation and rich in carbonic carbon, neutral in pH, no excessive accumulation of salts and with good water holding capacity.

CHAPTER III

MATERIALS AND METHODS

With a view to obtain higher precision in the results of the present experiment “Studies on seedling, nodulation, growth and yield parameters in promising genotypes of soybean [*Glycine max* (L.) Merrill] under Vindhyan plateau of Madhya Pradesh ” conducted during *kharif* 2009, the material used and the methods adopted during the course of experimentation in the field and laboratory is narrated in brief in this chapter.

3.1 Experimental Site:

The experiment was laid out under "All India Co-ordinated Research Project " on Soybean during Kharif season of 2009 at the research farm of R.A.K. College of Agriculture, Sehore (M.P.). The area having fairly uniform topography, normal fertility status and soil homogeneity with neutral pH.

3.1.1 Climate and Weather Conditions:

Sehore is situated in the western part of the Vindhyan Plateau in sub-tropical zone at the 27º12' North latitude and 77º05' East longitude at an altitude of 498.77 m above mean sea level in Madhya Pradesh. It has sub tropical climate with maximum temperature of 42 ºC in the month of June and minimum 18.36 ºC in the month of January. The average annual rainfall varies from 1000 to 1200 mm, concentrated mostly from June to September. The mean annual minimum and maximum temperature are 18.5 ºC and 31.76 ºC, respectively. The summer months are hot and May is the hottest month having maximum temperature up to 43.58 ºC, winter months experience mild cold with an average temperature from 16.56ºC to 8.74ºC. December is the coldest month as temperature reaches up to 2ºC.

The weekly meteorological data viz., rainfall, temperature, relative humidity and number of rainy days during crop season were recorded from meteorological observatory of RAK College of Agriculture, Sehore. The meteorological data are presented in Table-3.1 and graphically show in Fig. 1.

Table 3.1 indicates that during crop season total rainfall was 1031.2 mm concentration in 43 rainy days from June to October. The rainfall of 43.1 mm was received in the month of June in 4 rainy days with average humidity of 69.32 per cent. The rainfall of 486.5 mm was recorded in 19 rainy days in the month of July with an average relative humidity of 80.10 per cent.

Table 3.1 Meteorological data during crop season (June to October 2009)

Month	Standard week No.	Week	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Number of rainy days
			Max.	Min.			
June	23	4-10	40.85	26.71	67.28	0.00	-
	24	11-17	40.28	26.21	68.57	1.1	1
	25	18-24	41.00	26.35	70.57	19.4	1
	26	25-1	37.78	22.92	70.85	22.6	2
	Average		**39.98**	**25.55**	**69.32**	**Total 43.1**	**4**
July	27	2-8	33.42	21.78	75.71	48.5	5
	28	9-15	32.64	22.21	73.85	98.7	4
	29	16-22	27.42	20.42	82.00	296.7	5
	30	23-29	28.50	20.64	88.85	42.6	5
	Average		**30.49**	**21.26**	**80.10**	**Total 436.5**	**19**
August	31	30-5	31.07	22.14	74.42	0.00	-
	32	6-12	32.85	21.40	71.00	4.1	1
	33	13-19	29.85	20.42	71.00	46.6	4
	34	20-26	32.50	21.85	67.42	1.3	1
	Average		**31.57**	**21.48**	**70.96**	**Total 52**	**6**
September	35	27-2	31.00	20.07	75.85	176.6	5
	36	3-9	30.14	20.71	80.71	102.3	3
	37	10-16	30.86	21.21	75.57	39.1	1
	38	17-23	32.57	21.57	69.71	0.00	-
	39	24-30	33.00	21.57	70.28	1.2	2
	Average		**31.51**	**21.03**	**74.42**	**Total 319.2**	**11**
October	40	1-7	30.97	19.43	74.00	130.4	3
	41	8-14	30.86	18.36	69.14	0.00	-
	42	15-21	30.64	18.21	68.57	0.00	-
	43	22-28	30.28	16.21	68.71	0.00	-
	Average		**30.69**	**18.05**	**70.10**	**Total 130.4**	**3**
					GT	**1031.2**	**43**

Source: Meteorological observatory,R.A.K.College of Agriculture, Sehore (M.P.)

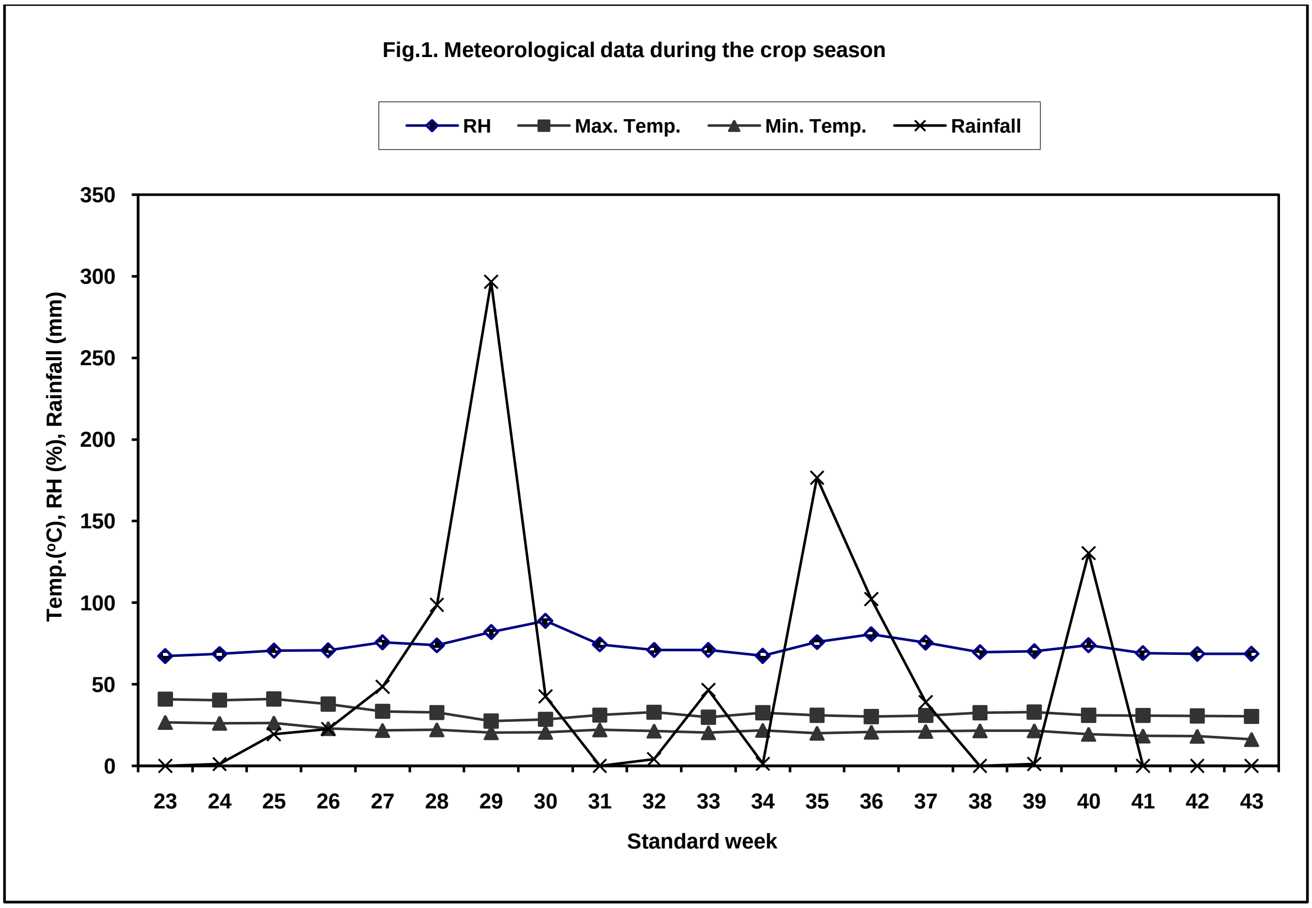


Fig.1. Meteorological data during the crop season
RH
Max. Temp.
Min. Temp.
Rainfall
Temp.(ºC), RH (%), Rainfall (mm)
350
300
250
200
150
100
50
0
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
Standard week

During August 52.0 mm rainfall was received in 6 rainy days with an average humidity of 70.96 per cent, while in September 319.2 mm rainfall was recorded in 11 rainy days with an average humidity of 74.42 per cent. During October 130.4 mm rainfall was received in 3 rainy days with an average humidity of 70.10 per cent.

During the *kharif* season, 2009 the maximum temperature ranged from 27.42ºC to 41.0ºC and the minimum temperature ranged from 16.21ºC to 26.71ºC. The maximum relative humidity of 88.85 per cent was observed in 30th meteorological week and the minimum relative humidity of 67.28 per cent in 23rd meteorological week.

3.2 Soil:

The soil of the experimental field was medium black, clay loam in texture, fairly deep having a slight slope from west to east, which provided good drainage.

3.2.1 Chemical properties of experimental field

In order to find out the inherent fertility-status of the experimental field, representative soil samples were collected from the experimental field. Soil samples were taken randomly with the help of auger up to a depth of 0-30 cm after the land preparation but prior to sowing of soybean. The samples were air dried, sieved through 2 mm sieve and used for mechanical and chemical analysis. The results are presented in Table 3.2.

Table 3.2. Chemical properties of experimental field

S.No.	Particulars	Contents	Level	Method adopted
1.	Organic carbon (%)	0.75	Medium	Walkey & Black method (1934)
2.	Available nitrogen N (kg/ha)	380	Medium	Alkali permanganate method (Subbaih and Asija, 1956)
3.	Available phosphorus P (kg/ha)	24.50	High	Olsen's method (Olsen *et al.*, 1954)
4.	Available potassium K (kg/ha)	360	Medium	N ammonium acetate extractact (Hanway and Heidal, 1954)
5.	Soil pH	7.5	Normal	pH meter
6.	Electrical conductivity (mmhos/cm)	0.20 dsm/m at 25^{0}C	Normal	Elico-conductivity bridge method

3.3 Cropping history of the experimental field

The knowledge of previous crops on experimental field is essential to judge its productivity potential. The crops grown in the experimental field during the past four years are presented in Table 3.3

Table 3.3. History of the experimental field

Year	Kharif season	Rabi season
2005-06	Soybean	Gram
2006-07	Soybean	Gram
2007-08	Soybean	Gram
2008-09	Soybean	Gram
2009-10	Present experiment	

3.4 Experimental Details:

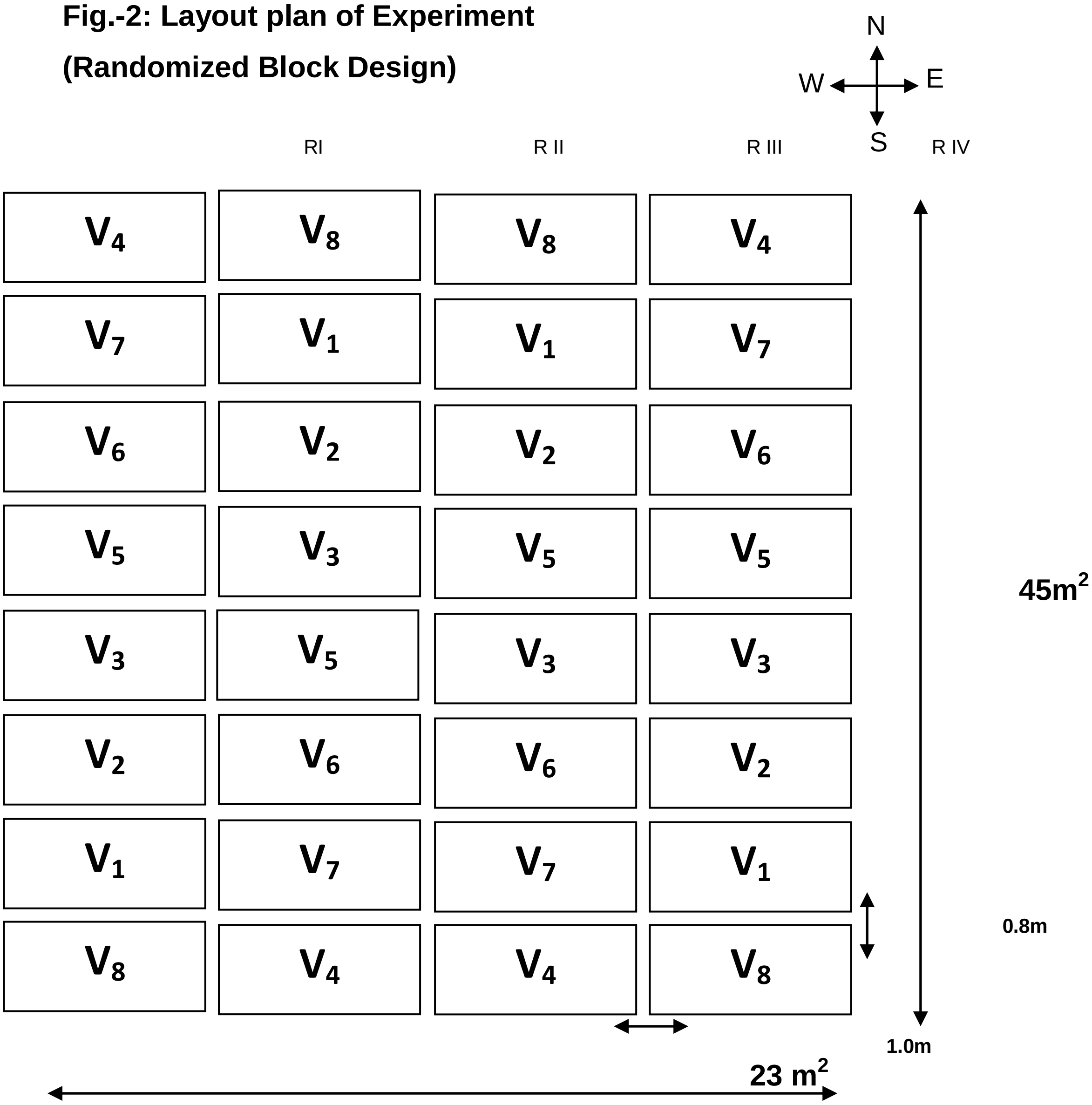
The present experiment was carried out in Randomized Complete Block Design with four replications. The material consisted with eight-advanced elite line of soybean. The details are listed below and the layout plan is illustrated in Fig.-2.

1.	Design	:	Randomized block design
2.	Replications	:	04
3.	No. of treatments	:	08
4.	Total number of plots	:	32
5.	Gross plot size	:	4.8m x 5m
6.	Net plot size	:	4 m x 5 m
7.	Number of rows per plot	:	12
8.	Row spacing	:	40 cm
9.	Distance between replication	:	1 m
10.	Distance between plot	:	80 cm
11.	Test variety	:	JS-335 (check)

12.	Seed rate	:	80 kg/ha
13.	Fertilizer dose	:	20: 60: 20: 20($N+P_2O_5+K_20+S$) kg/ha
14.	Date of sowing	:	5th July 2009
15.	Date of thinning	:	29th July 2009
16.	Date of harvesting	:	9 to 14 Oct (varied with genotypes)
17.	Date of threshing	:	19th October 2009

Fig.-2: Layout plan of Experiment

(Randomized Block Design)



Gross area = 45 m x 22 m = 990 m^2

Gross plot size = 4.8 m x 5 m = 24 m^2

Net plot size = 4.0 m x 5 m = 20 m^2

Treatments and symbols used :

S.No.	Varieties	Symbols	Pedigree/Cross
1	JS (SH) 2001-4	V_1	Dsb-1 x JS 90-41
2	JS (SH) 2003-2	V_2	NSP-7 x NRC-37
3	JS (SH) 2003-4	V_3	JS 2001- 4 (Selection)
4	JS (SH) 2003-8	V_4	JS (SH) 88-66 (Selection)
5	JS (SH) 2004-2	V_5	Dsb-1 x PK 1029
6	JS (SH) 2004-3	V_6	NRC-37 x PK 1029
7	JS (SH) 2004-4	V_7	Dsb-1 x JS 94-8
8	JS 335 (Check)	V_8	Check

3.4.1 Characters of the genotypes under evaluation:-

1. **JS (SH) 2001-4**: It is the cross between Dsb-1 x JS 90-41. The plant are 61 to 65 cm tall, lenciolate leaves, flower are white in colour and pods are hairy. Days to maturity ranges between 96-99 days. The grain yield of this genotype is 22 q/h with seed index of 9.5 g.

2. **JS (SH) 2003-2:** It is the cross between NSP-7 X NRC-37. The plant height ranges from 60-65 cm. The plants are broad leaved with white flowers and hairy pod. Days to maturity ranges between 95-98 days. The grain yield of this genotype is 25 q/ha with seed index of 8.8 g.

3. **JS (SH) 2003-4:** It is the selection of JS (SH) 2001-4. The plant height ranges from 62-65 cm. The plants have broad leaves, white colour flower and hairy pods. Days to maturity ranges between 97-99 days. The grain yield of this genotype is 18-22 q/ha with seed index of 9.8 g.

4. **JS (SH) 2003-8:** It is the selection of JS (SH) 88-66. The plant height ranges from 72-75 cm, the plant are broad leaves with purple flowers and pods are non hairy. Days to maturity ranges between 100-104 days. The grain yield of this genotype is 25-28 q/ha with seed index of 9.5 g.

