Effect of Sowing Dates on growth,Yield Attributes and Productivity of Soybean[*Glycine Max* (L) Merrill] Genotypes Under Rainfed Condition

THESIS

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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.)

In partial fulfilment of the requirements for the degree of

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(AGRONOMY)

By

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CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of Sowing Dates on growth,Yield Attributes and Productivity of Soybean [*Glycine max* (L) Merrill] Genotypes Under Rainfed Condition"** submitted in partial fulfilment of the requirement for the **DEGREE OF MASTER OF SCIENCE (Agronomy)** of the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafied research work carried out by **Miss Sadhana Raghuwanshi ID. No 143D05** 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. All the assistance and help received during the course of the investigation has been acknowledged by the scholar.

Place: Sehore
Date:

Signature
(Dr. M.D.Vyas)
Chairman of the Advisory Committee

MEMBER OF THE STUDENT'S ADVISORY COMMITTEE

Chairman (Dr.M.D.Vyas) .....

Member (Dr. R.P.Singh) …….....

Member (Dr. S.R.Ramgiry) …….....

CERTIFICATE –II

This is to certify the thesis entitle **"Effect of Sowing Dates on growth,Yield Attributes and Productivity of Soybean [*Glycine max* (L) Merrill] Genotypes Under Rainfed Condition"**submitted by **Miss Sadhana Raghuwanshi , ID. No 143D05** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in **Agriculture (Agronomy)** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

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Date

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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
G	Genotype
D	Sowing date
DAS	Days after sowing
d.f.	Degree of Freedom
et al.	And others
etc	and the rest
fig.	Figure (s)
g	Gram
ha	Hectare
HI	Harvest Index
i.e.	That is
K	Potassium
kg	Kilogram (s)
kg/ha	Kilogram per hectare
l	Litre
MSS	Mean sum of square
mg	Miligram
m	Meter (s)
N	Nitrogen
no	Number (s)
NS	Non significant
P	Phosphorus
T	Tonnes
R.V.S.K.V.V.	Rajmata Vijaya Raje Scindia Krishi Vishwa Vidyalaya
R.A.K.	Rafi Ahmed Kidwai
RH	Relative humidity
₹	Rupees
S.Em.±	Standard error of mean
S.S.	Sum of Square
Viz.	Namely
√	Square root
%	Percent
±	Plus or Minus

CHAPTER I
INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a legume that grows in tropical, sub tropical and temperate climates. Soybean is considered “Miracle Crop” or “Wonder Crop” owing to its good quality vegetable protein and edible oil. It is an excellent source of digestible protein (40%) and edible oil (20%). Therefore, it can play a significant role in making up protein deficiency in our Indian diet. The protein has a superior amino acid profile compared to other sources of plant protein (39% essential amino acids), the oil is highly digestible (good composition of fatty acids) and contains no cholesterol. The beans contain a high fraction of Phospholipids (Lecithin), a high content of Tocopherol (Vitamin E) and Isoflavons (anticancerogene). It is a multipurpose crop with many food and industrial values. Soybean is the cheapest source of vegetable protein equivalent to egg protein. The soybean plant has gained global importance within the last decades, with rapidly increasing production worldwide. It commonly used as pulses, oil seeds, vegetarian meals and milk. It improves soil fertility by fixing atmospheric nitrogen at the rate of 65-115 kg/ha per year with the process of symbiosis through *Rhizobium japonicum* micro- organisms. It also improves the structure and fertility of the soil by adding the leaves and straw having 9% nitrogen, 12% phosphorus and 8.9% potash. Thus it is soil fertility builder and eco-friendly. Now-a-days, at is considered the most important industrial economical crop of the country and world as well.

It is a major *Kharif* crop of Madhya Pradesh; therefore, it is called ‘Soya-State’ and ‘Soybean Boul’. During *kharif* 2014 in India it was sown in 108.83 Lakh ha with production 104.37 Lakh MT and productivity 959 Kg/ha. In Madhya Pradesh during this year it was sown in 55.46 Lakh ha with production of 60.26 Lakh MT and productivity 1089 Kg/ha(SOPA,2014)

Suitable sowing time is an important tool for optimum growth and maximum production. The proper time of sowing is one of the basic requirement for obtaining maximum yield and high return of any crop .Seed yield and oil yield of soybean is greatly influence by the variation in atmosphere temperature, humidity and other biotic factor. Increase in grain yield of soybean can be achieved by the adoption of suitable variety, and proper sowing time. Sowing time is the single most important

factor to obtain optimum yield from soybean. Early sowing of crop calls disease and insect while late sowing cause yield penalty due to short growing period.

Selection of proper genotype for a set of agro –climate condition is very important to achieve maximum yield potential because due to their different growth and behavior.The lack of suitable and high yielding varieties is major inhibitor. Varieties play a unique role in maximization of yield by improving the fertilizer use efficiency, water-use efficiency and cultural practices. . Thus the selection of suitable cultivar of soybean is of prime importance as the genetic potential of a variety limits the expression of its yield and affects plant growth in response of environmental condition .Varietal performance and sub optimal plant stand on an average cultivator's field are the important factors which are generally associated with low productivity of this crop in the state ..

Therefore, keeping above facts in consideration an experiment **"Effect of Sowing Dates on Growth, Yield Attributes and Productivity of Soybean [*Glycine max* (L.) Merrill] Genotypes Under Rainfed Condition"** was conducted with the following objectives :

- To find out optimum sowing date for soybean.
- To identify suitable genotype of soybean under rainfed condition.
- To study the effect of sowing dates on growth and productivity of soybean genotypes.
- To work out the economics of different treatments.

CHAPTER-II
REVIEW OF LITERATURE

To increase the productivity of soybean ,suitable genotypes and optimum sowing time play an important role. The development of the new genotypes with most desirable characters for a particular region is a continuous process.This is required to increase the productivity per unit area under the drought prone areas particularly under rainfed conditions. A sizeable research work has been carried out in the country and abroad with respect to suitability and adaptability of soybean varieties under different agro- climatic conditions. Brief reviews of earlier studies related to present investigation are reviewed in this chapter.

2.1 Performance of genotypes

Study of genetic variability in different genotypes for their growth habit, their ability to adopt in various climatic condition have been worked out by various workers, which are summarized in different heads as below:-

2.1.1 Growth and physiological parameters

Dubey and Billore (1993) observed that soybean genotype JS 81-335 and JS 81-1619 recorded higher number of nodules/plant.

Sharma and Sharma (1993) reported that variety JS 81-335 have better branches, higher CGR (21.6 g/m^2/day), LAI (5.9) and NAR (0.2 g/m^2/day) than other varieties.

Kumari *et al* (1993) found that all tested varieties reaches at maximum plant height at 90 days after sowing. Maximum plant height (70.72 cm) was observed in Davis and JN 2750 cultivars.

Paul and Guha (1994) reported that higher number of branches per plant in JS-2 than Bragg.

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

Choubey and Nema (1996) found that variety JS 89-27 produced maximum height,higher number of branches and trifoliates ,dry weight/plant than other tested varieties.

Rajput and Shrivastava (1999) found at Morena (M.P.) that variety JS 71-05 was at par with JS 335 and significantly superior to PK 472 in respect to physiological parameters *viz* LAI,CGR,RGR and NARunder Morena condition.

Panchariya and Lidder (2000) noticed that variety JS 90-41 produced higher number and dry weight of root nodules/plant. They further concluded that variety JS (SH) 92-46 produced higher NAR,CGR and dry weight/plant while variety NRC 37 recorded maximum height, branches and LAI and variety JS 80-21 produced higher number of trifoliate than the remaining varieties.

Parmar and Nema (2002) found that variety JS 335 produced higher LAI and NAR, and variety RAUS-5 had higher number of branches, while variety MAUS 61-2 recorded maximum plant height and variety JS 93-06 gave higher number of leaves, They further concluded that variety JS 93-07 produced higher dry weight/plant and variety NRC 41 produced higher crop growth rate (CGR).

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

Khan *et al.* (2004) observed that variety Epps (Epps,MGV) produced tallest plants as compared with Williams 82 (Williams 82,MG111). While, Khan *et al.* (2005) observed that cultivars spark produced maximum plant height (92.67 cm).

Kumar and Badiyala (2005) reported that cultivar PK 472 produced the higher plant height (84.91 cm), while cultivar SL 231 produced significantly higher number of branches/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/plant, dry weight /plant and leaf area index (LAI), while variety JS 95-60 produced higher CGR and variety JS 93-05 gave maximum NAR.

Patel and Singh (2008) reported that variety JS 335 was significant in plant height, number of branches, dry weight of plant , number of nodules/plant and dry weight of nodules followed by genotype JS 2002-14.

Deoker *et al.* (2009) found that genotype MACS-124 gave maximum plant height where-as genotype Kuber gave heighest dry weight /plant and relative growth rate (RGR).

Shami and Kobraee (2009) reported that variety Clark produced highest dry weight .

Singh (2011) reported that the genotype SL 525 was significantly better in plant height (90.8) than other genotypes.

Rehman and Hossain (2013) found that the plant height, branches/plant, leaf area index (LAI) , leaf area duration (LAD), total dry matter and crop growth rate (CGR) were varied significantly due to different cultivars. Cultivar BS-5 was highest for these growth parameter.

Mondal *et al.* (2014) observed that variety BINA soybean-1 had greater root length ,number of lateral root, pods bearing nodes ,leaves/plant, plant height , leaf area /plant and total dry mass/plant than BINA soybean-2.

Vyas and Khandwe (2014) reported that the cultivar JS 95-60 recorded significantly higher nodule (52.10) and nodule dry weight/plant (108.46 mg), chlorophyll content (1.452mg/g),NAR (0.008mg/cm2/day),photosynthesis rate (19.90 micro, mol CO/m2/sec), stomatal conductance (0.643 mol H2O/m2/s) as compared to JS 97-52.

2.1.2 Yield attributing parameters and yield

The effect of different varieties on yield attributing parameters *viz.* number of pods, number of seeds, seed yield/plant and seed index have been reported by many scientists.