5. **JS (SH) 2004-2:** It is the cross between Dsb -1 X PK-1029. The plant height ranges from 65-72 cm. Plants are broad leaved with white flowers and hairy pods. Days to maturity

ranges between 96 to 99 days. The grain yield of this genotype is 23-26 q/ha with seed index of 8.8 gm.

6. **JS (SH) 2004-3:** It is the cross between NRC-37 X PK-1029. The plant height ranges from 68-75 cm. Plants are broad leaved with white flowers and hairy pods. Days to maturity ranges between 99 to 101 days. The grain yield of this genotype is 28-30 q/ha with seed index of 8.6 gm.

7. **JS (SH) 2004-4:** It is the cross between Dsb-1. X JS-94-8. The plant height ranges from 72-75 cm. Plants are broad leaved with white flowers and hairy pods. Days to maturity ranges between 95 to 98 days. The grain yield of this genotype is 18-21 q/ha with seed index of 7.8 gm

8. **JS-335** : This variety has been evolved at JNKVV, Jabalpur from a cross between JS 78-77 X JS 71 - 05. The plants are 70-75 cm tall. The plants are broad leaves with purple colour flower and non hairy pods. It matures in about 95-100 days. The weight of 100 seeds is 10-12 g. Yield potential of this variety is 25-30 q/ha and has the potential of wider adoptability.

3.5 Details of field operation:

3.5.1 Preparation of field and layout of the experiment:

Land was prepared with tractor drawn plough followed by bakharing to obtain a well pulverized seed bed. Finally, it was leveled with the help of tractor drawn leveler. After this, the layout was made as illustrated in Fig.-.1.

3.5.2 Fertilizer application:

The fertilizer were applied @ 20 kg N, 60 kg P_2O_5, 20 kg K_2O and 20 kg S through diammonium phosphate, murate of potash, and gypsum respectively below beneath seed row as basal.

3.5.3 Seed and sowing:

Before sowing the seed was treated with fungicide with vitavex (carboxin a.i. 35.5% + thirum a.i. 37.5% @ 2.5 g/kg seed), *Rhizobium japonicum* @ 5 g/kg seed and P.S.B culture @ 5 g/kg seed. A recommended seed rate of 80 kg/ha was used.

3.5.4 Plant protection:

The plant protection measures were applied timely and when necessary. The incidence of girdle bettle was noticed in first week of August which was controlled by spraying the crop with chloropyriphos 20EC @ 2 litre per ha.

3.5.5 Irrigation:

The crop was grown as rainfed hence no irrigation was given.

3.5.6 Weed control:

Manual hand weeding was done at 30 and 45 DAS with the help of khurpi.

3.5.7 Harvesting and Threshing:

The harvesting was done manually with the help of sickle. The produce of each plot was tied in bundles, labeled carefully and sun drying in respective plots. The harvested bundles were weighed when the moisture content of the seed was around 10-12% with the help of spring balance.

Threshing of the produce was done plot wise and genotype wise by wooden sticks. The straw yield was obtained by deducting grain yield from total biomass produced (grain + straw) which was recorded by spring balance.

Five randomly tagged plants from net plot area were uprooted for post harvest studies. The net plot area was harvested by cutting the plants with the help of sickle closer to ground. The harvested materials were kept in the field for four days for sun drying. Then harvested material from each plot was tied in bundle and labeled. After this, bundles were weighed carefully on the spring balance.

Table 3.4: Schedule for pre-harvest and post-harvest operations carried out during the course of investigation

S. No.	*Operation*	Date	Remarks
1	Field preparation		
	Ploughing	05.7.09	By tractor
2	Layout	04.7.09	Manually
3	Sowing	05.7.09	Manually
5	Thinning	29.7.09	Manually
6	Plant protection		
	(a) 1^{st} spray of chloropyriphos	05.08.09	By Knapsack sprayer

7	Harvesting JS 2001-4 JS 2003-2 JS 2003-4 JS 2003-8 JS 2004-2 JS 2004-3 JS 2004-4 JS 335 (check)	 12.10.09 10.10.09 12.10.09 14.10.09 12.10.09 14.10.09 13.10.09 14.10.09	 Manually
8	Threshing and winnowing	19.10.09	Manually

Individual plot produce was threshed separately on threshing floor by beating the plants with wooden sticks and winnowed with indigenous winnower (*Supada*) manually. Grain yield of each plot was weighed after drying the seed upto moisture content about below 12%.

3.6 Experimental observations:

The five plants from each plot were selected at random. These were tagged for recording detailed observations of different parameters outlined below.

3.6.1 Pre-harvest studies:

A. Seedling character:

1. Seedling height (cm):

Seedling height including root length and shoot length of five plants were recorded in cm at 15^{th} days after sowing.

2. Root length (cm):

The root length of five plants were recorded at 15^{th} days after sowing in cm

3. Shoot length (cm):

The shoot lengths of five plants were recorded at 15^{th} days after sowing in cm.

4. Dry weight of seedling (g):

The oven dry weights of seedling were weighed at 15^{th} days after sowing.

B. Growth characters:

1. Plant population (per square meter)

With an object to see the effects of different treatments on germination this observation was taken. After 30 days of sowing when the germination was complete and at maturity, plant population was recorded by placing a quadrate of 0.25 m^2 at four places in each plot randomly and expressed as plant population per m^2.

2. Plant height and branches per plant:

Observations on plant height and branches per plant of five tagged plants in each plot were recorded at an interval of 30, 60, 90 days after sowing and at maturity

Height of each tagged plants was measured in centimeters with the help of meter scale from the ground level up to the apex level of the main stem in each plot and the mean was determined.

3. Dry weight per plant (g):

The dry weight per plant were recorded at 30, 60, 90 days after sowing and at maturity.

4. Number of root nodules per plant:

The number of root nodules per plant was recorded on 30th , 45th and 60th days after sowing. The plants were uprooted carefully, washed the root system with tap water and their nodules number were counted.

5. Dry weight of root nodules per plant (mg):

The dry weight of root nodules were recorded on 30th, 45th and 60th days after sowing. The nodules were dried with oven at 60 ^{0}C for one hour and their weight recorded.

6. Days to 50% of flowering:

Number of days from the date of sowing to the time when the 50% of the respective genotype flowered.

7. Days to maturity:

Number of days when 75% of the plants had physiologically matured from the date of sowing was recorded as days to maturity

3.6.2 Post-harvest studies:

Before harvesting five tagged plants were selected for recording observations on different yield attributing parameters.

1. Pods per plant:

Pods of five tagged plants were counted and thus obtained mean is used for statistical analysis.

2. Seeds per pod:

Number of seeds per pod were counted and divided with total number of pods.

3 Seed yield per plant (g):

The grains obtained from selected plant separately were weighed and mean weight of grains per plant was calculated.

4. Straw yield per plant (g):

Straw yield of five tagged plants and per plot was noted with the help of spring balance.

5 Seed index (g):

Random seed samples were taken from the pool of threshed seeds of each net plot. Hundred seeds from the produce of each plot were counted and weighed accurately on electronic balance.

6. Grain and straw yield per plot (kg):

These observations recorded with the help of spring balance.

3.6.3 Data to be computed:

1. Seed yield (kg/ha)

The seed yield per net plot was recorded after drying the seed. The plot yield was later on converted into kg per hectare by multiplying it by conversion factor.

2. Straw yield (kg/ha)

The straw yield per plot was obtained by subtracting grain yield from bundle weight of each plot. This was later on converted into kg per hectare.

3. Harvest index (%):

Harvest index was calculated by using the following formula and expressed in per cent.

$$\text{Harvest index} = \frac{\text{Economic (Grain) Yield}}{\text{Biological (Grain + Straw) Yield}} \times 100$$

4. Correlation coefficient:

Genotypic and phenotypic correlations were calculated by substituting the corresponding variance and covariance components in the formula as suggested by Johnson *et al.* (1955).

1. Genotypic correlation coefficient (rg) :

$$rg\ (x_1x_2) = \frac{\text{Genotypic covariance of } (x_1x_2)}{\sqrt{(\text{Genotypic variance } x_1).(\text{Genotypic var. } x_2)}}$$

$$= \frac{\text{Cov } (x_1.x_2)}{\sqrt{\text{Var. } (gx_1).\text{Var. } (g\ x_2)}}$$

2. Phenotypic correlation coefficient (rp):

$$rp\ (x_1x_2) = \frac{\text{Penotypic covariance of } x_1x_2}{\sqrt{(\text{Penotypic variance } x_1).(\text{Penotypic var. } x_2)}}$$

$$= \frac{\text{Cov } (x_1.x_2)}{\sqrt{\text{Var. } (Px_1).\ \text{Var. } (Px_2)}}$$

Test of significance for correlation coefficient:

$$t = \frac{|r|}{\sqrt{1 - r^2}}\ n - 2 \sqrt{\text{at } n - 2} \text{ d.f.}$$

Where,

r = correlation coefficient

n = number of genotypes

5. Vigour index (g): The vigour index by weight was recorded as by multiplication of germination percent (%) with seedling weight.

6. Grain production efficiency:

Grain production efficiency was calculated by dividing the total grain yield per hectare with corresponding duration in days required for the crop maturity.

3.7 Economics studies:

It was calculated as per existing market prices by method described by Yang (1956) and Dhondyal (1971).

1. Cost of cultivation (Rs. /ha):

It was worked out from the summation of cost of expenditure incurred on preparation of experimental field, sowing, intercultural operation, inputs applied, harvesting, daily wages, etc. in rupees in a hectare.

2. Gross Monetary Returns (Rs/ha):

It is calculated by adding the prevailing market rates of grain and straw obtained in different treatments.

3. Net Monetary Returns (Rs/ha):

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 return = Gross monetary return-Total cost of cultivation

4. 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 monetary return/Total cost of cultivation

3.8 Statistical methods:

3.8.1 Analysis of variance:

To test the significance of differences among the genotypes for various attributes, analysis of variance was carried out. ANOVA table with appropriate degrees of freedom used in the present investigation is given Appendix-1.

3.5 The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F Cal	F Tab5%
Replication(r)	(r-1)				
Treatment (t)	(t-1)				
Error	(r-1)(t-1)				
Total	(rt-1)				

The following formulae were used for various estimations.

1. S.Em ± $= \sqrt{\frac{EMS}{r}}$

2. C.D = S.Em ± x $\sqrt{2}$ x t value (at 5% level of significance)

Where,

S.Em ± = Standard error of mean

EMS = Error mean squares

r = Number of replication

C.D. = Critical difference

D.F. = Degree of freedom

MSS = Mean sum of square

SS = Sum of square

t = No. of treatment

CHAPTER-IV
RESULTS

The experimental findings of the present investigation have been presented in this chapter under following heads:

4.1 Seedling characters

4.2 Growth parameters

4.3 Yield attributes

4.4 Correlation studies

4.5 Economics of the treatments

4.1 Seedling characters

4.1.1 Seedling height (cm)

Seedling height was recorded for all the genotypes at 15th days. The seedling height was highest in genotype JS (SH) 2003-4 (25.98 cm) followed by JS 2003-2 (24.95 cm), which was significantly greater than JS (335) check (24.83 cm) only. The lowest seedling height was recorded in genotype JS 2004-2 (22.28 cm), the variation of this traits was found non significant.

4.1.2 Root length (cm)

Root length was calculated for each genotype showed non-significant differences. The highest value was obtained for JS 2003-4 (8.83 cm) followed by JS 2003-2 (8.55 cm), JS 2004-4 (7.40 cm) which was greater, than JS 335 check (6.85 cm) variety.

4.1.3 Shoot length (cm)

Shoot length varied significantly due to genotypes. Maximum shoot length of 19.48 cm was observed in JS 335 followed by JS 2001-4 (18.13 cm), which was significantly greater than all the genotypes expect JS 2004-2 (15.81 cm), JS (SH) 2003-2 (16.05 cm) exhibited the lowest value of shoot length.

4.1.4 Dry weight of seedlings (g)

The dry weight of seedlings was recorded at 15th days and the data presented in table 4.1.Genotype JS (SH) 2004-3 produced the highest dry weight of seedling (2.23 g), while genotype JS (SH) 2003-2 produced the lowest dry weight of seedling (1.18 g).

4.1.5 Vigour index (g)

The vigour index per plant ranged from 106.95 to 206 with the average value of 156.47.Genotype JS (SH) 2004-3 produced significantly higher vigour index 206.00 and genotype JS (SH) 2004-4 ranked second with vigour index (176.18) while genotype JS (SH) 2003-2 produced lower vigour index (106.95).

Table 4.1: Seedling characters of various genotypes

Trails	Genotypes	Root length (cm)	Shoot length (cm)	Seedling height (cm)	Dry weight of seedlings (g)	Vigour index (g)
V_1	JS (SH) 2001-4	6.68	18.13	24.53	1.33	119.15
V_2	JS (SH) 2003-2	8.55	16.05	24.95	1.18	106.95
V_3	JS (SH) 2003-4	8.83	16.95	25.98	1.83	165.25
V_4	JS (SH) 2003-8	6.83	18.08	22.63	1.63	146.38
V_5	JS (SH) 2004-2	6.85	15.88	22.28	1.80	157.90
V_6	JS (SH) 2004-3	5.93	17.20	22.53	2.23	206.00
V_7	JS (SH) 2004-4	7.40	18.08	23.48	1.95	176.18
V_8	JS 335 (check)	6.85	19.48	24.83	1.93	175.05
S Em ±		**0.24**	**0.65**	**0.44**	**0.17**	**14.65**
	CD at 5%	**0.34**	**1.91**	**1.30**	**0.50**	**43.09**

4.2 Growth parameters

4.2.1 Plant height (cm)

The height of soybean plants was recorded periodically at an interval of 30 days beginning from 30th and continued upto 90th days and at maturity time. A linear increase in plant height was observed with the advancement in age of soybean genotype except at maturity. It is also evident from Table 4.2 that the plant height increased rapidly upto 60th days after sowing and showed down at 90th days and there after the plant height was constant. The plant height at maturity stage was statistically analyzed & presented in Table 4.2 It is evident that plant height increased significantly at various growing stages.

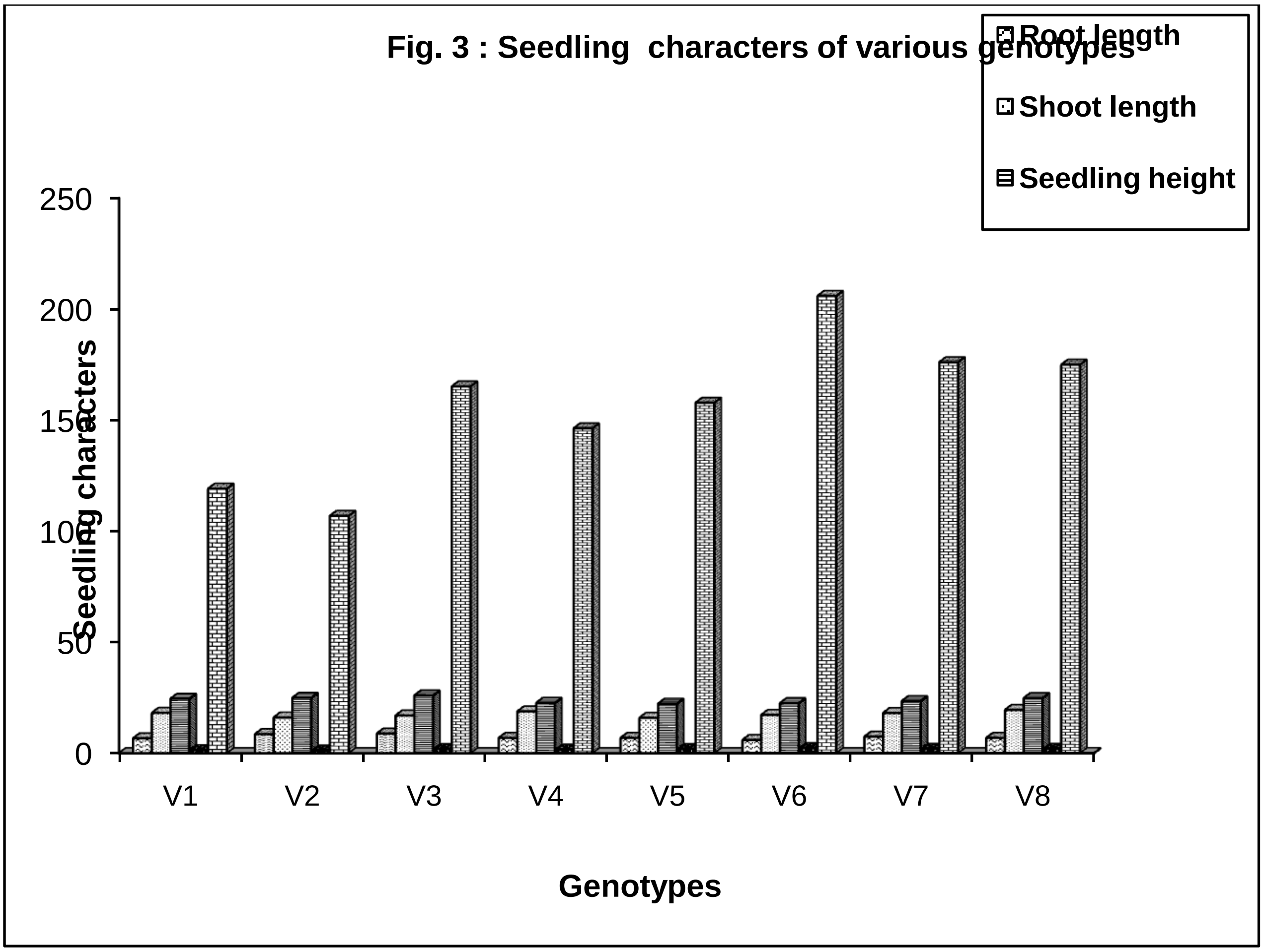


Fig. 3 : Seedling characters of various genotypes
Root length
Shoot length
Seedling height
Seedling characters
250
200
150
100
50
0
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

The maximum plant height at 30 DAS was recorded for JS 2003-4 (33.40 cm) followed by JS 2001-4 (32.20 cm) while, lowest was noted in JS (SH) 2004-2 (27.35 cm) which was significantly lower than the JS 335 (check). All the other genotypes were at par at this stage. Whereas at 60 DAS, 90 DAS and at maturity, JS (SH) 2003-8 had the highest plant height of 71.90 cm, 72.70 cm, 72.95 cm, respectively which was superior to all genotypes. On the other hand JS 2003-4 obtained the lowest plant height of (57.60 cm) followed by JS 2003-2 (58.20 cm), JS 335 (check)(58.30 cm). At 90 DAS and maturity JS (SH) 2003-8 and JS (SH) 2004-4 recorded significantly greater plant height (72.95 cm) and (72.25 cm), respectively than all genotype except JS (SH) 2001-4 produced the shortest height (61.35 cm).

Table: 4.2 Plant height (cm) at various stages

Trails	Genotypes	30 DAS	60 DAS	90 DAS	At maturity
V_1	JS (SH) 2001-4	32.20	59.30	61.35	61.35
V_2	JS (SH) 2003-2	28.35	58.20	61.90	62.15
V_3	JS (SH) 2003-4	33.40	57.60	62.65	62.65
V_4	JS (SH) 2003-8	31.70	71.90	72.70	72.95
V_5	JS (SH) 2004-2	27.35	65.90	66.75	67.25
V_6	JS (SH) 2004-3	27.98	70.49	70.78	71.10
V_7	JS (SH) 2004-4	29.20	72.25	72.06	72.25
V_8	JS 335 (check)	31.80	58.30	70.80	71.05
S Em ±		**1.04**	**2.10**	**1.52**	**1.49**
CD at 5%		**3.07**	**6.17**	**4.46**	**4.38**

4.2.2 Number of branches per plant

Number of branches per plant increased with the advancement of age of plant up to 90 DAS (Table 4.3) .All the genotypes exhibited significant differences regarding branches per plant at all the growth stages. At 60 DAS JS 335 (check) had the highest number of branches (5.41) followed by JS (SH) 2004-4 (4.73) which was significantly superior to JS 2003-8 (3.95), JS 2004-3 (3.83), JS 2003-4 (3.55), JS 2003-2 (3.50), JS 2004-2 (3.45) and JS 2001-4 (3.38). The similar results were obtained at 90 days and maturity.

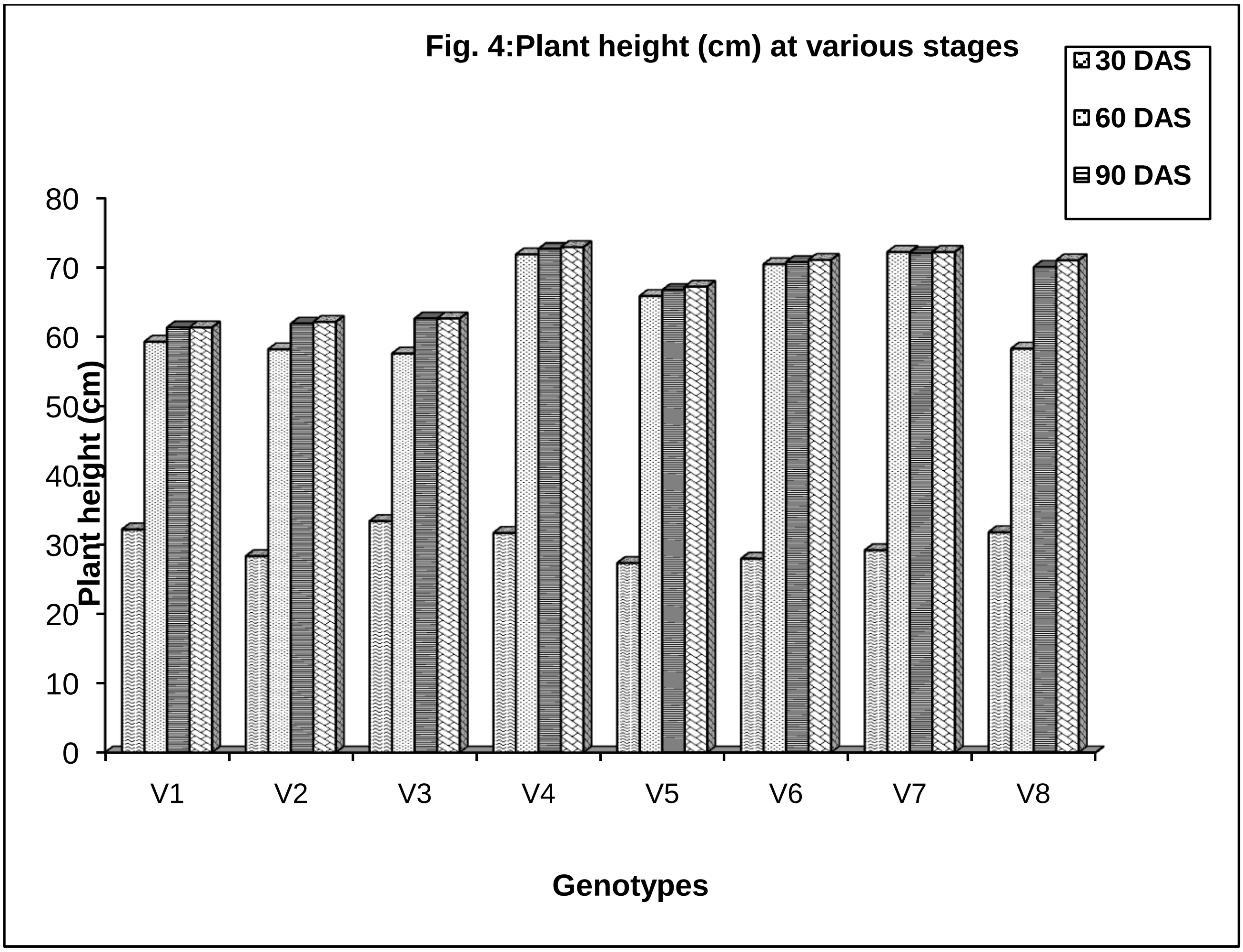


Fig. 4:Plant height (cm) at various stages
30 DAS
60 DAS
90 DAS
Plant height (cm)
0
10
20
30
40
50
60
70
80
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

Table: 4.3. Number of branches per plant at various stages

Trails	Genotypes	30 DAS	60 DAS	90 DAS	At maturity
V_1	JS (SH) 2001-4	2.50	3.38	3.57	3.60
V_2	JS (SH) 2003-2	2.75	3.50	3.80	3.88
V_3	JS (SH) 2003-4	2.90	3.55	3.93	3.93
V_4	JS (SH) 2003-8	3.40	3.95	4.20	4.31
V_5	JS (SH) 2004-2	2.50	3.45	3.63	3.70
V_6	JS (SH) 2004-3	3.07	3.83	4.25	4.35
V_7	JS (SH) 2004-4	3.50	4.73	5.08	5.18
V_8	JS 335 (check)	4.40	5.41	5.73	5.80
S Em ±		**0.39**	**0.40**	**0.40**	**0.40**
CD at 5%		**1.15**	**1.17**	**1.16**	**1.18**

4.2.3 Dry weight per plant

Dry weight per plant recorded at various growth stages (Table: 4.4) exhibited significant differences among genotypes. A perusal of the data indicates that there is continuous increase in dry weight up to maturity. The highest dry weight per plant at 30 DAS was recorded in JS (SH) 2004-3 (4.38 g) followed by JS (SH) 2004-4 (3.85 g), JS (check) 335 (3.63 g) and JS 2001-4 (3.45 g). The highest dry weight per plant at 60 DAS (14.95 g) was recorded in JS (SH) 2004-3 followed by JS 335 (check) (13.75 g) and JS (SH) 2004-4 (13.35 g), while it was lowest in JS (SH) 2003-4 (9.34 g) followed by JS (SH) 2003-2 (10.55 g). On the other hand JS 335 (16.08 g) at 90 DAS which was significantly higher than JS (SH) 2004-4 (15.53 g), JS (SH) 2003-2 (14.50 g), JS (SH) 2003-8 (13.88 g), JS 2001-4 (13.81 g) and JS (SH) 2003-4 (13.16 g) and JS (SH) 2004-2 (12.38 g).

Genotype JS (SH) 2004-3 produced the highest dry weight per plant (18.10 g) at maturity while genotype JS (SH) 2004-2 produced the lowest dry weight per plant at maturity (13.56 g).

JS (SH) 2004- 3 exhibited the highest average dry weight per plant were at par to all the genotypes at all under studied in growth and reproductive stages.

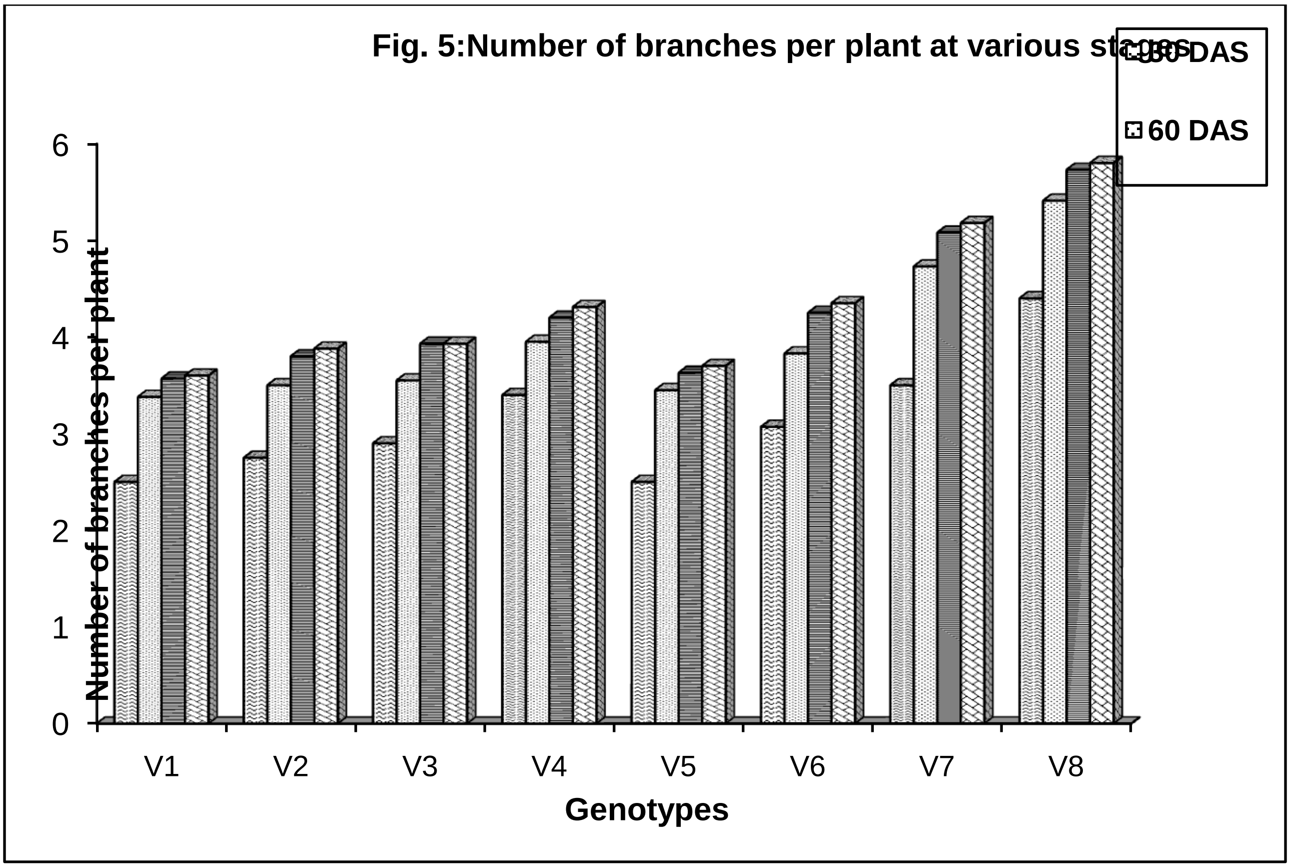


Fig. 5:Number of branches per plant at various stages
30 DAS
60 DAS
Number of branches per plant
0
1
2
3
4
5
6
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

Table: 4.4 Dry weight per plant (g) at various stages

Trails	Genotypes	30 DAS	60 DAS	90 DAS	At maturity
V_1	JS (SH) 2001-4	3.45	10.70	13.81	14.35
V_2	JS (SH) 2003-2	2.58	10.55	14.50	14.95
V_3	JS (SH) 2003-4	2.95	9.34	13.16	13.89
V_4	JS (SH) 2003-8	2.80	10.25	13.88	14.59
V_5	JS (SH) 2004-2	2.95	9.83	12.38	13.56
V_6	JS (SH) 2004-3	4.38	14.95	17.48	18.10
V_7	JS (SH) 2004-4	3.85	13.35	15.53	16.08
V_8	JS 335 (check)	3.63	13.75	16.08	16.75
S Em ±		0.26	0.77	1.02	0.97
CD at 5%		0.75	2.27	2.99	2.84

Data recorded for this parameter indicates that JS (SH) 2004-3 obtained the highest dry weight per plant (18.10 g) at maturity which was significantly greater than all the genotypes except JS 335 (check) (16.75 g) and JS (SH) 2004-4 (16.08 g) significantly lower dry weight per plant was noted for JS (SH) 2004-2 (13.56 g) which was at par with JS (SH) 2001-4 (14.35 g), JS (SH) 2003-8(14.59 g),JS (SH) 2003-4 (13.89 g) and JS(SH) 2003-2 (14.95 g).

4.2.4 Root nodules per plant

Root nodules per plant were counted at 30, 45, 60 DAS and data has been presented in Table 4.5. Data indicates that there were non-significant differences in root nodules per plant at 30 DAS although maximum and minimum were recorded in JS-335 (14.39) and JS (SH) 2001--4 (9.95) respectively. Whereas at 45 DAS and 60 DAS it differed significantly due to genotypes. JS (SH) 2004-3 exhibited maximum root nodules at 45 DAS and 60 DAS (31.25 and 38.03, respectively), at 45 DAS minimum root nodules per plant were counted in JS (SH) 2003-2 (19.63), which was at par with JS (SH) 2001-4 (20.80), JS (SH) 2004-2 (24.65) and JS 2003-4 (25.90). Root nodules per plant counted at 60 DAS revealed that JS (SH) 2004-3 (38.03) was significantly higher than all the genotypes except JS (SH) 2003-8 (37.80) and JS 335 (check)(35.33). While the lowest was recorded in JS (SH) 2003-2 (27.15) which was at par with JS (SH) 2001-4 (28.28), both were significantly inferior to all the genotypes regarding root nodules per plant.