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

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

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

Sharma and Sharma (1993) reported that CV JS 81-335 have significantly higher number of pods/plant (43.56) and grain yield/plant (12.01g) followed by varieties JS 80-21, JS 220,and JS 81-214,respectively.

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

AICRPS (1995) indicated that variety PK-1068 recorded significantly higher grain yield (23.8 q/ha) than check variety PK-472 (19.14 q/ha) and was at par with other two check varieties i.e.JS-335 (22.27 q/ha) and JS 80-21 (20.2q/ha).

Singh *et al*.(1995) found that CV PK-416 gave the highest seed yield (3.13 t/ha) followed by PK-1024 (2.09 t/ha). While ,Karmakar and Bhatnagar (1996) found that genotype PK-262,PK-564,PK-416,NRC-2 and PK-427 gave higher seed yield in rainy season.

Choubey and Nema (1996) observed that variety Pb-1 produced higher number of grain /pod than the other varieties, while JS 89-27 produced higher number of pods/plant and grain yield/plant.

Choubey and Nema (1996) found that genotype JS 71-05 produced higher grain, straw yield and grain production efficiency than other tested genotypes.

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

Taware *et al*. (1999) observed that MACS-63 cultivar gave the highest yield (20.32 q/ha) followed by MACS-124 (19.59 q/ha) and MACS-13 (19.24 q/ha).

Billore *et al.* (2000) observed at NRCS, Indore (M.P.) that the harvest index was higher in Ahilya 3 (55.51%) and seed/pod (8.71) was higher in JS 335 while seed index(12.7g) was better in JS 71-05 and pods/plant were highest in Ahilaya (39.03).

Billore *et a*l.(2000) observed highest seed yield in cultivar Ahilya 3 (24.56 q/ha) than other tested varieties.

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

AICRPS (2001) indicated that variety Pusa 9762 yielded highest (19.44 q/ha) than other tested varieties.

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

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

AICRPS (2003) at Dharwad the check variety JS 335 recorded significantly higher yield (2766 kg/ha) than other varieties but was at par with varieties NRC-51.

Rehman *et al*.(2003) reported that cultivar Hasting produced highest seed yield (average 365 g/m2).While, the lowest yield (204-210 g/m2) came from Nuhaka and Dorie cultivars.

Veni and Murthy (2003) reported that variety JS 335 produced significantly higher yield (1850 kg/ha). Straw yield (2420 kg/ha) than the other tested varieties.

Veni and Murthy (2003) found that variety JS 335 produced highest number of pods/plant, seed index and harvest index as compared to other tested varieties.

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

Kumar and Badiyala (2005) recorded significantly higher number of pods/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/plant than other varieties, while variety JS 95-60 produced higher number of seed/pods, seed index , grain yield /plant and harvest index.

Khan *et al*.(2005) observed that variety kharif-93 produced highest seed yield (2562 kg/ha) and grain production efficiency than other tested varieties.

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

Pandya *et al*. (2005) reported that variety JS 335 significantly higher in seed and straw yield (16.09 and 25.84 q/ha)than other varieties.

Thakur and Vyas (2005) reported that variety JS 95-60 produced highest grain yield (1012 kg/ha) and straw yield (1370 kg/ha).

Acko and Trdan (2009) found most productive cultivar was Borostyan (3974 kg/ha) and the lowest yield was recorded for Aldana (1472 kg/ha).

Singh (2011) reported that the pods/plant and 100 seed weight were varied significantly due to different genotypes, genotype SL 525 was highest for these parameter.

Singh (2011) reported that genotype SL 525 produced highest grain yield (2432 kg/ha) followed by SL 517 (1802 kg/ha).

Rehman *et al*. (2013) found the highest number of fertile and non-fertile pods/plant, number of seeds/pod, number of seeds/plant, weight of 100 seed and maximum harvest index (47.72%) was in cultivar BS-5 and the lowest in cultivar G-2.

Rehman *et al*. (2013) found that the cultivar BS-5 gave the highest seed yield (151.24 g/m2) and stover yield (16923 g/m2).

Mondal *et al*.(2014) observed that the number of pods, seeds/plant and seed weight/plant were significantly greater in BINA soybean-2 than in BINA soybean-1 but 100 seed weight was not 100 seed weight was not significant.

Mondal *et al.* (2014) observed that the significantly higher seed yield in BINA soybean-2 than BINA soybean-1.

Kolarik *et al.* (2014) reported the greater grain weight/plant (13.09 g) in cultivar Balkan.

Kolaric *et al.* (2014) reported that the highest grain yield was achieved with Balkan cultivar (4773 kg/ha) and the lowest with Dragana cultivar (4284 kg/ha).

Vyas and Khandwe (2014) reported that the cultivar JS 95-60 recorded significantly higher seed index (11.73g),HI (51.64%),net returns (38577 Rs/ha),B:S ratio (4.37) and protein content (38.96 %) as compared to JS 97-52.

Vyas and Khandwe (2014) reported that cultivar JS 95-60 recorded significantly higher seed yield (2274 kg/ha)as compared to JS 97-52.

2.2 Effect of sowing date

2.2.1 Growth parameters

Sharma *et al.* (2000) remarked wide variability among various cultivars, some of them were superior to the check for different characters, he further reported that days of emergence, days to flowering , days to maturity, yield and yield components were different in various date of sowing.

Khan *et al*.(2004) observed that variety Epps (Epps,MGV) produced the tallest plant as compared to Williums 82 (Williums 82,MG 111).

Ahmad *et al.* (2010) conducted an experiment at revealed that plant height,number of nodules/plant and branches/plant were significantly affected by sowing date.The tallest plant (55.12cm)highest nodes /plant (13.98) and branches/plant (2.71)was found with 16th December sowing.The lowest plant height (44.67) was found 27 November sowing.The lowest nodes/plant(9.13) and

branches(6.42)were found with 7th November sowing.Plant height,nodes/plant and branches/plant were also significantly affected by the varieties.

Dogra *et al.(*2014), faund that genotype planted in early June recorded maximum plant height tha those planted in early July.

2.2.2 Yield attributing parameters and yield

Ramesh P. and Gopalswamy N. (1992) revealed that planting on 20th February and 17 February during the summer 1988 and 1989 respectively recorded maximum number of pods and significantly higher seed yield compared with the other planting dates in their respective seasons. During the kharif planting on 16 June resulted in maximum number of pods, seed/pod, 100 seed weight and seed yield. Which was on a par with planting on 30, and further delay in planting resulted in significant reduction of these characters.

Singh V.K. and Bajpai R.P. (1992) reported that planting date significantly influenced the yield attributing characters and grain yield. The crop planted on 22th June showed significant increase in grain yield than the crop sown beyond 4 July during 1984.

Singh *et al* (2000) revealed that June 10th to be optimum date of sowing for obtain higher yield of soybean.Dry matter production was decreased in order of May 25>June10>June 25 sowing dates. Such non-monetary inputs besides improving the crop yield did not add to cost of production and agro-ecosystem pollution.Singh and Arya(1994) also obtained highest seed yield from crop sown on June 10th and observed decline in yield with delayed sowing.

Murthy *et al* (2001) found that genotypes differed significantly in expressing their yield potential under different dates of seeding in both winter and summer .The long duration genotype MACS 201 (120 days duration)proved superaior to all other genotypes.The early duration genotypes (72days duration)performed poor with lowest seed yield in both the season .The effect of seeding time was pronounced in both the seasons but the seed yields decreased with delay in the time of sowing of soybean genotypes .The seed yield was higher during winter season when sown on 15th Octomber and 25th,January in summer season.

Singh (2003) results revealed that maximum pod yield was recorded at 1st May sown crop followed by subsequent date of sowing at on interval of twenty days.

Maximum grain yield was recorded in JS series cultivars. Interaction effect between dates of sowing and different cultivars were found significant.

Shaikh et al. (2005)recorded that soybean sown on 15th June gave higher yield than rest of the sowing dates tried (30th June & 15th July).The yield obtained due to sowing of soybean on 15th June and 30th July were at par after pooling. However both date of sowing were significantly superior over sowing of soybean on 15th July.

De Bruin and Pedersen (2008) reported that by planting soybean in late April versus late May or early June,soybean yield increased by 41%.Improved in yield as a result of early planting is attributed to an increase in seed in seed m^2.

Hari ram *et. al* (2010) reported the highest grain yield of soybean in June 5th sown crop which was significantly higher than June 25th sowing but statistically at par with June 15th sowing in 2008.In 2009 June 15th sowing recorded highest grain yield which was statistically at par with June 5th but significantly higher than June 25th sowing.

Futules *et al.* (2011),reported that yield of variety samsoy -2 were significantly higher than those of other varieties at most of the sowing dates.This variety demonstrated maximum productivity ,when planted on 21th June .

Meisam *et. al* (2011) found that the planting date May 20th and variety Williams yielded better than other treatments .

Ngalamu *et al.* (2012) showed significant difference among the genotypes and sowing dates for all the measured traits ,with the exception of number of seed per pod in both years.The highest seed yield was obtained from a sowing on 10th August in 2009 and on 12th July and 26th July sowing dates in 2010.Genotype NA5009RG attains 50% flowering at 28 days from sowing and could be classified as extra-early maturing ,soja early maturing and TGx 1740-2F as intermediate whereas (TGx 1937-1F and TGx 1904-6F)reached 50%floering at 40 days and could be classified as late maturing.The highest yielding soybean genotype were TGx1937-1F (1.17t/ha)in 2009 and TGx 1904-6F (1.13t/ha).

Meotti et al.(2012) conduct the experiment Sao Domingos,S.C.,Brazil revealed that sowing on 15 Octomber and 15 Nevember maximized the number of pods per plant,number of grain per pod,plant height,grain yield.Medium or early cycle cultivars,with high plant height are more adequate for late sowing.

Mengxuan Hu and Wiatrak,P. (2012) revealed that combined effect of photoperiod,temp,and precipitation with delayed planting most likely contributes to decreased duration of vegetative and reproductive growth stages,reduced photosynthesis and plant growth,and therefore significant reduction in grain yield of soybean.Changes in photoperiod,temp and precipitation with delayed planting affect the duration of vegetative and reproductive stages,number of branches and pods,plant height, leaf area index and normalized difference vegetation index,and hence the grain yield.Delayed planting can also affect the soybean seed quality by changing the oil and protein content.