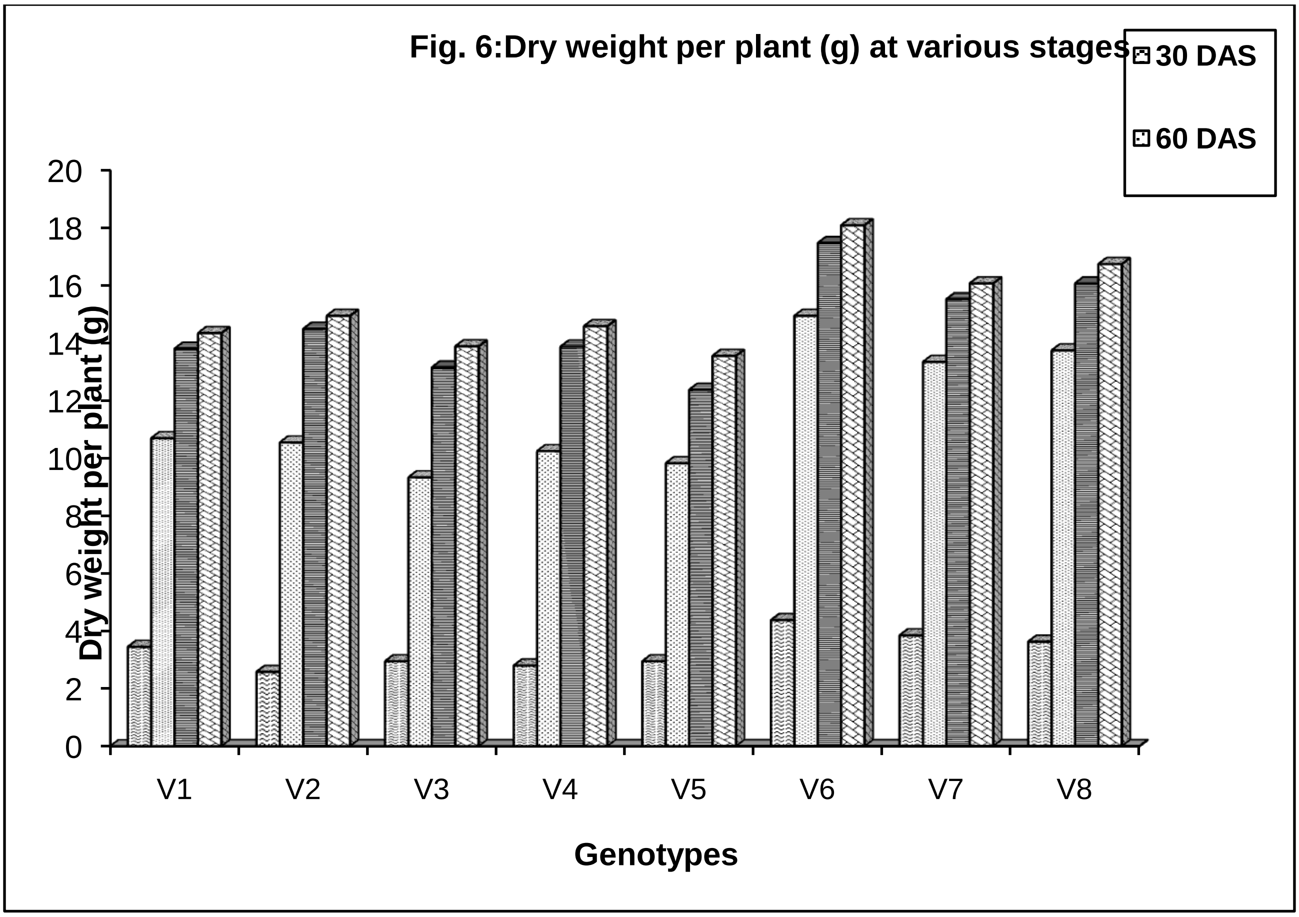


Fig. 6:Dry weight per plant (g) at various stages
30 DAS
60 DAS
Dry weight per plant (g)
0
2
4
6
8
10
12
14
16
18
20
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

Table 4.5: Root nodules per plant (g) at various stages

Trails	Genotypes	30 DAS	45 DAS	60 DAS
V_1	JS (SH) 2001-4	9.95	20.80	28.28
V_2	JS (SH) 2003-2	12.74	19.63	27.15
V_3	JS (SH) 2003-4	12.62	25.90	34.60
V_4	JS (SH) 2003-8	13.38	29.50	37.80
V_5	JS (SH) 2004-2	11.30	24.65	31.65
V_6	JS (SH) 2004-3	12.70	31.25	38.03
V_7	JS (SH) 2004-4	11.03	27.46	33.71
V_8	JS 335 (check)	14.39	28.80	35.53
S Em ±		0.81	2.12	2.48
CD at 5%		2.37	6.23	7.30

4.2.5: Dry weight of root nodules per plant (mg)

Dry weight of Root nodules was also recorded at an interval of 15 days from 30 DAS to 60 DAS perusal of data given in Table 4.6 clearly indicates that at 30 DAS all the genotypes were found at par except JS (SH) 2001-4 (72.14 mg) and JS (SH) 2004-4 (80.68 mg) this to were significantly inferior than other genotypes. At 45 DAS (SH) 2004-3 had the maximum dry weight of root nodules per plant (248.44 mg) which was significantly higher than JS (SH) 2003-2 (156.02 mg) and at par with other genotypes, whereas this trait showed highest in JS (SH) 2004-3 (303.82 mg) than all the genotypes, and the lowest value was obtained by JS (SH) 2003-2 (216.93 mg) followed by JS (SH) 2001-4 (225.92 mg) which were significantly lower than all the genotypes.

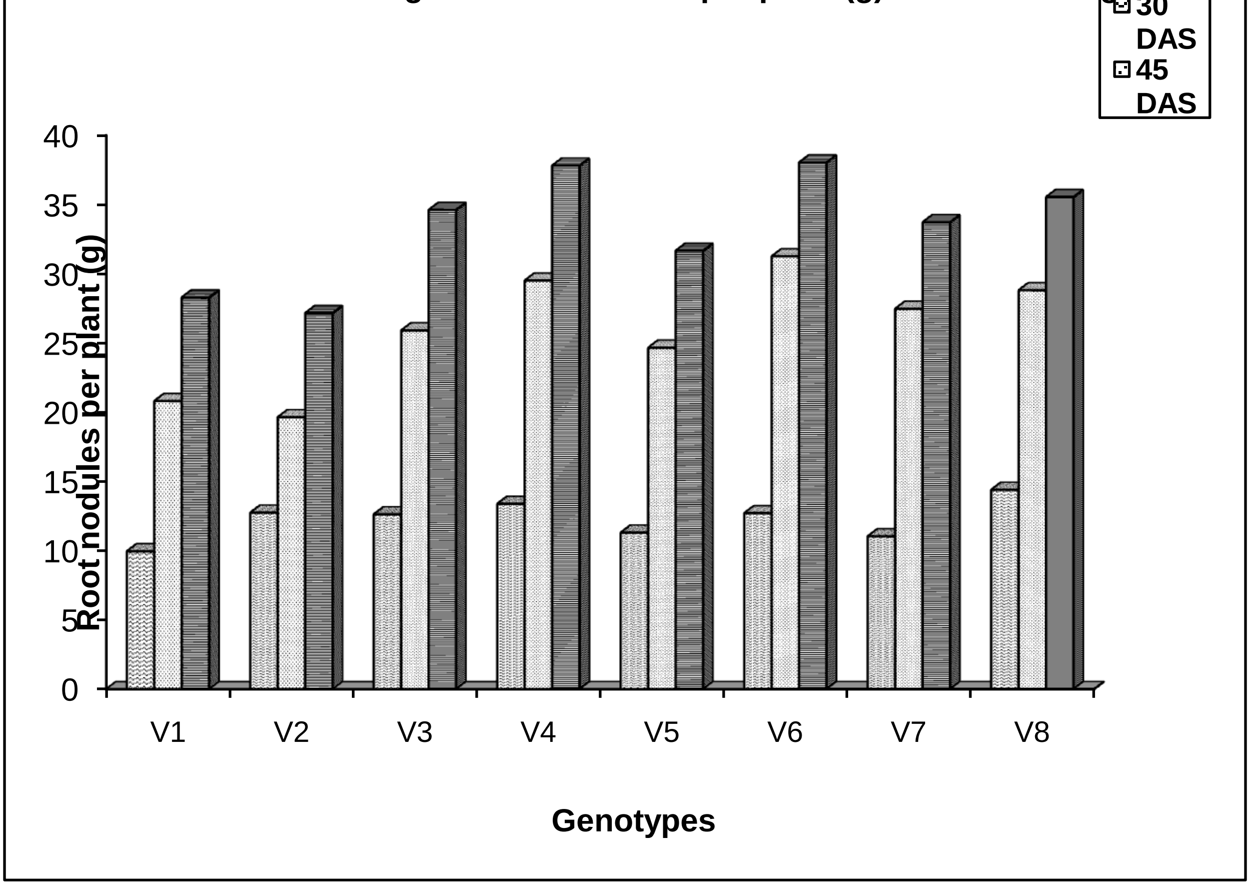


Fig. 7 : Root nodules per plant (g) at various stages

Table: 4.6 Dry weights of root nodules per plant (mg) at various stages

Trails	Genotypes	30 DAS	45 DAS	60 DAS
V_1	JS (SH) 2001-4	72.14	165.36	225.92
V_2	JS (SH) 2003-2	93.12	156.02	216.93
V_3	JS (SH) 2003-4	93.21	205.91	276.45
V_4	JS (SH) 2003-8	96.47	234.53	302.02
V_5	JS (SH) 2004-2	81.93	195.97	252.88
V_6	JS (SH) 2004-3	92.83	248.44	303.82
V_7	JS (SH) 2004-4	80.68	218.33	269.36
V_8	JS 335 (check)	103.80	228.96	283.84
S Em ±		5.84	16.83	19.83
CD at 5%		17.18	49.50	58.33

4.2.6 Days to 50% flowering

Days to 50 per cent flowering vary from 38.5 to 42.5 days with an average of 40.5 ± 0.59 days. Genotype showed earliness in 50 % flowering viz whereas genotype exhibited lateness in 50 % flowering was JS (SH) 2001-4 (42.5 days)

4.2.7 Days to maturity

Range of days to maturity from (94.0 to 98.50) days with an average of (96.25) days was recorded .The genotype, which is late maturity JS (SH) 2001-4 (98.5) days and JS (SH) 2004-2 is early maturity genotype matured in 94 days.

Table: 4.7 Days to 50% flowering and maturity at various stages

Trails	Genotypes	Days to 50% Flowering	Days to maturity
V_1	JS (SH) 2001-4	42.5	98.5
V_2	JS (SH) 2003-2	41.5	96.25
V_3	JS (SH) 2003-4	40.5	97.5
V_4	JS (SH) 2003-8	41.5	95.75
V_5	JS (SH) 2004-2	39.25	94
V_6	JS (SH) 2004-3	38.5	96
V_7	JS (SH) 2004-4	40	94.5
V_8	JS 335 (check)	40.25	95
S Em ±		0.59	0.80
CD at 5%		1.73	2.36

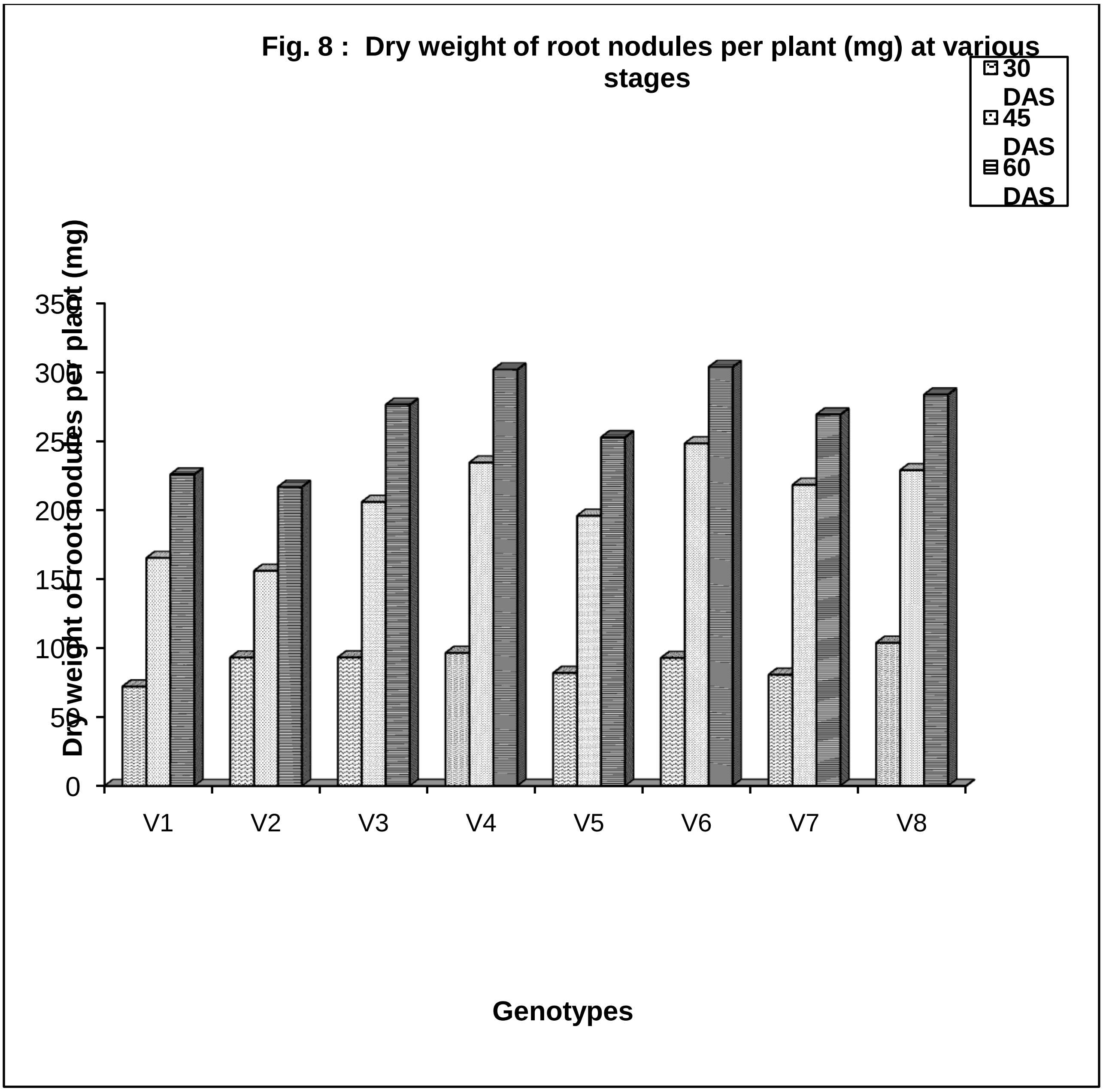


Fig. 8 : Dry weight of root nodules per plant (mg) at various stages
30 DAS
45 DAS
60 DAS
Dry weight of root nodules per plant (mg)
0
50
100
150
200
250
300
350
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

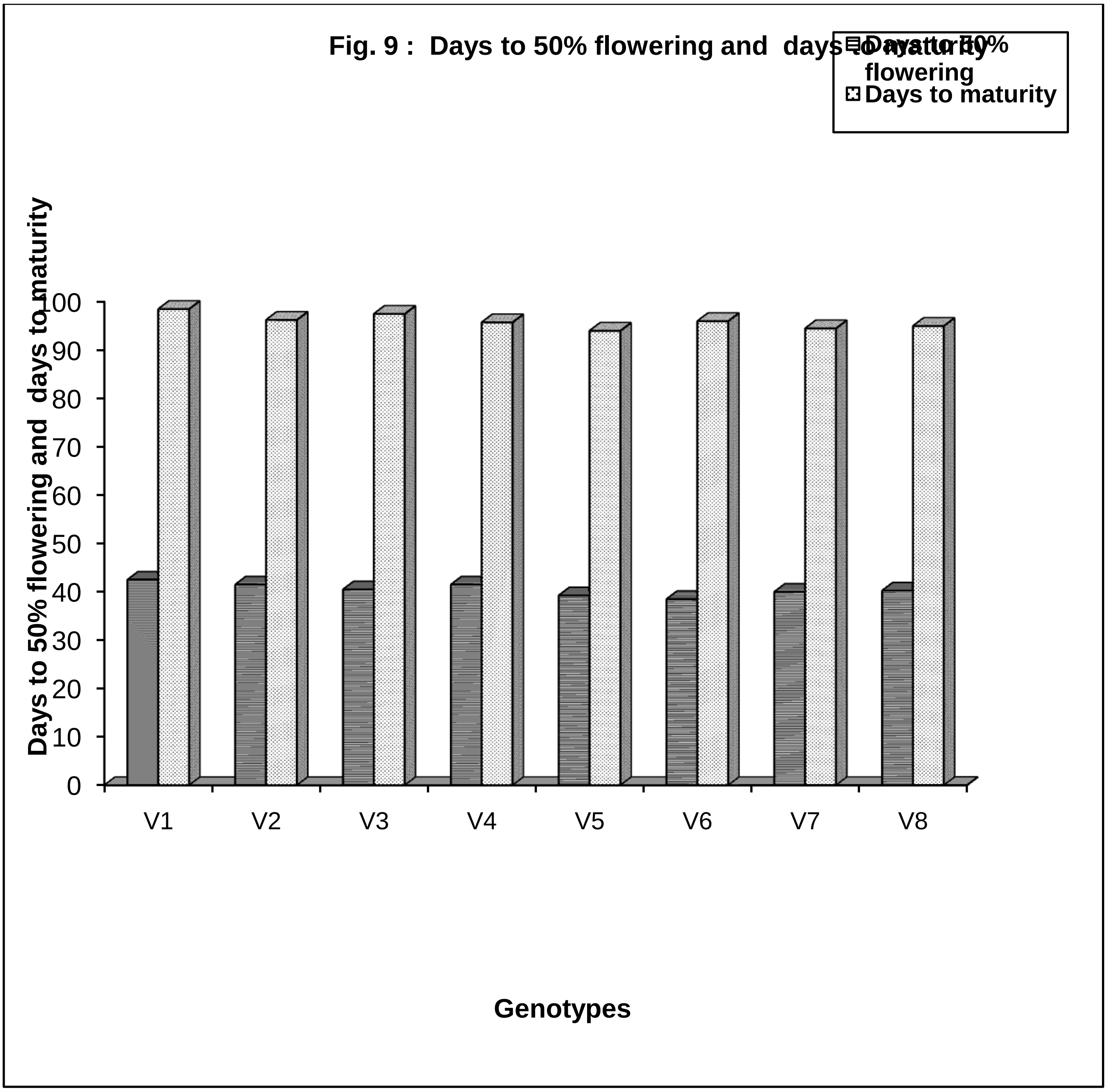


Fig. 9 : Days to 50% flowering and days to maturity
Days to 50% flowering
Days to maturity
Days to 50% flowering and days to maturity
0
10
20
30
40
50
60
70
80
90
100
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

4.3 Yield attributes

Yield attributes of various genotypes at harvest were recorded and has been presented in Table 4.8, 4.9 & 4.10.

4.3.1 Pods per plant

The number of pods per plant is one of the important yield attributing characters, which determines the grain yield of soybean crop. The numbers of pods per plant directly affects the number of grains per plant, and ultimately the final grain yield.

The data in the table 4.8 revealed a significant variation in the number of pods per plant .The maximum number of pods per plant was recorded under the genotype JS (SH) 2003-8 (44.30), which was significantly superior over all other genotypes but at par with the genotypes JS (SH) 2004-3 (40.75), which was again at par with the genotypes viz JS (SH) 2001-4 (40.45) and JS 335 (check) (40.30). The minimum number of pods per plant was rewarded under the genotype JS (SH) 2003-4 (33.05).

4.3.2 Seeds per pod

The maximum and minimum seeds per pod were recorded in JS 2003-4 (2.70) and JS (SH) 2003-8 (1.71) respectively. JS (SH) 2003-4 (2.70) and JS (SH) 2004-2 (2.59) were at par with regard to seeds per pod and were significantly superior to JS (SH) 2003-8 (1.71) and JS (SH) 2001-4 (1.75) and JS (SH) 2004-3 (1.75). Whereas, JS 2003-4 was found to be superior to all the genotypes except JS 2004-2.

4.3.3 Seed yield per plant (g)

The data on the seed yield per plant is the most important character by which the superiority of particular genotype over other is judged. The perusal of the Table 4.8 reveals that the significant variations in seed yield per plant of soybean due to effect of different genotypes. The various genotypes significantly affected the seed yield per plant.

Critical examination of the data revealed that genotype JS 335 (check) produced the maximum seed yield per plant (9.08 g), which was significantly superior over the other genotypes. It was followed by the genotype JS (SH) 2003-8 (8.55 g). The lowest seed yield per plant was recorded under the genotype JS (SH) 2004-3 (5.60 g).

4.3.4 Straw yield per plant (g)

Significantly higher straw yield per plant was recorded in JS (SH) 2003-4 (13.53 g) as compared to all the genotypes except JS (SH) 2003-8 (12.16 g), JS 335 (check) (11.98 g) and JS (SH) 2003-8 (10.96 g). The lowest straw yield per plant (7.78 g) was recorded in JS (SH) 2003-2, which was significantly lower than all the genotypes. The difference between other genotypes were non significant.

4.3.5 Seed index (g)

Seed index varied significantly due to genotypes maximum seed index of (9.80 g) was obtained for JS (SH) 2003-4 followed by JS (SH) 2003-8 (9.58 g), which was significantly greater than all the genotypes except JS (SH) 2001-4 (9.50 g) and JS 335 (check) (9.45 g). JS (SH) 2004-4 exhibited the lowest value of seed index (7.75 g), which was at par with JS (SH) 2004-3 (8.63 g), JS (SH) 2004-2 (8.88 g), JS (SH) 2003-2 (8.88 g), JS 335 (9.45 g), respectively.

Table: 4.8 Yield attributes of various genotypes at harvest

Trails	Genotypes	Pods / Plant	Seeds /pod	Seed yield / plant (g)	Straw yield / plant (g)	Seed index (g)
V_1	JS (SH) 2001-4	40.45	1.75	5.83	9.93	9.50
V_2	JS (SH) 2003-2	38.70	2.29	7.50	7.78	8.88
V_3	JS (SH) 2003-4	33.05	2.70	7.20	13.53	9.80
V_4	JS (SH) 2003-8	44.30	1.71	8.55	12.16	9.58
V_5	JS (SH) 2004-2	34.40	2.59	6.91	10.96	8.88
V_6	JS (SH) 2004-3	40.75	1.75	5.60	9.75	8.63
V_7	JS (SH) 2004-4	36.40	2.26	5.98	10.62	7.75
V_8	JS 335 (check)	40.30	2.02	9.08	11.98	9.45
S Em ±		1.70	0.16	0.61	1.02	0.36
CD at 5%		5.01	0.46	1.81	2.99	1.07

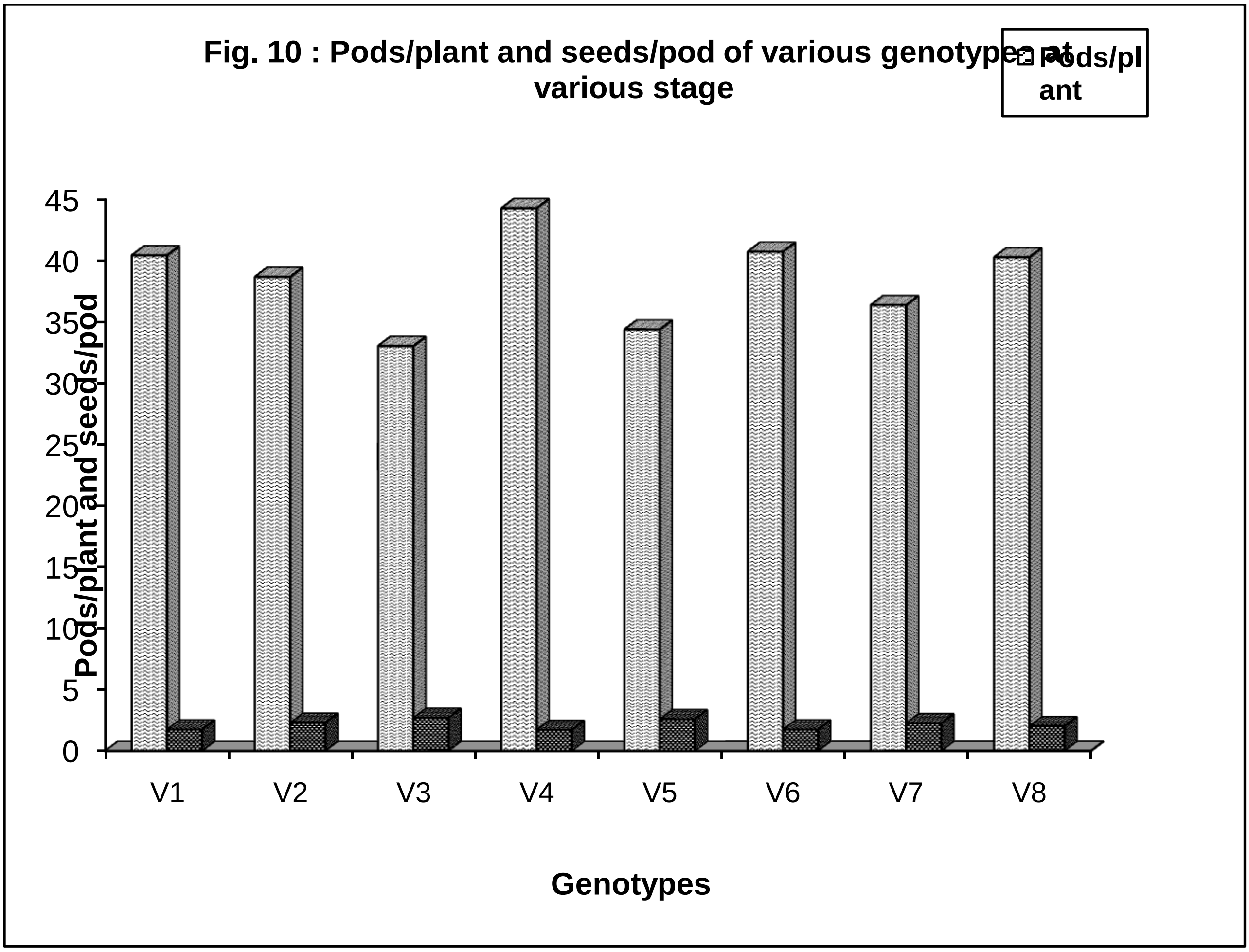
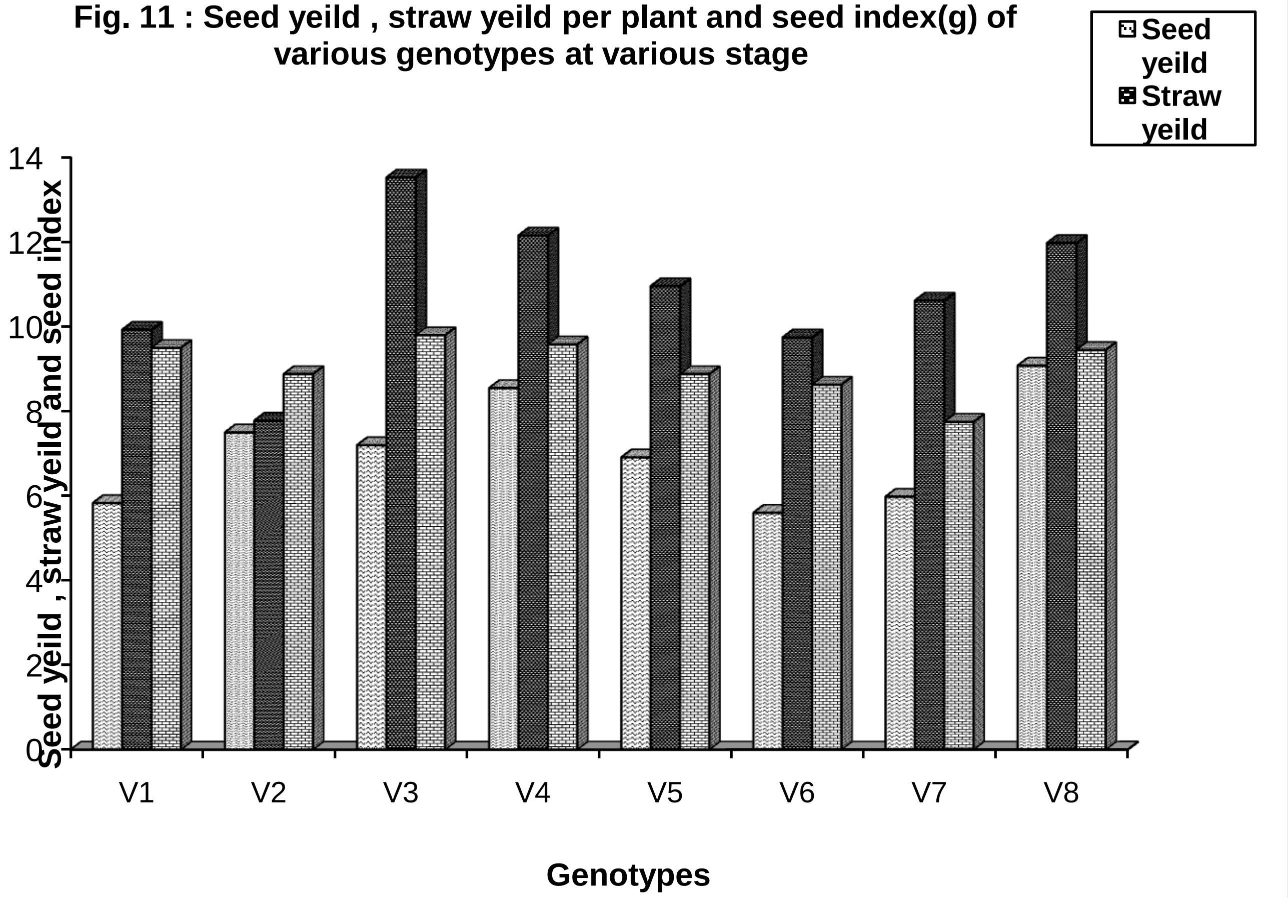


Fig. 10 : Pods/plant and seeds/pod of various genotypes at various stage
Pods/pl ant
Pods/plant and seeds/pod
45
40
35
30
25
20
15
10
5
0
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

Fig. 11 : Seed yeild , straw yeild per plant and seed index(g) of various genotypes at various stage



4.3.6 Seed yield per plot (kg)

Seed yield per plot was recorded for each genotype. The highest seed yield per plot was recorded in JS (SH) 2003-8 (4.54 kg) followed by JS (SH) 2001-4 (4.27 kg) which was significantly greater than JS (SH) 2004-2 only which gave the lowest seed yield per plot (2.89 kg). The variations between all the genotypes were non significant.

4.3.7 Straw yield per plot (kg)

Significantly higher straw yield per plot was recorded in JS (SH) 2003-8 (7.96 kg) as compared to all the genotypes longest straw yield per plot (3.94 kg/ha) was recorded in JS (SH) 2003-2 which was significantly lower than all the genotypes. The difference between genotypes was non significant.

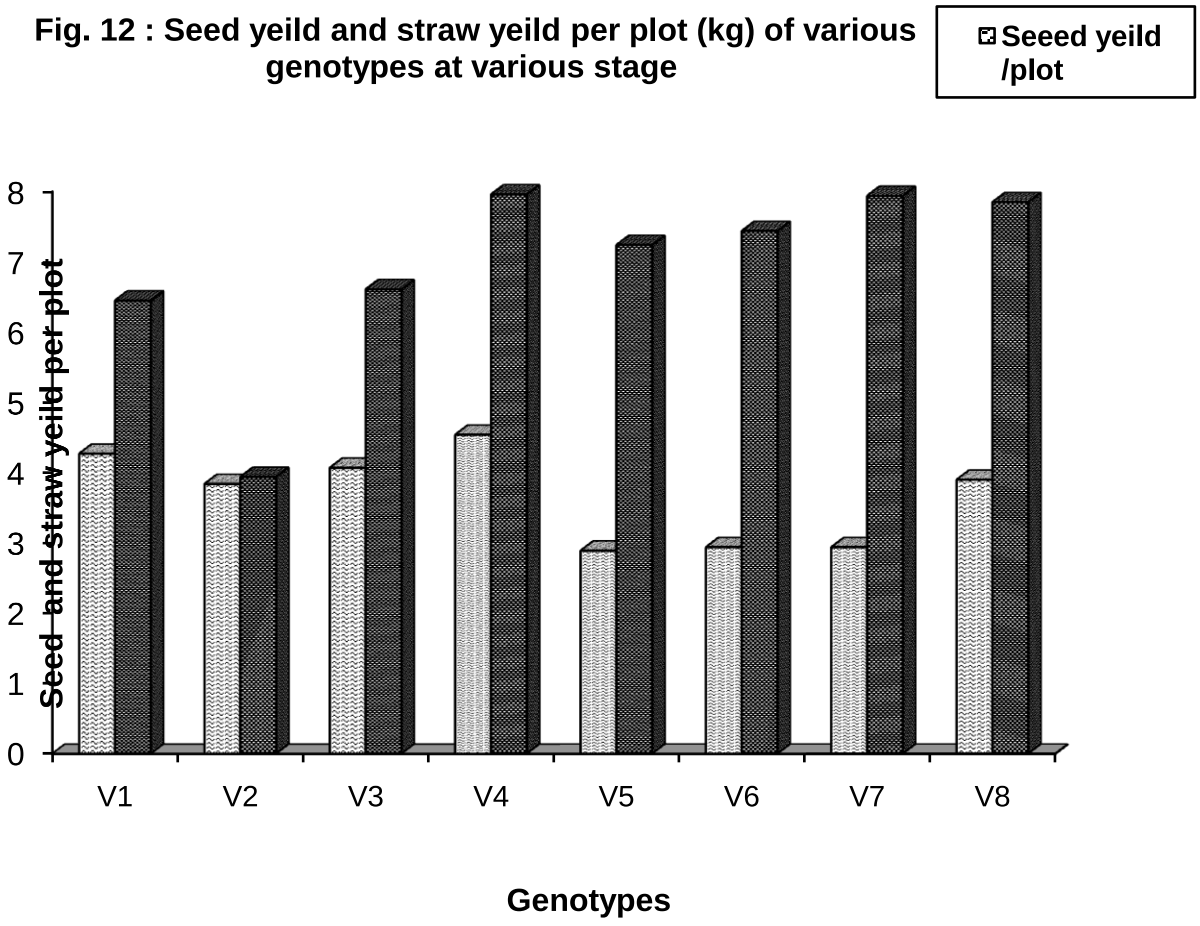
Table: 4.9 Seed yield and straw yield per plot (kg) of genotypes at various stages

Trails	Genotypes	Seed yield/plot	Straw yield/plot
V_1	JS (SH) 2001-4	4.27	6.45
V_2	JS (SH) 2003-2	3.84	3.94
V_3	JS (SH) 2003-4	4.07	6.61
V_4	JS (SH) 2003-8	4.54	7.96
V_5	JS (SH) 2004-2	2.89	7.24
V_6	JS (SH) 2004-3	2.94	7.44
V_7	JS (SH) 2004-4	2.94	7.94
V_8	JS 335 (check)	3.90	7.85
S Em ±		0.13	0.26
CD at 5%		0.38	0.78

4.3.8 Seed yield kg per hectare

Seed yield kg per hectare was calculated as per the yield obtained from net plot of each genotype. The data presented in table 4.10. Revealed that the highest seed yield per hectare was noted for JS (SH) 2003-8 (2243.75 kg/ha) followed by JS (SH) 2001-4 (2137.50 kg/ha). Although the seed yield per hectare for all the genotypes was at par except JS (SH) 2004-3 (1468.75 kg/ha), JS (SH) (1468.75 kg/ha) and JS (SH) 2004-2 (1418.75 kg/ha). The lowest seed yield was recorded in JS (SH) 2004-2 (1418.75 kg/ha), which was at par with JS (SH) 2004-3 (1468.75 kg/ha), JS (SH) 2004-4 (1468.75 kg/ha).