Kandil *et al*.(2013) reported that planting on 5th May recorded highest values in all studied characters,except of crop growth rate and net assimilation rate was obtained higher from planting on 5th June Giza 21 cultivar was consistently produced higher 100 seed weight,seed yield (t/ha),protein and oil yields (kg/ha)than those the other genotypes. Planting in the first May is an effective management strategy to increase soybean yield in Egypt.

Somia Osman Yagoub *et al*.(2013) reported that sowing date (16th June) is best to improve yield attributes (pod/plant , 100 seed weight ,H.I.) and yield ,where as sowing in the last June must be avoided due to reduce in yield and yield component .The genotype showed non significant for yield and it attributes.

Sadeghi and Niyaki (2013) observed significant difference in interaction of date of planting and culivars.The planting date 20 April with cultivar Sahar produced higher numbers of pods per plant ,seeds/plant and grain yield Kg/ha.

Rehman *et al.* (2014) conducted a field study to optimize the planting time for different soybean cultivars in agro-ecological condition of Faisalabad ,Punjab (Pakistan).The result revealed that cultivars with early planting produced higher yield and quality as compared to the late planting dates.Planting on 28th January was the best for high yield of spring soybean .While ,among two cultivars Faisal soybean (1440.23 Kg/ha)performed best.

Dogra *et al.* (2014) reported that significant affect to intraction between planting time and genotype in seed yield and its attributes. Genotype SL958 and early planting (early June) seen to be more effective in getting higher seed yield. Egli and Bruening (2000) their study reportsd in yield with delayed sowing.

CHAPTER -III
MATERIAL AND METHODS

The Details of material used and methods adopted during the course of investigation are presented in this chapter.

3.1 Experimental site

The experiment was laid out in field number 12 at the Research Farm of R.A.K. college of Agriculture, Sehore (Madhya Pradesh) under, All India Coordinated Research Project on Soybean during *Kharif* 2015 on 904.4 m^2 area having fairly uniform topography, normal fertility status and soil homogeneity. The selected field was naturally infested with location specific weeds on the tract.

3.2 Climate and weather condition

Sehore is situated in sub tropical zone of Vindhyan Plateau of Madhya Pradesh, North of 27^0 12' latitude and East of 77^0 05' longitude with an altitude of 498.77 m from mean sea level. The average annual rainfall varies from 1000 to 1200 mm, concentrated mostly from June to September. The mean annual maximum and minimum temperatures are 40.16^0Cand 18.5^0C, respectively. The summer months are hot and May is the hottest month having a maximum temperature up to 43.52^0C. Winter month experienced mild cold with an average temperature from 8.74 ^{0}C to 16.56^0C. January is the coldest month as temperature reaches up to 4^0C.

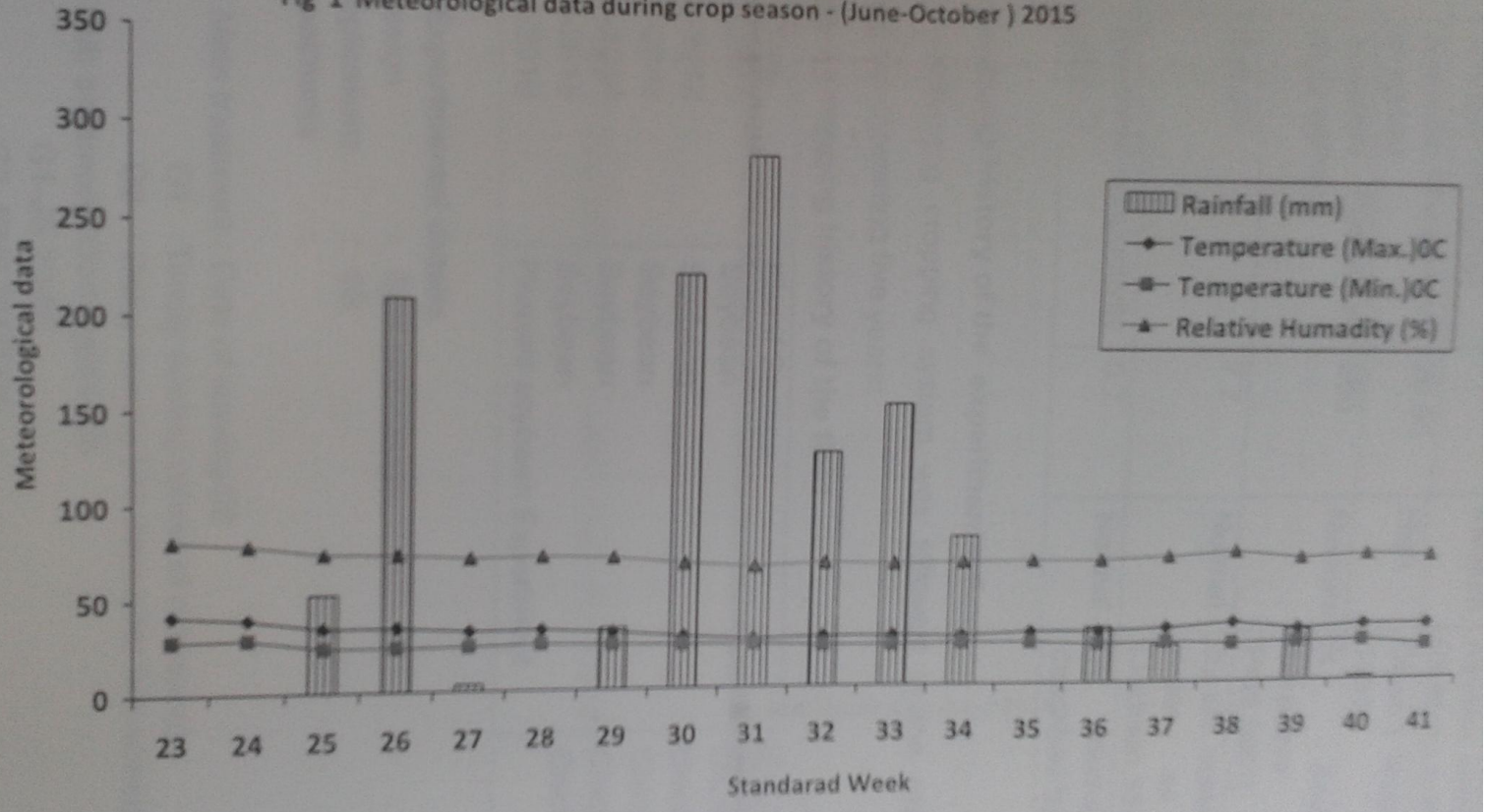
The weekly meteorological data viz., rainfall, temperature, relative humidity and number of rainy days during crop season were recorded in meteorological observatory of R.A.K. College of Agriculture, Sehore and presented in Table 1.The data in Table 1 indicates that during the crop season total rainfall was 1263 mm concentrated in 49 rainy days with maximum and minimum rainfall, ranged from 287.5 mm to 2mm was observed in 31^{th} and 40^{th} meteorological standard week, respectively. The maximum temperature ranged from 41.3^0C to 26.48^0C was observed in 23^{th} and 31^{th} meteorological standard week, respectively, and the minimum temperature ranged from 18.26^0C to 28.12^0C was observed in 41^{th} and 23^{rd} meteorological standard week, respectively, while, the maximum relative humidity of 80.85 per cent was observed in 23^{th} meteorological week and the minimum relative humidity of 66.28 per cent was recorded in 31^{th} meteorological week.

Table1 Meteorological data during the crop season

Year & Std. Week	Week ending	Temp. ^{0}C		RH (%)	Rainfall (mm.)
		Max.	Min.		
23	3 June	41.30	28.13	80.86	0.00
24	10	39.10	28.66	78.43	0.00
25	17	34.26	23.63	73.86	52.50
26	24	34.37	23.66	73.71	210.50
27	1 July	32.47	24.37	71.86	3.50
28	8	32.96	25.44	72.43	0.00
29	15	31.30	24.51	71.60	33.50
30	22	28.33	23.93	68.26	224.50
31	29	26.49	22.63	66.29	287.50
32	5 Aug	27.44	22.686	68.00	129.00
33	12	27.88	23.486	67.57	155.50
34	19	27.27	23.214	67.97	82.50
35	26	29.21	22.14	68.71	0.00
36	2 Sept	29.17	22.94	68.71	31.50
37	9	30.94	21.81	70.43	21.00
38	16	33.67	22.61	73.29	0.00
39	23	30.16	22.80	69.86	29.50
40	30	32.04	19.81	71.57	2.00
41	7 Oct	31.65	18.269	70.59	0.00
	Total				**1263.00**

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

Fig 1 Meteorological data during crop season - (June-October) 2015



3.3 Edaphic factor

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 provides good drainage.

To access the initial fertility status of experimental field, soil samples were collected randomly from different places of the field at 0 to 30 cm depth with the help of a screw type soil auger. After this a composite sample was prepared for the analysis of organic carbon, available nitrogen, phosphorous and potassium, pH and electrical conductivity. The analytical values are presented in Table-2

Table 2: Chemical composition of soil

S. No.	Particulars	Content	Level	Method adopted
1.	Available Nitrogen (N kg/ha)	315	Medium	Alkaline permanganate method (Subbiah and Asija,1956)
2.	Available Phosphorus (P kg/ha)	20.90	High	Olsen's reagent (Olsen's *et al. 1954)*
3.	Available Potassium (K_2O kg/ha)	260	Medium	N Ammonium acetate extractent (Chapman and Prutt,1961)
4.	Soil pH	7.7	Normal	By pH meter using 1:2.5 soil : water as described by (Jackson,1973)
5.	Electrical conductivity (dSm^{-1})	0.7	Normal	By conductivity meter as described by (Jackson,1973)

3.4 Cropping history of the experimental field

Following cropping system was followed in the experimental field during the preceding five years:

Table-3 Cropping history of the field

Year	Kharif Season	Rabi Season
2010-2011	Soybean	Chickpea
2011-2012	Soybean	Chickpea
2012-2013	Soybean	Chickpea
2013-2014	Soybean	Chickpea
2014-2015	Soybean	Chickpea
2015-2016	Present soybean Experiment	

3.5 Experimental details

1. Design : Split plot design

2. Replications : 03
3. Treatments :

A. Main treatment : Date of sowing-02
D1 :Timely sowing (onset of monsoon)
D2 : Delay sowing (20 days after first sowing)
B. Sub treatment :Genotypes -05
G1-JS 20-89
G2- RVS 2002-04
G3-JS 20-79
G4 -JS 20-53
G5 -JS 97-52

4.Treatment combinations :10
D1G1,D1G2,D1G3,D1G4,D1G5
D2G1,D2G2,D2G3,D2G4,D2G5

5. Plot size :

Gross	:	6.0 m x 3.6 m
Net	:	5.0 m x 2.7 m

6. Distance between plots : 1.0 m
7. Distance between replications : 1.5 m
8.Row distance : 45cm
9. Number of rows per plot : 8
10. Seed rate : 75 kg/ha
11.Variety (V5) : As per treatments
12.Fertilizer dose : 20:60:20:20 (N:P_2O_5:K_2O:S)kg/ha

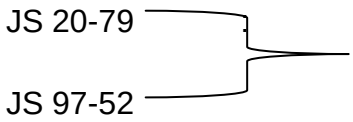
13.Date of harvesting

JS 20-89
RVS 2002-4 — 29/09/2015 & 20/10/2015
JS 20-53

JS 20-79
JS 97-52 — 5/10/2015 & 26/10/2015

14.Date of threshing :

JS 20-8
RVS 2002-4
JS 20-53



29/09/2015 & 20/10/2015

5/10/2015 & 26/10/2015

3.6 Characteristics of genotypes:

1.JS 20-89:This genotype has been evolved by JNKVV(M.P.) from a cross between JS 97-52xJS M 286.It attains the plant height 60.81cm and its complete 50 percent flowering in 46 days with white flower.It matures in about 98 days.The weight of 100 seed weight is 8 g .The yield potential of this genotype in present experiment is 1282 kg /ha.

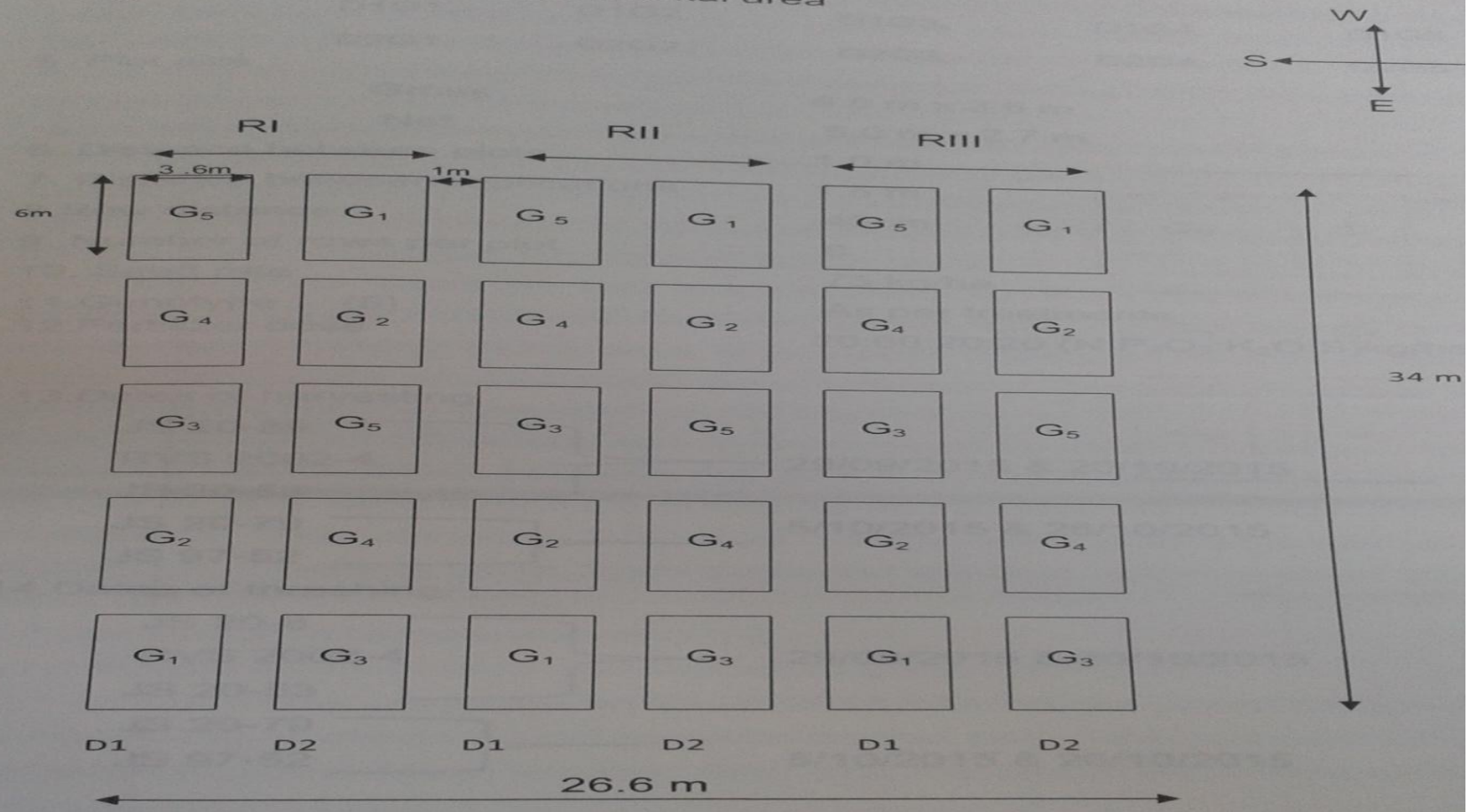
2.RVS 2002-4:This genotype has been evolved by RVSKVV(M.P.) from a cross between JP 120 x JS 335.It attains plant height 58.03cm and its complete 50 percent flowering in 46 days with white flower.It matures in about 98 days.The weight of 100 seed weight is 9.16 g .The yield potential of this genotype in present experiment is 1389 kg/ha.

3.JS 20-79:This genotype has been evolved by JNKVV(M.P.) from a cross between JS 97-52 x JS (15) 90-5-12-1.It attains plant height 68.11cm and its complete 50 percent flowering in 50 days with purple flower .It matures in about 103 days.The weight of 100 seed weight is 6.5 g .The yield potential of this genotype in present experiment is 768 kg/ha.

4.JS 20-53:This genotype has been evolved by JNKVV(M.P.) from a cross between JS 97-52 x JS 20-02.It attains plant height 57.48cm and its complete 50 percent flowering in 46 days with purple flower.It matures in about 98 days.The weight of 100 seed weight is 9.16g .The yield potential of this genotype in present experiment is 1078 kg/ha.

5.JS 97-52:JS 97-52 variety has been evolved by JNKVV, Jabalpur Madhya Pradesh from a cross between PK 327 x L 129.It attains the plant height 58.75 cm and complete 50% flowering in 53 days with white colour. It is medium to long duration 103 days variety with yield potential of 2000-2200kg/ha. Flower is white ,hairy pods and medium yellow seed of 10.0 seed index suitable for central M.P.

Fig 2 Layout plan of experimental area



3.7 Details of field operations:

3.7.1 Preparation of field and layout of the experiment

Land was prepared on 24.06.2015 with tractor drawn plough followed by harrowing to obtain a well pulverized seed bed. Finally, it was levelled with the help of tractor driven leveller. After this, the layout was made as illustrated in Figure 1

3.7.2 Fertilizer application

The nutrients were applied @ 20 kg N ,60 kg P_2O_5, 20 kg K_2O and 20 kg S /ha through fertilizers diammonium phosphate, muriate of potash and gypsum, respectively, below and near the seed row as basal.

3.7.3 Seed rate and seed treatment

Before sowing the seeds were treated with fungicide (Thirum 2g + Carbaxin1g/kg seed),insecticide thiomethoxum 1.5g/kg seed and thereafter, inoculated with soybean culture(*Bradyrhizobium japonicum)*and phosphorus solubilising bacteria (PSB) culture each @ 5g/kg seed. A recommended seed rate of 75 kg/ha, was used.

3.7.4 Method of sowing

Sowing was done on 25th June 2015 and second sowing date on 15/07/2015. Seed was drilled with the help of desi plough locally known as 'NAI', keeping distance of 45 cm between rows. Seed was sown at depth of 3 -4 cm.

3.7.5 Application of Herbicides and Insecticides

Weed management

To keep the field weeds free, herbicide pendimithalin 30 EC@ 1kg a.i. /ha PE was applied followed by hand weeding at 30 DAS with the help of khurpi.

3.7.6 Plant protection :

The plant protection measure were applied timely and whenever necessary. The incidence of semilooper (*Thysanoplusia orichalcea*) was noted in last week of July .The incidence was controlled by spraying the crop with chloropyriphos 20EC @ 1.5 l/ha(29/07/2015).On last week of August incidence of tobacco caterpillar(*Spodoptera litura*) was noted, and was controlled by spraying the crop with Indoxacarb 14.5 SC 600 ml/ha(07/08/2015). The White fly (*Bemisia tabaci*) was also noted in last week of August and was controlled by spraying the crop with Thiomethocxam 25% WG 100 g/ha (01/19/2015).

3.7.7 Harvesting and threshing

The harvesting was done,when pods were fully ripened. At the time of harvesting, the plants of one border row from each side and 25 cm on the remaining two side of the plot were removed and the crop from the net plots was harvested, bundle separately and tagged. Harvested produce was left in the respective plots for sun drying and weighed to record biological yield.

Harvested produce was threshed by beating with sticks with the help of manual labour and finally seeds were winnowed by using ‘supas’. Threshed seeds were sun dried for 2-3 days to reduce the moisture content and then the seed yield per plot was recorded.