Fig. 12 : Seed yeild and straw yeild per plot (kg) of various genotypes at various stage



4.3.9 Straw yield kg per hectare

Similar to the seed yield kg per hectare straw yield kg per hectare was also calculated from the straw yield of net plot area. The maximum straw yield was obtained for JS (SH) 2003-8 (3981.25 kg/ha) followed by JS (SH) 2004-4 (3968.75 kg/ha), JS 335 (check) (3925 kg/ha) and JS (SH) 2003-2 (3875 kg/ha), which was significantly greater than JS (SH) 2001-4 (3112.50 kg/ha) and JS (SH) 2003-4 (3306.25 kg/ha)

4.3.10 Harvest index (%)

Harvest index was calculated for each genotype exhibited significant differences. The highest value was obtained for JS (SH) 2001-4 (68.94 %) followed by JS (SH) 2003-4 (61.72 %). The lowest harvest index was recorded for JS (SH) 2004-4 (37.57 %) which was significantly lower than JS (SH) 2001-4 (68.94%), JS (SH) 2003-4 (61.72%), JS (SH) 2003-8 (56.58%) , JS (SH) 2003-2 (50.33%) and JS 335 (check) (49.96%) while it was at par with rest of the genotypes.

Table: 4.10 Seed yield, straw yield (kg/ha) and harvest index(%) of various genotypes

Trails	**Genotypes**	Seed yield (kg/ha)	**Straw yield (kg/ ha)**	**Harvest index (%)**
V_1	JS (SH) 2001-4	2137.50	3112.50	68.94
V_2	JS (SH) 2003-2	1950.00	3875.00	50.33
V_3	JS (SH) 2003-4	2037.50	3306.25	61.72
V_4	JS (SH) 2003-8	2243.75	3981.25	56.58
V_5	JS (SH) 2004-2	1418.75	3618.75	39.35
V_6	JS (SH) 2004-3	1468.75	3718.75	40.16
V_7	JS (SH) 2004-4	1468.75	3968.75	37.57
V_8	JS 335 (check)	1950.00	3925.00	49.96
S Em ±		2.81	61.28	2.81
CD at 5%		8.28	180.27	8.28

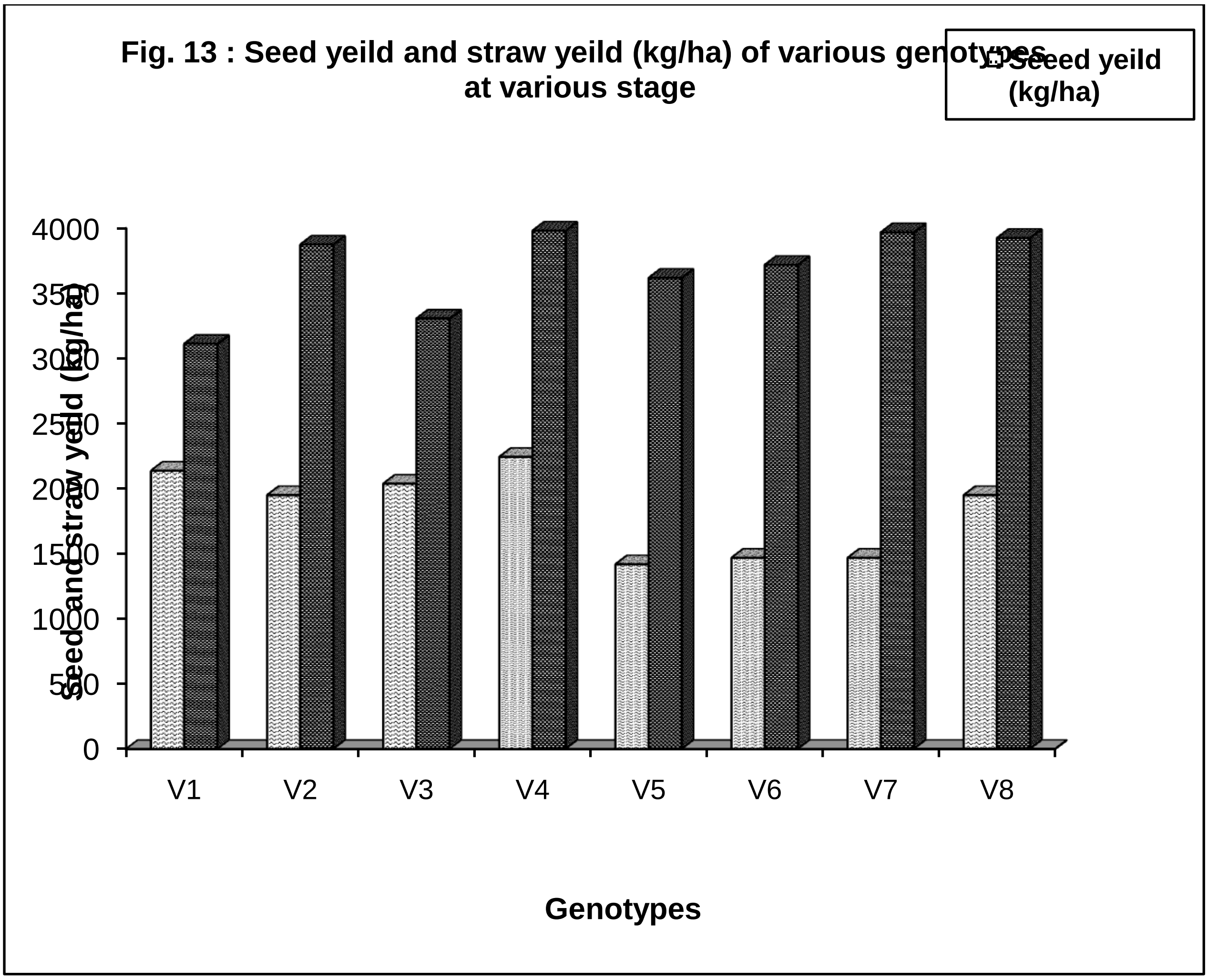


Fig. 13 : Seed yeild and straw yeild (kg/ha) of various genotypes at various stage
Seeed yeild (kg/ha)
Seed and straw yeild (kg/ha)
4000
3500
3000
2500
2000
1500
1000
500
0
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

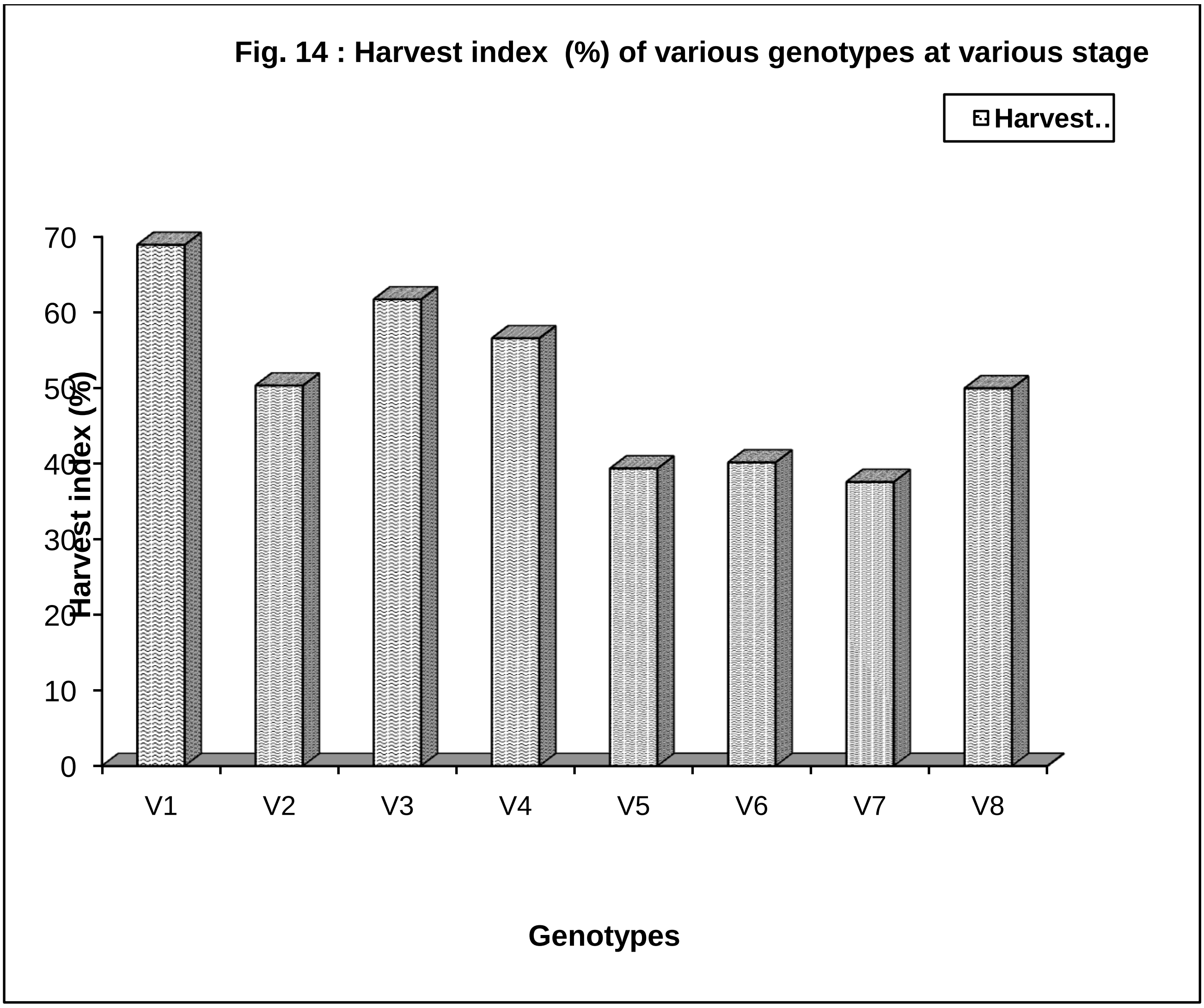


Fig. 14 : Harvest index (%) of various genotypes at various stage
Harvest..
Harvest index (%)
0
10
20
30
40
50
60
70
V1
V2
V3
V4
V5
V6
V7
V8
Genotypes

4.3.11 Grain production efficiency (kg/ha/day)

Grain production efficiency was estimated for various genotypes (table 4.11) It revealed significant variation for this parameter amongst genotypes. The maximum grain production efficiency JS (SH) 2003-8 (22.66 kg/ha/day) followed by JS (SH) 2001-4 (22.50 kg/ha/day) and JS (SH) 2003-4 (21.22 kg/ha/day). The lowest grain production efficiency was recorded in JS (SH) 2004-2 (14.78 kg/ha/day) followed by JS (SH) 2004-3 (14.84 kg/ha/day) and JS 335 (check) (20.53 kg/ha/day), which were significantly inferior to other genotypes regarding this parameter. The differences among rests of the genotypes other than JS (SH) 2004-2 and JS (SH) 2004-3 were non-significant.

Table: 4.11 Grain production efficiency of various genotypes

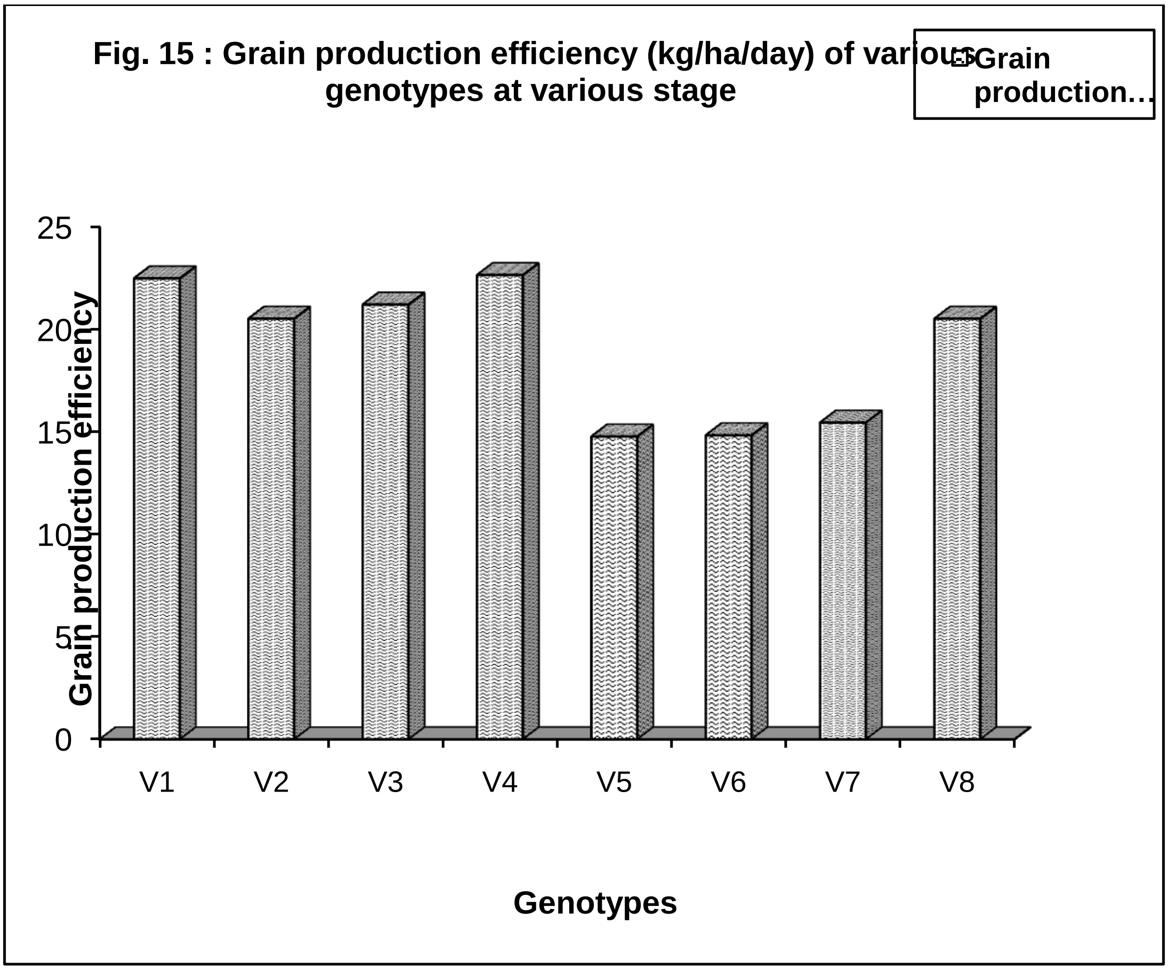
Trails	Genotypes	Grain production efficiency (kg/ha/day)
V_1	JS (SH) 2001-4	22.50
V_2	JS (SH) 2003-2	20.53
V_3	JS (SH) 2003-4	21.22
V_4	JS (SH) 2003-8	22.66
V_5	JS (SH) 2004-2	14.78
V_6	JS (SH) 2004-3	14.84
V_7	JS (SH) 2004-4	15.46
V_8	JS 335 (check)	20.53
S Em ±		0.64
CD at 5%		1.88

4.4 Correlation studies

4.4.1 Correlation with growth parameters

Seed yield per plant had positive and significant association with number of nodules at 30 DAS (0.647), dry weight of plant at maturity (0.546) and dry weight of root nodules at 30 DAS (0.334). Plant population at 30 DAS exhibited significant positive correlation with dry weight of plant at 90 DAS (0.286). Plant height at 60 DAS showed significant and positive correlation with dry weight of root nodules at 60 DAS (0.328), number of nodules at 60 DAS (0.328) , number of nodules at 45 DAS (0.403), dry weight of root nodules at 45 DAS (0.403), dry weight of root nodules at 45 DAS (0.403), plant height at maturity (0.768) and plant height at 90 DAS (0.776).

Plant height at 90 DAS had noticed significant positive correlation with dry weight of plant at 60 DAS (0.348) , number of branches at 30 DAS (0.501) , number at branches at 60 DAS (0.511), number of branches at 90 DAS (0.568), number of nodules at 60 DAS (0.548), dry weight of root nodules at 60 DAS (0.545) , branches at maturity (0.600), number of nodules at 45 DAS (0.682).



Plant height at maturity indicated significant positive correlation with dry weight of plant at 60 DAS (0.364) , branches at 60 DAS (0.510) , dry weight of root nodules at 60 DAS (0.541) , number of nodules at 60 DAS (0.543) , branches at 90 DAS (0.561) , number of nodules at 45 DAS (0.679) and dry weight of root nodules at 45 DAS (0.682).

Branches per plant at 30 DAS exhibited strong positive correlation with branches at 60 DAS (0.932) followed by branches at maturity (0.895), branches at 90 DAS (0.657), dry weight of root nodules at 30 DAS (0.473) and number of nodules at 30 DAS (0.467) where as showed positive association with number of nodules at 45 DAS (0.323) and dry weight of root nodules at 45 DAS (0.341).

Branches at 60 DAS inferred positive and significant correlation with number of nodules at 45 DAS (0.308) , dry weight of root nodules at 45 DAS (0.316) , dry weight of root nodules 30 das (0.359) number of nodules at 30 DAS (0.348) , branches maturity (0.964) and branches at 90 DAS(0.971).

Branches at 90 DAS had computed positive and significant association with dry weight of plant at 90 DAS (0.293), dry weight of plant at 60 DAS (0.308), dry weight of plant at maturity (0.316), dry weight of root nodules at 45 DAS (0.320), number of nodules at 30 DAS (0.333), dry weight of root nodules at 30 DAS (0.348) and branches at maturity (0995).

Branches at maturity had significant positive correlation with dry weight of plant at 90 DAS (0.299), dry weight of plant at 60 DAS (0.319), dry weight of root nodules at 45 DAS (0.321) , dry weight of plant at maturity (0.325), number of nodules at 45 DAS (0.328) , number of nodules at 30 DAS (0.346) and dry weight of root nodules at 30 DAS (0.362).