3.8Studies on crop

For studying the influence of different treatments on soybean, several observations were recorded on the growth parameters and yield attributing characters of crop. For recording pre and post - harvest observations, five plants were randomly selected in each plot and tagged with labels for various observations on growth parameters and yield attributes as followes:

Pre harvest studies

Plant height – Plant height was measured in order to estimate the effect and extent of plant growth due to various treatments. Height of the five randomly selected plants in each plot was measured at 30 DAS and then 20 days interval up to maturity. Height was measured in cm from the soil surface to the main stem (apical).

Branches per plant (no.) – The number of branches per plant was counted from randomly selected five plants in each plot at 30 DAS and subsequently at an interval of 20 days up to maturity.

Dry weight per plant (g) – The dry weight per plant was also recorded from randomly selected five plants in each plot at 30, 50, 70, 90 DAS. Plants were oven dried for 48 hours at 70^0C and their weight was recorded with the help of electronic balance.

Root nodules per plant (no.) – The number of root nodules of five randomly selected plants were recorded in each plot at 30 and 50 DAS. Plants were uprooted carefully and after washing root nodules were separated from the roots of the plants, counted and number was recorded.

Dry weight of root nodules per plant (mg) – The dry weight of root nodules of five randomly selected plants were recorded in each plot at 30 and 50 DAS.The root

nodules were dried in the sun then transferred to thermostatically controlled drying oven regulated at 80℃ ± 2℃ for 45 hours and dried up to a constant weight and finally their weight were recorded in mg with the help of electronic balance.

Root length (cm)-The root length of five plant were recorded at 30,50,70 and 90 DAS.

Physiological parameters

Crop growth rate (CGR)

It is the rate of dry matter production per unit ground area per unit time (Watson,1952). It was calculated by using the following formula and expressed as g/m^2/day.

$$CGR = \frac{W_2 - W_1}{P(t_2 - t_1)}$$

Where, W_2 and W_1 are dry matter of preceding and succeeding stages and t_1 and t_2 represent the time period at which W_1 and W_2 were recorded. P is the ground area.

Relative growth rate (RGR)

Relative Growth Rate (RGR) is also a measure used to quantify the speed of plant growth. It is measured as the mass increase above ground biomass per day, as g g-1 d-1. It is considered to be the most widely used way of estimating plant growth.

It expresses the dry weight increase in time interval in relation to the initial weight and is expressed in g/day. It is also called efficiency index. It is proposed by Fisher (1921).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the dry weight (g) at time t_1 and t_2 respectively and $\log_e$ is natural log.

Post -harvest studies

At harvest, the earlier tagged plants were harvested for the purpose of recording observation on yield attributing parameters.

Number of pods per plant

The pods from the tagged plants were counted and thus obtained mean was used for statistical analysis.

Number of seeds per pod

Randomly selected 25 pods from each plot were threshed; numbers of seed were counted and divided by twenty five to obtain the seeds per pod.

Grain yield per plant (g plant^{-1})

The grains obtained from three selected plants from each plot were weighed and mean weight of grain yield per plant was calculated.

Grain and straw yield

The harvested produce from each plot was tied in bundles separately sun dried and bundle weight (biological yield) was recorded with the help of spring balance.

The weight of cleaned grains obtained from each net plot after threshing and thereafter converted into kilograms per hectare by using appropriate factor. Straw yield was calculated for each net plot by subtracting the grain yield from the biological yield of the respective plot.

Seed index (100 seed weight) (g)

Random seed sample were taken from each net plot. Hundred seeds from the produced of each plot were counted and the weighed accurately on electronic balance and expressed in grams.

Harvest index (%)

Harvest index was calculated by using the following formula of Nichiporovich (1967) and expressed in per cent.

$$HI = \frac{\text{Economical Yield}}{\text{Biological yield}} \times 100$$

Economical yield = Grain yield

Biological yield = Grain yield + straw yield

Grain production efficiency: The grain production efficiency is the ratio of total grain yield produce and grain development period and it is expressed in terms of kg/ha/day.

$$GPE = \frac{\text{Total grain yield produce}}{\text{Grain development period}} \quad \text{Kg/ha/day}$$

3.10 Economics

The economics of various treatments was worked out taking into account the existing market rate of various production factors and produce during the course of

investigation. The details with respect to economics analysis have been given in Appendix 2.

Cost of cultivation (₹/ha)

Cost of cultivation is an important factor for economic analysis. It can be calculated by considering prevailing market price of inputs, wages and actually cost involved on various aspects during the investigation.

Gross monetary returns (₹/ha)

Gross monetary returns are the total earnings from crop produce (grain + straw) in terms of ₹/ha. The gross monetary return was calculated by considering the prevailing price of the produce at time of harvesting.

Net monetary returns (₹/ha)

The net monetary returns (₹/ha) was calculated after deducting all the expenditure (₹/ha) from gross return. It was obtained by subtracting cost of cultivation from gross return. This represents the actual income of farmer.

The net monetary returns (₹/ha) for different treatments were calculated with the following formula-

Net monetary returns (₹/ha) = Gross returns (₹/ha)–Cost of cultivation (₹/ha).

Benefit Cost Ratio

Benefit Cost Ratio is the ratio of the benefits of an activity or production, relative to its costs, both expressed in monetary terms. Mehmood *et al.*(2011).

BCR = Gross return / Cost of cultivation

3.11 Statistical analysis

Analysis of variance

The experimental data was statistically analyzed by adopting split plot design. The critical difference values were computed at five per cent level. The model of analysis of variance is as given below.

Table 4: The skeleton of analysis of variance

Source of variance	D.F.	SS	MSS	F cal	F tab
Replication (r)	(r-1)				
Main factor(D)	(D-1)				
Error (a)	(r-1)(D-1)				
Sub factor(G)	(G-1)				
Interaction (D x G)	(G-1)(D-1)				
Error (b)	D(r-1)(G-1)				
Total	rDG-1				

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

a) S Em± for sowing dates (D) = $\sqrt{\frac{Ems(Ea)}{R \times G}}$

b) S Em± for genotype (G) = $\sqrt{\frac{Ems(Eb)}{R \times D}}$

c) S Em± for D×G = $\sqrt{\frac{ems(Eb)}{R}}$

d) C.D. = SEm (±) × $\sqrt{2}$ × t value at 5% level of significance for error d.f.

e) C.V. = $\frac{\sqrt{EMS}}{\text{Grand mean}} X\ 100$

Where;

R : number of replication
G : Genotype
D : Sowing date
DF : Degree of freedom
SS : Sum of square
MSS : Mean sum of square
EMS : Error mean sum of square
Ea : Error of main factor a
Eb : Error of sub-factor b
C.D. : Critical difference
C.V (%) : Coefficient of variance

CHAPTER – IV
RESULT

This chapter deal with the results obtained on growth, yield attributing parameters, seed and straw yield and economic return recorded during the course of investigation. The data were statistically analyzed using standard methods and processed through Tables.

Pre harvest studies

4.1. Growth parameters

4.1.1. Plant height (cm)

The vegetative growths of soybean were determined by evaluating the plant height. The data recorded are presented in Table-1

The effect of sowing date on plant height of soybean was recorded at 30,50,70,90 DAS and at maturity stage.At all observation stages the effect of sowing date on plant height was significant except 50 DAS.First date of sowing (25^{th} June)recorded significantly higher plant height then 2^{nd} date of sowing (15^{th} July) at all stages.

Observation at 30 DAS genotype JS 20-79 was significantly higher,then genotypes JS 20-89,RVS 2002-4,JS 97-52 but it was at par with genotype JS 20-53.Similarly at 50 and 70 DAS genotype JS 20-79 was recorded maximum height followed by genotype JS 20-53.But at 90DAS and at maturity genotype JS 20-89 was next to JS 20-79.

The interaction between sowing date and genotypes was found not-significant at 50,70,90DAS and at maturity.But at 30 DAS it was significant and combination of 25^{th} June sowing with genotype JS 20-79 was significantly higher then all the combinations.

JS 20-89

Table-1 Plant height (cm) as influenced by sowing dates and genotypes.

Plant height (cm)															
Treatment	30 DAS			50 DAS			70 DAS			90 DAS			At maturity		
Date of sowing / Genotype	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	30.70	20.39	25.54	46.10	44.63	45.36	57.97	45.63	51.8	66.63	54.93	60.78	66.70	54.93	60.81
RVS 2002-4	30.44	17.70	24.07	42.83	41.96	42.40	57.73	45.87	51.8	63.43	52.63	58.03	63.43	52.63	58.03
JS 20-79	40.44	18.00	29.22	56.63	39.20	47.91	73.27	52.07	62.66	81.07	55.07	68.00	81.07	55.17	68.11
JS 20-53	35.20	20.93	28.06	51.30	43.30	47.30	65.97	48.60	57.28	66.00	48.97	57.48	66.00	48.97	57.48
JS 97-52	31.11	15.83	23.46	43.16	36.10	39.63	69.73	42.73	56.23	73.10	44.40	58.75	73.10	44.40	58.75
Mean	33.57	18.56		48.00	41.04		64.93	46.98		70.04	51.20		70.06	51.22	
	G	D	G x D	G	D	G x D	G	D	G x D	G	D	GxD	G	D	GxD
S Em+_	1.17	0.62	1.65	2.38	2.33	3.37	2.68	1.02	3.79	2.80	2.43	3.96	2.79	2.44	3.95
CD at 5%	3.50	3.70	4.90	NS	NS	NS	NS	6.26	NS	NS	14.82	NS	NS	14.84	NS

4.1.2. Number of branches per plant

Branching is one of the important character which have direct effect on seed yield.The observation on number of branches per plant were recorded, starting from 30 DAS and was continued up to maturity stage at 20 days interval.But at 30 days no branches were emerged in any genotype.

The data on number of branches at various successive growth stages are presented in Table-2 .It is clear from the data that number of branches increased up to 75 days after sowing and there after became constant in all the treatments.

The effect of sowing date on number of branches' per plant was recorded at 50,70,90 DAS and at maturity stage.At 50,90 DAS and at maturity stage sowing date was found not significant.At 70 DAS 1st date of sowing(25th June) recorded significantly higher number of branches then 2nd date of sowing(15th July).

The difference among the genotypes for branches was not significant at all observation stages.Althrough,genotypes RVS 2002-4 recorded higher number of branches.

The interaction between sowing date and genotype was found not significant

4.1.3.Plant dry weight (g.)

Dry weight per plant was recorded at 30,50,70,90 and at maturity stage. It was observed that dry weight increased consistently up to 90 DAS in all the treatments.The data presented in Table-3 revealed that at 30 and 70 DAS effect of sowing date was significant and sowing on 25th June was significantly higher then sowing on 15th July.At 50,90DAS and at maturity effect of sowing date on plant dry weight was found not significant.

At 30 ,50 and 70DAS effect of genotype on plant dry weight was found not significant but at 90 DAS and at maturity it was significant and genotype JS 97-52 was better than other.

The interaction between sowing date and genotype was found not significant at all stages.

Table-2 Branches/plant as influenced by sowing dates and genotypes.

Number of branches per plant												
Treatment	50 DAS			70 DAS			90 DAS			At maturity		
Date of sowing / Genotype	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	3.43	1.11	2.26	4.10	3.22	4.30	5.11	4.51	4.80	5.11	4.51	4.80
RVS 2002-4	3.20	2.22	2.71	4.77	3.67	5.07	5.85	4.30	5.07	5.835	4.30	5.07
JS 20-79	2.55	0.44	1.49	4.31	3.63	3.97	5.33	3.89	4.60	5.33	3.89	4.60
JS 20-53	2.75	1.66	2.20	4.10	3.83	3.96	5.00	4.00	4.49	5.00	4.00	4.49
JS 97-52	3.55	1.78	2.66	5.09	4.17	4.62	5.33	4.22	4.77	5.33	4.22	4.77
Mean	3.09	1.41		4.47	3.70		5.32	4.18		5.32	4.18	
	G	D	G x D	G	D	G x D	G	D	G x D	G	D	G x D
S Em+_	0.35	0.32	0.50	0.21	0.03	0.30	0.26	0.29	0.37	0.37	0.29	0.37
CD at 5%	NS	NS	NS	NS	0.21	NS	NS	NS	NS	NS	NS	NS

Table3-Dry weight/plant (g) as influenced by sowing dates and genotypes.

Plant Dry weight (g)															
Treatment	30 DAS			50 DAS			70 DAS			90 DAS			At maturity		
Date of sowing / Genotype	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	2.11	0.77	1.44	3.55	4.16	3.85	19.05	12.22	15.63	23.65	15.05	19.35	23.69	15.05	19.36
RVS 2002-4	1.44	0.55	0.99	2.89	3.44	3.16	16.28	11.67	13.97	22.40	15.17	18.78	22.43	15.23	18.83
JS 20-79	1.55	0.44	0.99	3.78	3.11	3.44	19.15	9.61	14.38	22.57	14.42	18.49	22.57	14.46	18.51
JS 20-53	1.44	0.55	0.99	3.44	3.72	3.58	17.33	10.61	13.11	17.93	13.85	15.89	17.97	13.96	15.96
JS 97-52	1.88	0.44	1.16	4.99	3.83	4.41	22.31	11.27	16.79	26.44	16.58	21.50	26.47	16.58	21.52
Mean	1.68	0.55		3.73	3.65		18.82	11.07		22.59	15.01		22.62	15.05	
	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD
S Em+_	0.16	0.13	0.22	0.53	0.06	0.75	1.67	1.126	2.37	1.11	6.16	1.57	1.11	6.17	1.57
CD at 5%	NS	0.82	NS	NS	NS	NS	NS	6.85	NS	3.64	NS	NS	3.63	NS	NS

\

RVS 2002-4

4.1.4. Root Nodules per plant

The observations on number of root nodules per plant were recorded at 30 DAS and 50 DAS and presented in Table-4

The data revealed that the effect of date of sowing on number of root nodules was found significant at 30 DAS. Sowing on 25th June recorded maximum root nodules (12.54),whereas at 50 DAS effect of sowing date was found not significant.The numbers of root nodules were decreased with delayed sowing.

During both the stages,effect of genotype was not-significant on number of root nodules.Genotype JS 20-89 was found better then other genotypes.

The interaction between date of sowing and genotyps was found not significant.

4.1. 5. Dry weight of root nodules/plant (mg)

Dry weight of root nodules /plant was recorded at 30 and 50 DAS .The data of dry weight of root nodules per plant are presented in Table-4

The data showed that the date of sowing did not affected dry weight of root nodules significantly at both stages.However, the dry weight of root nodules decreased with delay in sowing time.

At 30 and 50 DAS genotype JS 20-89 was recorded higher nodules dry weight followed by genotype JS 20-53.

The interaction between sowing date and genotype was found not significant.

4.1.6. Root length (cm)

The root length per plant at different stage was analyzed statistically and presented in table-.5 It is revealed that the sowing date gave significant effect on root length per plant at 30 DAS.At 30 DAS 25th June sowing gave maximum root length (17.43cm).At 50,70,90DAS root length was not influenced significantly due to date of sowing.At maturity stage 25th June sowing was significantly higher then sowing date of 15th July.

Table-4 Number of root nodules and dry weight of nodules as influenced by sowing dates and genotypes.

Number of nodules							Nodule's dry weight (mg)					
Treatment	30 DAS			50 DAS			30 DAS			50 DAS		
Date of sowing / Genotype	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	13.73	12.33	13.07	44.73	34.83	39.78	48.66	41.33	44.90	157.0	276.66	216.83
RVS 2002-4	14.30	8.65	11.47	32.73	25.43	29.08	39.11	29.11	34.10	96.22	185.74	140.98
JS 20-79	9.89	9.55	9.76	30.93	28.10	29.51	21.11	26.89	23.99	125.44	114.00	119.71
JS 20-53	9.63	9.55	9.53	29.54	20.87	25.20	34.44	49.11	41.88	142.44	163.89	153.16
JS 97-52	15.18	8.67	11.93	34.30	28.87	31.58	21.66	26.00	23.83	189.33	162.00	175.66
Mean	12.54	9.75		34.44	27.62		32.99	34.53		426.26	541.37	
	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD
S Em+_	1.48	0.27	6.29	4.21	4.39	5.96	6.20	3.84	8.77	22.81	21.66	32.26
CD at 5%	NS	1.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-5 Root length as influenced by sowing dates and genotypes.

Root length (cm)															
Treatment	30 DAS			50 DAS			70 DAS			90 DAS			At maturity		
Genotypes / Date of sowing	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	16.05	10.66	13.36	20.41	16.53	18.47	24.11	20.11	22.10	30.07	23.53	26.80	29.56	23.47	26.54
RVS 2002-4	17.87	11.47	14.67	19.04	16.33	17.68	20.78	19.89	20.33	24.87	20.17	22.51	24.79	21.04	22.91
JS 20-79	17.63	10.64	14.13	17.44	14.1	15.77	25.88	20.00	22.94	28.30	20.11	24.20	28.38	20.00	24.19
JS 20-53	15.43	12.05	13.74	17.98	15.73	16.86	23.44	18.63	21.03	28.20	20.44	24.32	28.49	20.45	24.47
JS 97-52	20.18	10.88	15.53	24.33	14.5	19.41	25.88	19.77	22.82	30.30	20.12	25.21	30.17	20.67	25.42
Mean	17.43	11.14		19.84	15.44		24.01	19.67		28.34	20.87	28.4	28.27	21.12	
	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD
S Em+_	1.55	0.41	2.21	1.39	1.42	1.97	2.84	1.07	4.02	2.58	3.65	3.65	1.68	1.28	2.38
CD at 5%	NS	2.49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

JS 20-79

At all stages root length was not affected significantly due to genotypes.But genotype JS 97-52 was recorded maximum root length then other genotypes.

The interaction between sowing date and genotypes was found not significant.

Physiological parameters

4.2.1 Crop growth rate (CGR)

For the assessment of average daily increment in stand biomass, crop growth rate is an important characteristic, which is termed as rate of dry matter production.

The observation on this parameter were recorded at 30-50 ,50-70 and 70-90 days interval and present in Table-6

The effect of sowing date on crop growth rate was not-significant at 30-50 and 70-90 days interval but at 50-70 days interval it was significant. At 50-70 days interval CGR was significantly higher in 25th June sowing than 15th July sowing.

The genotype response at all days interval or CGR was found not-significant. However genotype JS 97-52 gave higher CGR at 30-50 and 50-70 days interval, while RVS 2002-4 was highest at 70-90 days interval.

The interaction between sowing date and genotypes was found not significant.

4.2.2 Relative growth rate (RGR)

The observation on RGR were recorded at 30-50,50-70 and 70-90 days interval. The data were analyzed statistically and presented in Table -6

The effect of sowing date on RGR was not-significant at 30-50 and 70-90days interval.But at 50-70 days interval it was significant. Sowing on 25th June RGR was significantly higher then sowing on 15th July at 50-70 days interval.At all days interval response of genotype on RGR was not significant.

The interaction between sowing date and genotypes was also found not significant.

Table-6 Crop growth rate(g/m^2/day) and Relative growth rate (g/g/day) as influenced by sowing dates and genotypes at different days intervals.

Crop growth rate(g/m^2/day)										Relative growth rate (g/g/day)								
Genotypes / Date of sowing	30-50			50-70			70-90			30-50			50-70			70-90		
	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	3.20	7.90	5.55	34.43	17.53	25.98	10.22	6.29	8.255	0.028	0.086	0.057	0.083	0.051	0.067	0.014	0.009	0.012
RVS 2002-4	3.21	6.41	4.81	29.75	18.27	24.01	13.60	9.26	11.43	0.086	0.097	0.063	0.085	0.061	0.073	0.023	0.015	0.019
JS 20-79	4.93	5.92	5.42	34.16	14.44	24.30	7.58	10.70	9.13	0.044	0.099	0.071	0.082	0.055	0.069	0.008	0.020	0.014
JS 20-53	4.45	7.04	5.74	30.86	15.30	23.08	1.33	7.20	4.26	0.042	0.096	0.069	0.081	0.054	0.068	0.001	0.011	0.006
JS 97-52	6.91	7.53	7.21	38.48	16.54	27.50	9.17	11.78	10.47	0.046	0.109	0.077	0.077	0.054	0.066	0.009	0.019	0.014
Mean	4.54	6.96		33.53	16.41		8.38	9.04		0.038	0.097		0.081	0.055		0.01	0.01	
	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD	G	D	GxD
SEm+	0.98	0.44	1.399	3.48	2.39	4.92	2.84	4.76	4.02	0.008	0.005	0.011	0.008	0.003	0.011	0.004	0.006	0.007
CD at 5 %	NS	NS	NS	NS	14.54	NS	NS	NS	NS	NS	NS	NS	NS	0.02	NS	NS	NS	NS

Post harvest studies

4.3. Yield attributory characters

The various yield attributory characters were recorded at maturity and were subjected to statistical analysis

4.3.1 Number of pods/ plant

The numbers of pods per plant is one of the important yield attributes, which has direct correlation with seed yield per hactare.The observation on this attribute were made at maturity.(Table 7)

The sowing date gave significant effect on pods per plant .The 1st date of sowing was significantly higher then second date of sowing.The genotype JS 97-52 recorded significantly higher pods/plant(59.88) then genotype JS 20-79,JS 20-89,RVS 2002-4 and JS 20-53.