Dry weight of plant at 30 DAS exhibited positive significant association with dry weight of root nodules at 60 DAS (0.335), number of nodules at 60 DAS (0.338) dry weight of root nodules at 45 DAS (0.442), number of nodules at 45 DAS (0.448), dry weight of plant at maturity (0.695) , dry weight of plant at 90 DAS (0.696) and dry weight of plant at 60 DAS (0.829).

Dry weight of plant at 60 DAS showed strong and positive correlation with dry weight of plant at maturity (0.891) , dry weight of plant at 90 DAS (0.889) followed by number of nodules at 45 DAS (0.379) , dry weight of root nodules at 45 DAS (0.374).

Dry weight of plant at 90 DAS had strong significant and positive correlation with dry weight of plant at maturity (0.992).

Dry weight of plant at maturity showed significant association with dry weight of root nodules at 45 DAS (0.293) and number of nodules at 45 DAS (0.298).

Number of nodules at 30 DAS had positive and significant association with dry weight of root nodules at 45 DAS (0.312), number of nodules at 45 DAS (0.316) and dry weight of root nodules at 30 DAS (0.996).

Number of nodules at 45 DAS exhibited strong positive association with number of nodules at 60 DAS (0.782) , dry weight of root nodules at 60 DAS (0.924) and dry weight of root nodules at 45 DAS (0.982).

Number of nodules at 60 DAS showed significant positive correlation with dry weight of root nodules at 45 DAS (0.783) and dry weight of root nodules at 60 DAS (0.971).

Dry weight of root nodules at 30 DAS had positive and significant association with dry weight of root nodules at 45 DAS (0.309).

Dry weight of root nodules at 45 DAS had shown significant and positive association with dry weight of root nodules at 60 DAS (0.924).

4.4.2 Correlation between seed yield and its components

The correlation coefficients among yield and its components reveled that seed yield per plant showed significant positive association with pods per plant (0.675) followed by dry weight at maturity (0.62) , harvest index (0.382) and straw yield per plant (0.373).

Similarly harvest index exhibited significant positive correlation with seed index (0.569), straw yield per plant (0.471), and dry weight of plant at maturity (0.379), while it had negative association with plant height (-0.426) and branches per plant (-0.244).

Straw yield per plant recorded high significant positive association with pods per plant (0.521).

Whereas seeds per pod had shown significant positive association with pods/plant (0.292) and have negative correlation with plant height (-0.347).

Pods per plant noticed significant association with dry weight of plant at maturity (0.651) and plant height (0.561). Dry weight of plant at maturity exhibited positive and significant correlation with branches per plant (0.325).

Branches at maturity showed strong positive association with plant height (0.561). However other correlation coefficient were found low magnitudes and not described.

Table: 4.12 Correlation coefficient between yield and yield attributes.

Characters	Branches maturity	Dry wt. at Maturity	Pods/plant	Seeds/pod	Straw yield / plant	Seed index	Harvest Index%	Seed yield/plant
Plant height	0.561**	0.283	0.561**	-0.347	0.209	-0.333	-0.426	0.138
Branches	-	0.325*	0.133	-0.132	0.286	-0.267	-0.244	0.173
Dry wt. at maturity		-	0.651**	-0.197	0.038	-0.021	0.379*	0.612**
Pods/plant			-	0.292*	0.521**	0.096	0.094	0.675**
Seeds/pod				-	0.118	-0.137	-0.122	0.030
Straw yield /plant					-	0.280	0.471**	0.373**
Seed index						-	0.569**	0.236
Harvest Index%							-	0.382*

Table: 4.13 Correlation coefficient between yield and growth parameters at various growth stages.

	Plant popu at maturity	PH at 30 DAS	Plant height at 60 DAS	Plant height at 90 DAS	PH at matu	Bran 30 DAS	Branch 60DAS	Bran 90 DAS	Bran matur	DW 30 DAS	DW 60 DAS	DW 90 DAS	DW Matur	Nodul 30 DAS	Nodul 45 DAS	Nodul 60 DAS	DW RN 30 DAS	DW RN 45 DAS	DW RN 60 DAS	Seed Y/Pla
Plant popu 30DAS	0.833**	-0.123	-0.121	-0.239	-0.241	-0.039	-0.002	0.045	0.047	0.234	0.219	0.286*	0.254	-2.84	-0.393	-0.467	-0.264	-0.393	-0.467	-0.316
Plant popu at Maturity	-	-0.022	-0.107	-0.246	-0.244	0.007	0.012	0.059	0.062	0.132	0.177	0.203	0.186	-0.113	-0.370	-0.421	-0.091	-0.370	-0.421	-0.231
P H 30DAS		-	-0.225	-0.139	-0.157	0.227	0.095	0.104	0.091	-0.135	-0.210	-0.153	-0.140	0.153	-0.031	0.067	0.146	-0.031	0.067	0.231
PH 60DAS			-	0.776**	0.768**	0.137	0.146	0.200	0.206	0.193	0.169	0.085	0.118	-0.210	0.403*	0.328*	-0.214	0.403*	0.328*	-0.157
PH 90DAS				-	0.854**	0.501**	0.511**	0.568**	0.600**	0.240	0.348*	0.241	0.279	0.170	0.682**	0.548**	0.160	0.672**	0.545**	0.152
PH matu					-	0.494*	0.510**	0.561**	0.558**	0.248	0.364*	0.243	0.283*	0.185	0.679**	0.543**	0.174	0.682**	0.541**	0.138
Branch 30DAS						-	0.932**	0.657**	0.895**	0.125	0.223	0.221	0.236	0.467**	0.323*	0.282	0.473**	0.341*	0.282	0.210
Branch 60DAS							-	0.971**	0.964**	0.131	0.279	0.237	0.252	0.348*	0.308*	0.234	0.359*	0.316*	0.234	0.171
Branch 90DAS								-	0.995**	0.172	0.308*	0.293*	0.316*	0.333*	0.331*	0.241	0.348*	0.320*	0.241	0.159
Branches maturity									-	0.178	0.319*	0.299*	0.325*	0.346*	0.328*	0.239	0.362*	0.321*	0.239	0.173
DW 30DAS										-	0.829**	0.696**	0.695**	0.030	0.448*	0.338*	0.024	0.442**	0.335*	-0.313
DW 60DAS											-	0.889**	0.891**	0.183	0.379*	0.187	0.180	0.374*	0.187	-0.167
DW 90DAS												-	0.992**	0.228	0.273	0.111	0.242	0.273	0.111	-0.111
DW Maturity													-	0.228	0.298*	0.123	0.241	0.293*	0.123	-0.546**
Nodules 30DAS														-	0.316*	0.268	0.996**	0.312*	0.268	0.647**
Nodules 45 DAS															-	0.782**	0.309	0.982**	0.924**	0.074
Nodules 60DAS																-	0.271	0.783**	0.971**	0.204
DWRN 30DAS																	-	0.309*	0.271	0.334*
DWRN 45 DAS																		-	0.924**	0.074
DWRN 60 DAS																			-	0.204

4.5 Economic evaluation of different genotypes in terms of monetary returns (Rs. /ha) and benefit: cost (B: C) ratio

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

The cost of cultivation was common for all the genotypes of soybean under evaluation. The cost of cultivation included the initial cost of field preparation and the post sowing cost. The total cost of cultivation was found to be Rs. 10440/ha for all the genotypes under study.

4.5.2 Gross return (Rs.ha^{-1})

The gross return (Rs.ha^{-1}) was variable from genotype to genotype depending upon total seed and straw production (kgha^{-1}) soybean. A perusal of data presented in Table 4.14 revealed that the highest value (Rs. 36045.3 ha^{-1}) of gross return obtained from the genotype JS (SH) 2003-8 followed by the genotype JS (SH) 2001-4 (Rs. 33930 ha^{-1}). The lowest gross monetary return was obtained from the genotype JS (SH) 2004-3 (Rs. 24262.5 ha^{-1}).

4.5.3 Net return (Rs.ha^{-1})

The perusal of Table 4.14 revealed that the net monetary returns followed the same trend as that of gross monetary returns. The maximum net return of Rs. 25605 ha^{-1} was obtained by the genotype JS (SH) 2003-8 followed by the genotype JS (SH) 2001-4 (Rs. 23490 ha^{-1}). The lowest net monetary return was obtained from the genotype JS (SH) 2004-2 (Rs. 13014 ha^{-1}).

4.5.4 Benefit cost ratio

The benefit: cost ratio is one of the very important parameter, which decides the success of a particular treatment tested for the commercial cultivation by the farmer. The data presented in Table 4.14 reveals that the highest benefit: cost ratio was obtained from the genotype JS (SH) 2003-8 (2.45). The genotype which was found to be economically better after the genotype JS (SH) 2003-8 was the genotype JS (SH) 2001-4 (2.25). The lowest benefit: cost ratio was obtained under the genotype JS (SH) 2004-2 (1.24).

Table 4.14: Economics of various treatments

Tr. No.	Genotypes	Cost of cultivation	Yield (kg/ha)		Monetary returns (Rs)		B:C ratio
			Grain	Straw	Gross	Net	
V_1	JS (SH) 2001-4	10440	2137.5	3112.50	33930.00	23490	2.25
V_2	JS (SH) 2003-2	10440	1950.00	3875.00	31575.00	21135.00	2.02
V_3	JS (SH) 2003-4	10440	2037.5	3306.25	32546.25	22106.00	2.11
V_4	JS (SH) 2003-8	10440	2243.75	3981.75	36045.30	25605.00	2.45
V_5	JS (SH) 2004-2	10440	1418.75	3618.75	23452.50	13014.00	1.24
V_6	JS (SH) 2004-3	10440	1468.75	3718.75	24262.50	13822.00	1.32
V_7	JS (SH) 2004-4	10440	1468.75	3968.75	24412.50	13972.00	1.33
V_8	JS 335 (check)	10440	1950.00	3925.00	31605.00	21165.00	2.02

CHAPTER-V
DISCUSSION

The present investigation entitled "Studies on seedling, nodulation, growth and yield parameters in promising genotypes of soybean [*Glycine max* (L.) Merrill] " was conducted during kharif season, 2009 at R.A.K. College of Agriculture, Sehore (M.P.).

The experimental results reported in the previous chapters are discussed on present findings with available research evidences in order to find out possible explanation under following heads:

5.1 Growth parameters

5.2 Yield attributes

5.3 Correlation coefficient

5.4 Economics of the treatments

5.1 Growth parameters

5.1.1 Plant height

A linear increase in plant height was observed with the advancement in age of all soybean genotypes. Height of all soybean genotypes increased rapidly up to 60 DAS. The slow increase in plant height in the initial stage of plant growth may be attributed to lesser number of leaves produced for growth. Thereafter plants were developing more and large leaves for preparing more food which increased cell division and resulted in rapid growth of the plants.

The statistical analysis of plant height at harvest stage indicates that the response of genotypes was significant.

Genotypes JS (SH) 2003-8 produced significantly tallest plants (72.95 cm) and genotype JS (SH) 2004-4 ranked second with height (72.25 cm) while genotype JS (SH) 2001-4 produced the shortest height (61.35 cm). It is observed from the data that the plant height increased and continued up to 90 DAS. These results are in close conformity with the results of Soni (1984), Kumari et al. (1993) choubey (1996), Dubey (1997), Parmar (2002), Mandloi *et al*. (2003), Islam *et al*. (2004), Khan *et al*. (2004), Thakur (2005) Patidar (2006), Abayomi (2008), Patel (2008) and Baghel (2009)..

5.1.2 Number of branches per plant

Branching is an important character of crop, which is directly related with number of pods per plant and ultimately the yield of the crop. A rapid increase in branches per plant was observed up to 60 DAS and then slight increase up to 90 DAS. The degree of magnitude of increase was higher in initial stage of growth due to available nutrients which were utilized for the lateral growth of the plants.

A perusal of the data presented in Table 4.3 showed that response of genotypes were significant.

Check variety JS 335 (check) produced significantly maximum number of branches per plant (5.80) followed by genotype JS (SH) 2004-4, JS (SH) 2004-3, JS (SH) 2001-4 (5.18, 4.35 and 3.60 respectively). However, genotype JS 2001-4 produced minimum number of branches per plant (3.60).The variation in production of branches in genotypes may be due to genetically make up of individual genotype. These results are in confirmation with the results of Soni (1984), Singh and Sharma (1985), Kim *et al*. (1993), Paul and Guha (1994), Sharma (1994) Choubey (1996), Akbari and Peat (2001), Parmar (2002), Islam *et al*. (2004) Kaul (2004), Thakur (2005), Abayomi (2008), Patel (2008) and Baghel (2009).

5.1.3 Dry weight per plant

A critical examination of Table 4.4 indicated that response of genotypes for dry weight per plant was significant at all the stages of crop growth. Genotype JS (SH) 2004-3 produced the highest dry weight per plant (18.10 g) followed by genotype JS 335 (16.75 g) while genotype JS (SH) 2004-2 produced the lowest dry weight per plant (13.56 g). This may be due to variation in overall growth and development of individual genotype as it is also evident from various growth observations like plant height and branches per plant as discussed in earlier chapter by several researchers namely Sharma (1994), Choubey (1996) Dubey (1997), Akbari and Peat (2001), Parmar and Nema (2002) Mandloi *et al*. (2003) and Kaul (2004) Thakur and Vyas (2005) and Patel (2008).

5.1.4 Number of nodules per plant

Nodulation in a genotype is governed by certain genetic factors associated with microclimatic conditions of soil in which plants grow; hence it varies from one genotype to another.

A perusal of the data presented in Table-4.5 revealed that the response of genotype for this trait was found significant.

Genotype JS (SH) 2004-3 produced maximum number of nodules per plant (38.03) than other genotype at 60 DAS and genotype JS (SH) 2003-8 ranked second while genotype JS (SH) 2003-2 produced minimum number of nodules per plant (27.15). Similar results were also reported by Sharma and Sharma (1981), Dubey and Billore (1993), Choubey (1996), Mandloi *et al*. (2003) ,Kaul (2004) Patel (2008) and Baghel (2009).

5.1.5 Dry weight of nodules per plant (mg)

A perusal of data in Table-4.1.6 showed that the response of genotype were found significant, regarding dry weight of nodules per plant.

Genotype JS (SH) 2004-3 recorded the highest dry weight per plant (303.82 mg) than other genotypes at 60 DAS followed by JS (SH) 2003-8(302.02 mg).

Genotype JS (SH) 2003-2 gave the lowest dry weight of nodule per plant (216.93 mg). This is more probably due to their genetic behavior of *Rhizobium japonicum* strain. These results are in close conformity with the findings of Soni (1984), Mohammad *et al*. (1994), Choubey (1996) ,Kaul (2004) , Patel (2008) and Baghel (2009).

5.2 Yield attributes:

5.2.1 Pods per plant:

The yield of soybean per unit area is influenced to a greater extent by the number of pods per plant. More number of pods per plant led to higher seed yield. A critical examination of Table 4.8 reveals that the response of genotypes for this trait was found significant.

Genotype JS (SH) 2003-8 produced significantly higher pods per plant (44.30), while JS (SH) 2004-3 and JS (SH) 2001-4 ranked second and third respectively. Genotype JS 2003-4 produced lower number of pods per plant (33.05). The variation in pod bearing ability among genotypes may be due to varietal characters. Similar results were also reported by Soni (1984), Nigam *et al*. (1989), Billore *et al*.(2000), Panchariya (2000), Akbari and Peat (2001), Khan *et al*. (2005), Kumar *et al*. (2005) and Samaiya *et al*. (2007).

5.2.2 Seeds per pod

A Critical examination of Table 4.8 infers that the response of genotypes were significant.

Genotype JS (SH) 2003-4 produced the highest number of seeds per pod (2.70) followed by JS (SH) 2004-2 and JS (SH) 2004-4 while genotype JS (SH) 2003-8 produced the lowest number of seeds per pod (1.71). This variation in seeds per pod among genotypes may be accounted by genetic and environmental conditions. Similar results were also reported by Billore *et al*. (2000), Panchariya (2000), Akbari and Peat (2001), Khan *et al*. (2005), Kumar *et al*. (2005) Samaiya *et al*. (2007), Patel (2008) and Baghel (2009).

5.2.3 Seed index (g)

Seed is a product of cumulative effect of all factors contributing towards growth and development through the source and sink relationship and it is a parameter, which describes the size of the seed. The analysis of variance revealed significant differences among genotypes.

Genotypes JS (SH) 2003-4 gave significantly highest seed index (9.8 g) while genotype JS (SH) 2003-8and JS (SH) 2001-4 were at par with it(9.57 and 9.5 g respectively). The genotype JS (SH) 2004-4 gave the lowest seed index (7.75 g). The variation in seed size among genotypes may be accounted for genetic inheritance. These results were in accordance with the findings of Nigam *et al*. (1989), Kim *et al*. (1993), Billore *et al*.(2000), Panchariya (2000), Akbari and Peat (2001), Khan *et al*. (2005) , Mandloi et al. (2003) and Vyas (2005).

5.2.4 Seed yield / plant (g)

Seed yield per plant is the final expression of physiological genetical and biochemical activities of a plant and a final product of cumulative action of all factors contributing to growth viz; pods per plant branches per plant and seed index.

The data indicated that seed yield per plant varied significantly among genotypes, statistically.

Variety JS 335 (check) gave significantly higher seed yield per plant (9.08 g) followed by JS (SH) 2003-8 (8.55 g). Whereas genotype JS 2004-3 produced lower seed yield per plant (5.60 g). This yield variation in respect of various genotypes may be due to variation in branches and pod bearing ability of various genotypes. Soni (1984), Sharma and Sharma (1991), Dahtonde and Shava (1992), Sharma and Sharma (1993), Choubey (1996), Parmar (2002), Mandloi *et al*. (2003), Thakur (2005) and Patidar (2006) reported the variation in yield levels of different genotypes, which are in accordance with the present findings.