The interaction between date of sowing and genotype was found not significant.

Table-7 Yield attributory characters as influenced by date of sowing and genotypes.

Treatment	Pods/plant			Number of seeds/ pod			Seed yield/ plant		
Genotypes / Date of sowing	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	70.88	26.77	48.82	3.17	2.77	2.96	13.61	1.55	7.57
RVS 2002-4	59.68	24.55	42.10	3.40	2.77	3.08	14.78	2.00	8.38
JS 20-79	77.88	20.52	49.20	3.23	2.43	2.83	11.55	1.11	6.33
JS 20-53	63.33	19.77	41.55	3.03	2.60	2.81	7.27	0.77	4.02
JS 97-52	90.77	28.97	59.87	3.13	2.80	2.96	6.78	0.66	3.71
Mean	72.50	24.18		3.19	2.67		10.79	1.21	
	G	D	GxD	G	D	GxD	G	D	GxD
S Em+_	3.07	3.27	4.34	0.06	0.09	0.09	0.60	0.40	0.86
CD at 5%	9.22	19.89	NS	NS	NS	NS	1.82	2.44	2.58

4.3.2 Number of Seeds/pod

The number of seed per pod was counted in each treatment and the mean values were subjected to statistical analysis. The average data are presented in Table -7

The effect of date of sowing on seed/pod was found not significant. Althrough,1st date recorded more number of seed/pods then 2nd date of sowing.

JS 20-53

Genotype RVS 2002-4 had more seeds/pods than other genotype's. But the difference among genotypes was not significant.

The interaction between date of sowing and genotype was found not significant.

4.3.3. Seed yield/plant(g)

The data on seed yield/plant was analyzed statistically and presented in Table-7.It is evident from the Table-7 that the effect of sowing date on seed yield/plant was significant and 1st date of sowing gave significantly higher seed yield per plant (10.71g) than second date of sowing(1.21g).

The genotype RVS 2002-4 was found significantly better than genotypes JS 20-79,JS 20-53 and JS 97-52 but at par with genotype JS 20-89.

The interaction between date of sowing and genotype was found significant. Combination of genotype RVS 2002-4 at sowing date 25th June was significantly higher in seed yield/plant (14.78) than all other combinations.

4.3.4. Seed index(g)

The seed index is the criteria to estimate the seed size and seed quality. The seed index directly influence the seed yield .The observation on seed index is presented in Table-8.

The sowing date gave significant effect on seed index .Sowing on 25th June was significantly higher than second date of sowing (15th July).

The effect of genotypes on seed index was significant and genotype JS 20-53 recorded significantly higher seed index than JS 20-79 and JS 97-52 but at par with genotypes JS 20-89 and RVS 2002-4.

The interaction between date of sowing and genotypes was found significant. Combination of genotype JS 20-53 at sowing date on 25th June gave significantly higher seed index (7.0g) then all combinations. The lowest seed index was noted in combination RVS 2002-4 at 2nd date of sowing (4.0g).

Table-8 Seed index and grain production efficiency as influenced by date of sowing and genotypes.

Treatment	Seed index (g)			Grain production efficiency (kg/ha/day)		
Genotypes / Date of sowing	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	8.00	5.00	6.50	13.22	5.29	9.03
RVS 2002-4	9.17	4.00	6.58	12.84	5.29	9.82
JS 20-79	6.50	4.50	5.50	6.51	2.58	5.04
JS 20-53	9.17	5.00	7.08	9.54	4.01	7.45
JS 97-52	6.33	4.83	5.58	6.06	2.89	4.57
Mean	7.83	4.66		10.39	3.97	
	G	D	GxD	G	D	GxD
S Em+_	0.27	0.35	0.38	0.24	0.3	0.35
CD at 5 %	0.80	2.14	1.14	0.71	1.82	1.04

4.3.5. Grain production efficiency (kg/ha/day)

Grain production efficiency was estimated for various treatments.It was observed significant variation for this parameters among genotypes and sowing dates.(Table 8)

The sowing date gave significant effect on grain production efficiency .Sowing on 1st date (25th June) was significantly higher GPE (10.39 kg/ha/day) then second date of sowing (15th July).

The genotype RVS 2002-4 had the significantly higher GPE (9.82 kg/ha/day) then all genotype.

The interaction between date of sowing and genotype was found significant. Combination of genotype RVS 2002-4 at sowing date 25th June was significantly higher in grain production efficiency (9.82 kg/ha/day) than all other combinations.

4.3.6. Seed yield (kg/ha)

Seed yield is the most important character and superiority of the treatment is judged by its capacity to produce more seed yield. It enable the investigator to select superior treatment or treatment combination. The data on seed yield per hectare under different treatment were statistically analyzed and the same are presented in Table.9 .The data showed that the seed yield of soybean was significantly affected by date of sowing and genotypes.

JS 97-52

Sowing of soybean on 25th June produced significantly higher seed yield (1033 kg/ha)as compared to second sowing date(15th July)(3931 kg/ha).

The genotype RVS 2002-4 produced significantly higher seed yield (963kg/ha) than genotypes JS 20-79, JS 20-53 and JS 97-52 but it was at par with genotype JS 20-89.

The interaction between date of sowing and genotypes was found significant. Combination of genotype RVS 2002-4 at sowing date on 25th June gave significantly higher seed yield (1389kg/ha) than all other combinations except combination of genotype JS 20-89 sown on 25th June(1282 kg/ha).

Table-9 Grain yield (kg/ha),straw yeld (kg/ha) and biological yield (kg/ha) as influenced by sowing date and genotypes.

Treatment	Grain yield (kg/ha)			Straw yield (kg/ha)			Biological yield (kg/ha)		
Genotypes / Date of sowing	25th June	15th July	Mean	25th June	15th July	Mean	25th June	15th July	Mean
JS 20-89	1282	486	884	2991	1273	2129	4273	1759	3009
RVS 2002-4	1389	537	963	2764	1143	1949	4148	1680	2916
JS 20-79	768	273	518	3398	1094	2245	4166	1370	2768
JS 20-53	1078	379	726	2838	847	1842	3916	1226	2569
JS 97-52	643	301	472	3555	898	2222	4194	1199	2699
Mean	1033	393		3106	1050		4138	1444	
	G	D	GxD	G	D	GxD	G	D	GxD
S Em+_	23	14	32	55	32	79	60.18	60.18	421.2
CD at 5%	65	83	92	162	194	231	175.9	365.7	NS

4.3.7. Straw yield (kg/ha)

The effect of sowing date on straw yield was significant.Sowing on 25th June was significantly higher(3106 kg/ha) than 15th July sowing (Table 9)

The genotype JS 20-79 was significantly better then genotypes RVS 2002-4, JS 20-53 but was at par with genotype JS 20-89 and JS 97-52.

The interaction between date of sowing and genotypes was found significant. Combination of genotype JS 20-79 sown on 25th June gave significantly higher straw yield (2245kg/ha.) than all other combinations except combinations of JS 97-52 and JS20-89 sown on 25th June.

4.3.8. Biological yield(kg/ha)

The observation on this parameter were analyzed statistically and the data present in Table-9 and reveals that the effect of sowing date on 25th June gave significantly higher biological yield then sown on 15th July.

The genotype JS 20-89 significantly better then genotypes JS 97-52,JS 20-53 and genotype JS 20-79 but is was at par genotype RVS 2002-4.

The interaction between date of sowing and genotypes was found not significant.

4.3.12.Harvest index(%)

The data presented in table-10 indicates that the effect of genotype and interaction was significant on HI but the effect of sowing date was found not significant .

The genotype RVS 2002-4 was recorded significantly higher harvest index then genotype JS 20-89,JS 97-52 and JS 20-79 but was at par with JS 20-53.

The interaction between date of sowing and genotype was found significant. Combination of genotype RVS 2002-4 sown on 25th June gave significantly higher harvest index (33.42%) than all other combinations except combinations of JS 97-52 and JS 20-89 sown on 25th June and RVS 2002-4 and JS 20-53 sown on 15th July.

Table-10 Harvest index (%) dates of sowing and genotypes.

Genotypes / Date of sowing	Harvest index (%)		
	25th June	15th July	Mean
JS 20-89	30.04	27.72	28.87
RVS 2002-4	33.42	32.04	32.72
JS 20-79	18.41	19.97	19.19
JS 20-53	27.52	31.08	31.08
JS 97-52	32.04	25.23	25.23
Mean	24.94	27.20	
	G	D	GxD
SEm+	0.60	0.62	0.85
Cd at 5 %	1.79	NS	2.5

4.4 Economics

The economics of various treatments was worked out by taking prevailing market rates of various production inputs and produce into account during the investigation period. The highest net profit (₹ 21349) and B.C ratio (1:1.92) were obtained with combination of genotype RVS 2002-4 sown on 25th June.(Table 11)

Table-11 Economics of soybean as influenced by sowing date and genotype.