5.2.5 Harvest Index (%)

The analysis of variance for harvest index revealed that the response of genotypes was found statistically significant.

Genotype JS (SH) 2001-4 recorded significantly higher harvest index (68.94 %) followed by JS (SH) 2003-4 (61.72 %). However genotype JS (SH) 2004-4 exhibited the lowest harvest index (37.57%). Nigam *et al*. (1989), Kim *et al*. (1993), Billore *et al*. (2000) , Thakur and Vyas (2005) and Patidar et al. (2006) also reported similar findings for variation in 20 germplasm of soybean.

5.2.6 Seed yield (kg/ha)

Seed yield is a complex trait resulted from different yield contributing characters. In the present investigation pods per plant, seeds per pod and seed index have shown maximum contribution on seed yield by different genotypes. It is evident from the statistical analysis of data that the response of genotypes on seed yield was significant.

Genotype JS (SH) 2003-8 produced significantly higher seed yield (2243.75 kg/ha) followed by JS (SH) 2001-4, JS (SH) 2003-4, JS (SH) 2003-2 and JS 335 (check) respectively. The genotype JS (SH) 2004-2 produced the lowest seed yield (1418.75 kg/ha). The highest yield in JS (SH) 2003-8 may be due to the maximum root nodules per plant, plant height per plant, number of branches per plant, maximum pods per plant comparatively greater dry weight of root nodules per plant, pods per plant. seeds per pod and seed yield per plant. This favorable morphological phenomenon in this genotype resulted in significantly highest yield. These results are in agreement with the results reported by Anonymous (1995), Karmakar and Bhatnagar (1996) Anonymous (1999), Anonymous (2001), Anonymous (2002-03), Rahman *et al*. (2002-03), Islam *et al*. (2004), Khan *et al*. (2005), Kumar *et al.* (2005), Thakur (2005),Pandya *et al.* (2005) and Patidar (2006).

5.2.7 Straw yield (kg/ha)

The increase in straw yield is directly related to an increase in the vegetative growth and to a negligible extent the increase in the reproductive portion of the plants.

The perusal of data in Table-4.10 revealed that straw yield showed significant differences.

Genotype JS (SH) 2003-8 produced the highest straw yield (3981.75 kg/ha) followed by genotype JS (SH) 2004-4, JS (SH) 2003-2 and JS (SH) 2004-3. The genotype JS (SH) 2001-4 gave the lowest straw yield (3112.50 kg/ha). Similar findings were also observed by Veni and Murthy (2003), Kumar *et al*. (2005), Pandya *et al*. (2005), Thakur (2005) and Patidar. (2006).

5.2.8 Grain production efficiency (kg/ha.day)

The data given in Table 4.11 indicates that grain production efficiency varied significantly among genotypes.

Genotype JS (SH) 2003-8 gave the highest grain production efficiency (22.66 kg/ha.day) followed by genotypes. JS (SH) 2001-4, JS (SH) 2003-4 ,JS (SH) 2003-2 and JS 335. Whereas genotype JS (SH) 2004-2 gave the lowest grain production efficiency (14.78 kg/ha/day). The variations among genotypes were also reported by Singh and Sharma (1985), Sharma and sharma (1993), Choubey (1996) and Panchariya (2000).

Correlation coefficients

Yield is a complex trait and its expression is determined by the association among yield attributes and the interaction of genotypes with the environmental factors. Direct selection for seed yield may sometimes prove in effective due to high environmental influence.

Many plant characters which are highly heritable and also positively correlated with seed yield provide an opportunity for making direct and effective selection for increasing seed yield. Associations among desirable characters often help in direct selection for the improvement in such desirable attribute. Association analysis brings out character association which are generally due to linkage and pleiotrophy and physiological association. Manipulation of positive effects of such association is useful in increasing yield. Yield is the final product of morphological components which influence it directly and indirectly. A change in any of these may bring change in others and finally in the economic yield. Therefore, in order to obtain high yields, the information regarding correlation coefficients between the seed yield and its contributing characters which are significantly and positively associated will definitely help as a guide to breeders in selecting the superior genotypes for the characters of economic importance.

The results of the present study have been discussed in the light of the available literature.

5.3.1 Correlation coefficients between seed yield and its attributing traits

The seed yield per plant exhibited high significant positive correlation with pods per plant followed by dry weight at maturity, harvest index and straw yield per plant. These results are in accordance with the findings of Gwal (1990), Narolia (1990), Yaduwanshi (1992), Jadhav *et al*. (1995), Shinde *et al*. (1996), Ramgiry and Raha (1997), Rajput *et al*. (1998), Pooranchand and Chand (1999). Thorate *et al.* (1999), Nimbalkar and Gujar (2000), Patware *et al*. (2001), Jain *et al*. (2002), Chamundeshwari (2003), Dwivedi (2003), Oneml (2003), Patel (2008) and Baghel (2009).

Pods per plant exhibited positive correlation with dry weight of plant at maturity, plant height similar results were also reported by Shukla *et al.* (1998), Dubey and Tomar (2000).

Harvest index exhibited significant positive correlation with seed index, straw yield per plant, dry weight of plant at maturity, while it had negative association with plant height reported by Narolia (1990),Yaduvanshi (1920),Mehetre *et al.(*1997),Patware *et al.* (2001), Frederick and Hesketh (1994) and Singh *et al.* (2000).

Seeds per pod had shown significant positive association with pods per plant and have negative correlation with plant height. Dry weight of plant at maturity exhibited positive and significant correlation with branches per plant. Branches at maturity showed strong positive association with plant height, However other correlation coefficient were found low magnitudes and not described similar findings were reported by Amarnath *et al.* (1990), Narolia (1990), Jagtap and Choudhary (1993), Singh *et al*. (1996), Shukla *et al*. (1998), Pooranchand and Chand (1999),Patware *et al.* (2001), Oneml (2003), Mohammed arshad *et al.(*2006), Mohammed faisal *et al.(*2007),Patel (2008) and Baghel (2009).

5.3.3 Correlation coefficients among Growth parameters

Plant height at maturity indicated significant positive correlation with dry weight of plant at 60 DAS, branches at 60 DAS, dry weight of root nodules at 60 DAS, Number of nodules at 45 DAS and dry weight of root nodules at 45 DAS similar studies were carried out by Narolia (1990), Dekha and Talukdar (1994), Yaduvansi (1992) , Jadhav *et al.*(1995), Rajarathinam *et al*.(1996), Shinde *et al*. (1996), Singh *et al.* (1996),Taware *et al.* (1997), Patware *et al.* (2001) and Mohammad faisal *et al.* (2007),

Number of branches had significant positive correlation with dry weight of plant at 90 DAS, dry weight of plant at 60 DAS, dry weight of root nodules at 45 DAS , dry weight of plant at maturity . Number of nodules at 45 DAS, number of nodules at 30 DAS. Present finding are in close agreement with the findings of Rajarathinam an Pandian (1996), Shinde *et al.* (1996), Kumar *et al.* (1997) Kumar et al. (1997), Patware *et al*.(2001, Oneml (2003), Mohammad Arshad *et al.* (2006) and Mohammad faisal *et al.* (2007).

Straw yield per plant was found to be negatively correlated with harvest index but positively correlated with seed yield. Present findings are in close agreement with the findings of Narolia (1990), Yaduvanshi (1992), Mehetre *et al*. (1997) and Patware *et al.* (2001).

However, Singh *et al.* (2000) reported negative correlation with almost all the characters under study except grains per pod.

Dry weight per plant at 30 DAS was positively correlated with dry weight per plant at 60 DAS. While dry weight per plant at 90 DAS had positive correlation with dry weight per plant at maturity. Similar, results were reported by Dwivedi (2003) and Baghel (2009).

5.4 Economics

The comparative economics of various treatments are given in Table-4.4.7 which showed that genotype JS (SH) 2003-8 gave the highest net return Rs. 25605.00 per hectare followed by genotypes JS (SH) 2001-4 and JS (SH) 2003-4 which ranked second and third with Rs. 2349.00 and Rs.22106.00 per ha respectively, Similar results were also reported by Thakur (2005), Patidar (2006), Patel (2008) and Baghel (2009).

The benefit cost ratio was also highest with genotype JS (SH) 2003-8 (2.45) followed by JS (SH) 2001-4 (2.25) and JS (SH) 2003-4 (2.11) in comparison to other genotypes under study.

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

The present investigation entitled “Studies on seedling, nodulation, growth and yield parameters in promising genotypes of soybean [*Glycine max* (L.) Merrill] genotypes under Vidhyan plateau of Madhya Pradesh “ was carried out at the research farm of R.A.K. College of Agriculture, Sehore (M.P) during *Kharif* season 2009.

The experiment was laid out in Complete Randomized Block Design with 4 replications on 8 promising soybean genotypes viz. JS (SH) 2001-4, JS (SH) 2003-2, JS (SH) 2003-4, JS (SH) 2003-8, JS (SH) 2004-2, JS (SH) 2004-3, JS (SH) 2004-4 and JS-335 (Check). The Soil of the experimental field was medium and black, medium in available organic carbon, nitrogen and potassium and high in available phosphorus and was normal in soil pH (7.5) and electrical conductivity.

The study was carried out for studying different growth parameters yield attributes and relationship with various characters among the genotypes. The analysis of variance carried out for all the traits recorded significant differences among genotypes for all the characters under study.

The different growth characters i.e. plant height, branches, dry weight of plant, nodule number ,dry weight of nodules, days to 50% flowering and days to maturity and yield attributing characters i.e. pod number, Seeds per pod, seed index, seed yield per plant, seed yield per plot , seed yield per hectare and grain production efficiency were studied to make out look of straw and seed yield.

6.2 The results obtained from present investigation has been summarized as under:

1. The genotypes response on seedling and growth parameters viz; root length, shoot length, seedling height, dry weight of seedling, plant height, dry weight per plant, were found significant. JS (SH) 2003-8 found best for the majority of the characters followed by JS (SH) 2004-3.

2. Genotype JS (SH) 2003-8 performed best for a post harvest parameter viz pods/plant, seed yield (Kg/ha), Straw yield (kg/ha) and grain production efficiency (kg/ha/day) were found significant among genotypes.

3. Seed yield per plant had recorded significant positive correlation with pod per plant dry weight per plant, harvest index and straw yield per plant.

6.3 Economics:

Genotype JS (SH) 2003-8 gave the highest net return and cost benefit ratio (Rs 25605 /ha. and 2.45) than other genotypes.

6.4 Conclusions:

Genotypes JS (SH) 2003-8, JS (SH) 2004-3 and JS 335 were found to be superior for characters like plant height ,number of branches, dry weight of per plant, number of nodules per plant, dry weight of nodules per plant , seed yield per plant , seed yield (kg/ha), straw yield (kg/ha) and grain production efficiency.

Genotypes JS (SH) 2003-8 was found superior over all genotypes for straw yield (kg/ha).

Among the genotypes tested genotype JS (SH) 2003-8 (2243.75 kg/ha) appeared suitable for cultivation in Sehore agro-climatic condition in Vidhyan Plateau of Madhya Pradesh followed by JS (SH) 2001-4 and JS (SH) 2003-4.

6.5 Suggestions for further work:

The present investigation needs further confirmation and the field experiment may be repeated for two more growing seasons taking into consideration the following points:

(i) Most of the genotypes are newly developed these must be tested for more than two growing seasons before recommending them for commercial cultivation.

(ii) These genotypes must be tested over various agro-climatic zones for stable performance.

(iii) Study of correlation coefficient analysis of physiological parameters with yield would be more rewarding to know the true relationship between seed yield and its attributes through other refine biometric technique like path analysis.

(iv) The study of disease and insect attack on these newly bred genotypes may be worked out before their commercial cultivations.

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APPENDICES

Appendix (I) Basic cost of cultivation

S. no.	Particulars	Cost Rs/ha
1	Field preparation and sowing	1800.00
2	Cost of fertilizer D.A.P. (18:46:0) 130 kg	1263.00
	M.O.P (0:0:60) 33.33 kg	133.00
	Gypsum 129.0 kg	200.00
3	Cost of seed 80 kg	2400.00
4	Cost of seed treatment	
	Carboxin 35.5% + Thirum 0.2 kg	36.00
	Rhizobium japonicum ***0.4 kg***	16.00
	P.S.B. culture 0.4 kg	20.00
5	Plant protection	
	Chloropyriphos 2 liter/ha	392.00
6	Weeding and hoeing	
	Hoeing dora 450 Rs/day	900.00
	Weeding 18 labours	1440.00
7	Harvesting 15 labours	1200.00
8	Threshing 8 labours	640.00
	Total cost of cultivation	**10440.00**

According to prevailing rates

Rent of tractor	@	Rs 250 / hours
Labour charge	@	Rs 80 / day
Cost of fertilizer		
D.A.P.	@	Rs 9.70 per kg
M.O.P	@	Rs 3.99 per kg
Gypsum	@	Rs 1.55 per kg
Cost of seed	@	Rs 30 per kg
Cost of chloropyriphos	@	Rs 196 per litre
Cost of fungicide and culture		
Thirum	@	Rs 180 per kg
Rhizobium	@	Rs 40 per
P.S.B. culture	@	Rs 50 per kg

(II) Values of mean sum of squares for seedling characters at various genotypes

Source of Variation	d.f	Seedling characters at				
		Root length (cm)	Shoot length (cm)	Seedling height (cm)	Dry weight of seedling (g)	Vigour index (g)
Replication	3	0.04	2.26	1.53	0.11	979.53
Treatment	7	-3.87**	5.76**	7.42**	0.47	4121.50**
Error	21	0.24	1.69	0.78	0.12	858.44

* Significant at p = 0.05

** Significant at p = 0.01

(III) Values of mean sum of squares for plant population at various stages (per square meter)

Source of variation	d.f.	Plant population at	
		30 DAS	At maturity
Replication	3	4085.75	2929.21
Treatment	7	10729.21**	5234.84**
Error	21	2939.82	1644.97

(IV) Values of mean sum of squares for plant height at various stages (in cm)

Source of Variation	d.f.	Plant height at			
		30 DAS	60 DAS	90 DAS	At maturity
Replication	3	9.17	3.19	5.20	7.21
Treatment	7	20.86**	174.22**	92.92**	95.88**
Error	21	4.38	17.60	9.21	8.88

(V) Values of mean sum of squares for branches per plant at various stages

Source of variation	d.f.	Branches per plant at			
		30 DAS	**60 DAS**	**90 DAS**	**At maturity**
Replication	3	0.01	0.13	0.25	0.17
Treatment	7	1.61	2.11	2.29	2.39
Error	21	0.61	0.63	0.62	0.64

(VI) Values of mean sum of squares for dry weight per plant at various stages

Source of variation	d.f.	Dry weight per plant at			
		30 DAS	**60 DAS**	**90 DAS**	**At maturity**
Replication	3	0.34	4.28	6.70	6.42
Treatment	7	1.49	17.66**	11.13**	9.77**
Error	21	0.26	2.37	4.14	3.74

(VII) Values of mean sum of squares for root nodules per plant at various stages

Source of variation	d.f.	Root nodules per plant at		
		30 DAS	**45 DAS**	**60 DAS**
Replication	3	3.89	22.14	20.84
Treatment	7	8.06**	68.17**	65.81**
Error	21	2.59	17.92	24.64

(VIII) Values of mean sum of squares for dry weight of root nodules per plant at various stages (mg)

Source of variation	**d.f.**	**Dry weight of root nodules per plant at**		
		30 DAS	**45 DAS**	**60 DAS**
Replication	3	177.86	1399.55	1330.69
Treatment	7	415.44**	4308.77**	4201.33**
Error	21	136.37	1132.87	1572.97

(IX) Values of mean sum of squares for days to 50% flowering and maturity at various stages

Source of variation	**d.f.**	**Days to 50 % flowering**	**Days to maturity**
Replication	3	3.75	1.46
Treatment	7	6.79**	9.05**
Error	21	1.39	2.58

(X) Values of mean sum of squares for yield attributes of various genotypes

Source of variation	**d.f.**	**Pods / plant**	**Seeds / pod**	**Seed yield /plant**	**Straw yield / plant**	**Seed index**	**Harvest index**
Replication	3	15.70	979.53	2.70	2.71	0.05	75.69
Treatment	7	55.25**	4121.50**	6.48**	12.41**	1.79	515.22**
Error	21	11.59	858.44	1.51	4.14	0.53	31.72

(XI) Values of mean sum of squares for seed yield/plot, straw yield/plot, seed yield/ha, straw yield/ha and grain production efficiency at various genotypes

Source of variation	**d.f.**	**Seed yield /plot**	**Straw yield /plot**	**Seed yield/ha**	**Straw yield/ha**	**GPE**
Replication	3	0.63	0.19	41718.75	130019.53	4.59
Treatment	7	7.18**	1.74	438616.07**	422073.10**	47.39**
Error	21	0.28	0.07	15022.32	77340.96	1.64

VITA

The author of the thesis **Miss Preeti Sisodia D**/o Shri. Ishwar Singh Sisodia was born on 14th Feburary, 1985 at Bagli , Dewas (M.P.).

She passed her High School in the year 2001 from Sharda Vidhya Mandir H.S.S., Sehore M.P.. After that she passed Higher Secondary in the year 2003 from Sharda Vidhya Mandir H.S.S., Sehore (M.P.).

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