Treatment	Gross return (₹/ha)		Cost of cultivation (₹/ha)		Net return (₹/ha)		B:C ratio	
Genotypes / Date of sowing	25th June	15th July	25th June	15th July	25th June	15th July	25th June	15th July
JS 20-89	48500	18734	23113	23113	25387	-4378	1:2.09	1:0.81
RVS 2002-4	51357	20042	23113	23113	28244	-3070	1:2.22	1:0.86
JS20-79	33071	11479	23113	23113	9958	- 11633	1:1.43	1:0.49
JS 20-53	41590	14246	23113	23113	18477	-8866	1:1.79	1:0.61
JS 97-52	29464	11877	23113	23113	6351	-11235	1:1.27	1:0.51

CHAPTER VI
SUMMARY,CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

SUMMARY

The experiment was conducted to study the "Effect of Sowing Dates on Growth, Yield Attributes and Productivity of Soybean Genotypes [*Glycine max* (L.) Merrill] Under Rainfed Condition" during *kharif* season of 2015-16 at R.A.K. College of Agriculture, Sehore (M.P.)

Ten treatment combinations with two dates of sowing (25th June and 15th July) and five genotypes (JS 20-89,RVS 2002-4,JS 20-79,JS 20-53,JS 97-52) were replicated three times in split plot design. The plot size was 6 m x 3.6 m.

The soil of the experiment field was medium black, medium in available nitrogen and potassium, high in phosphorus and was normal in soil pH (7.7) and electrical conductivity.

The causes of low yield of soybean is due to aberrant weather condition because just after sowing dry spell was occurred and thereafter heavy rains received. At pod filling stage again dry spell with high atmospheric temperature was recorded, due to that yield was reduced.

Various growth and yield attributing characters to support grain and straw yield were studied. The important results of this investigation are summarized below.

Growth and physiological parameters

1. Genotype RVS 2002-4 recorded significantly higher number of branches, CGR, RGR. Whereas genotype JS 20-89 recorded higher number of nodules, dry weight of root nodules and root length. Genotype JS 20-79 recorded higher plant height and genotype JS 97-52 was higher in plant dry weight.
2. Sowing on 25th June recorded higher plant height, number of branches, plant dry weight, number of nodules and dry weight of root nodules, root length, CGR and RGR.
3. The interaction between date of sowing and genotype was found not significant for all growth and physiological parameters.

Yield attributing parameters

1. Genotype RVS 2002-4 recorded significantly higher seed yield/plant and RVS 2002-4 recorded higher number of seeds/pod. Whereas genotype JS 97-52 recorded significantly higher pods/plant and genotype JS 20-53 recorded significantly higher seed index.
2. Sowing on 25th June recorded significantly higher seed yield/plant, pods/plant , seed index and higher number of seeds/pod.
3. The interaction between date of sowing and genotype was found significant for seed yield/plant and seed index. The combination of genotype RVS 2002-4 at sowing date on 25th June gave significantly higher seed yield/plant than all other combination. The combination of genotype JS 20-53 at sowing date on 25th gave significantly higher seed index than all other combination.

Seed and straw yield

The combination of genotype RVS 2002-4 at sowing date on 25th June gave significantly higher seed yield than all other combinations of genotype except combination of genotype JS 20-89 sown on 25th June. Whereas combination of genotype JS 97-52 at sowing date on 25th gave significantly higher straw yield than all other combinations except combination of genotype JS 20-79 sown on 25th June.

Harvest index and Grain production efficiency

1. Genotype RVS 2002-4 recorded significantly higher harvest index and grain production efficiency.
2. Sowing on 25th June recorded significantly higher harvest index and grain production efficiency.
3. The combination of genotype RVS 2002-4 at sowing date on 25th gave significantly higher grain production efficiency than all other combinations. Combination of genotype RVS 2002-4 sown on 25th June gave significantly higher harvest index (33.42%) than all other combinations except combinations of JS 97-52 and JS 20-89 sown on 25th June and RVS 2002-4 and JS 20-53 sown on 15th July.

Economics

The comparative economics of various treatments of genotypes and sowing date was analysed. The combination of genotype RVS 2002-4 with

first date of sowing gave highest net return (₹ 28244) and B.C ratio (1:2.22) as compare to other treatment combinations.

Conclusion

The most suitable treatment combination was 25th June date of sowing with genotype RVS 2002-4 for obtaining higher yield and net profit.

Suggestion for further work

In the light of experience gained during the course of investigation and result obtained, it was felt that the following points should be taken in to consideration in future studies.

1. In order to confirm the validity of result the experiment must be repeated over years and location with more accuracy.
2. The investigation may be tested with some other promising genotype and sowing date.

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APPENDICS

Appendix-I : Mean sum of square of plant height at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Plant height				
			30 DAS	50 DAS	70 DAS	90 DAS	At maturity
1.	Rep.	2	14.83	37.72	52.63	75.31	75.22
2.	D	1	1689.60	364.01	2417.42	2663.98	2661.72
3.	Ea	2	11.06	81.91	15.91	89.07	89.61
4.		4	37.43	72.53	122.12	113.26	114.47
5.		4	31.15	66.78	60.15	100.26	99.34
6.	Eb	16	21.02	34.15	43.18	47.07	46.95

Significant at 5% level

Appendix-II : Mean sum of square of number of branches per plant at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Branches/plant (no)			
			50 DAS	70 DAS	90 DAS	At maturity
1.	Rep.	2	0.45	1.09	2.27	2.27
2.	D	1	19.51	4.45	9.75	9.75
3.	Ea	2	2.01	0.02	1.81	1.81
4.	V	4	1.37	0.78	0.29	0.29
5.	V*D	4	0.79	0.15	0.22	0.22
6.	Eb	16	1.02	0.28	0.29	0.29

Appendix-III : Mean sum of square of number of nodule's and nodule dry weight at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Number of nodule's		Nodule dry weight	
			30 DAS	50 DAS	30 DAS	50 DAS
1.	Rep.	2	12.35	132.49	720.47	4961.17
2.	D	1	58.41	349.94	17.65	11043.08
3.	Ea	2	1.13	284.56	221.76	7039.22
4.	V	4	13.13	175.38	576.63	8247.11
5.	V*D	4	14.02	11.63	155.97	6116.73
6.	Eb	16	13.25	106.59	230.81	3123.30

Appendix-IV : Mean sum of square of dry weight per plant at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Dry weight/plant				
			30 DAS	50 DAS	70 DAS	90 DAS	At maturity
1.	Rep.	2	0.49	2.55	88.20	35.56	35.75
2.	D	1	9.64	0.02	466.18	431.53	429.64
3.	Ea	2	0.28	0.11	16.01	25.58	24.71
4.	V	4	0.23	1.06	10.27	24.29	23.80
5.	V*D	4	0.10	1.09	8.23	7.10	7.38
6.	Eb	16	0.16	1.78	16.75	7.48	7.38

Appendix-V : Mean sum of square of root length at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Root length				
			30 DAS	50 DAS	70 DAS	90 DAS	At maturity
1.	Rep.	2	3.65	4.38	21.85	42.72	43.77
2.	D	1	296.92	172.94	141.27	418.58	383.42
3.	Ea	2	2.62	29.45	30.31	20.80	19.20
4.	V	4	4.33	7.80	7.76	14.68	10.96
5.	V*D	4	7.07	23.72	6.67	6.18	7.70
6.	Eb	16	1.66	11.37	8.67	12.27	12.11

Appendix-VI : Mean sum of square of crop growth rate and relative growth rate at different successive stages of growth as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Crop growth rate			Relative growth rate		
			30-50 days interval	50-70 days interval	70-90 days interval	30-50 days interval	50-70 days interval	70-90 days interval
1.	Rep.	2	21.06	272.85	146.06	0.00223	0.00019	0.00047
2.	D	1	43.90	2199.06	3.32	0.02682*	0.00521*	0.0001
3.	Ea	2	3.00	85.72	340.58	0.00005	0.0002	0.00007
4.	V	4	4.78	18.59	46.04	0.00035	0.00005	0.00013
5.	V*D	4	4.17	24.08	31.18	0.00005	0.00002	0.00013
6.	Eb	16	5.88	72.73	48.61	0.0040	0.0004	0.00015

Appendix-VII : Mean sum of square of yield attributry characters as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Pods/plant (No)	seed/pod (No)	Seed yield/plant (g)	Seed index (g)	Grain production efficiency (kg/ha/day)	Harvest index (%)
1.	Rep.	2	143.24	0.01	4.42	1.23	0.99	0.56
2.	D	1	17560.97	2.03	688.13	75.21	308.80	38.19
3.	Ea	2	160.62	0.13	2.42	1.86	1.35	5.84
4.	V	4	328.36	0.07	26.11	2.81	32.83	215.02
5.	V*D	4	179.42	0.06	14.47	3.44	7.72	35.39
6.	Eb	16	56.76	0.03	2.23	0.44	0.37	2.21

Appendix-VIII : Mean sum of square of yield attributry characters as influence by genotypes and sowing date.

S.N.	S.V.	d.f.	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
1.	Rep.	2	23.14	92.59	199.07
2.	D	1	6550.88	68643.0	117531.65
3.	Ea	2	27.77	41.66	124.99
4.	V	4	606.47	402.77	398.14
5.	V*D	4	148.14	587.95	148.14
6.	Eb	16	7.40	41.66	50.92

Appendix-IX: Cost of Cultivation

1.	Field preparation and sowing		
a.	Ploughing	2.5 hours	1250
b.	One harrowing	2 hours	1000
c.	Sowing by tractors	2 hours	1000
2.	Cost of fertilizer		
	DAP (18:46:0)	130 kg	3108
	MOP (0:0:60)	33.33 kg	294
	Gypsum	107 kg	399
3.	Seed	75 kg	4125
4.	Cost of seed treatment		
	Thirum+Carbaxin	3g/ha seed	450
	Thiomethacxam	1.5 g/kg seed	427
	Rhizobium	2 Packet	26
	PSB	2 Packet	32
5.	Weeding		
	Pendimethalin 35 EC	1 kg a.i./ha	360
	Hand weeding	15 Labour	3000
6.	Plant protection		
	Chloropyriphos 20 EC	1.5 L /ha	412
	Thiomethacxam	100 g/ha	430
	Indoxacarb	600 ml/ha	1800
7.	Harvesting	15 Labour	3000
8.	Thresing	2 hour	1000
9	Thresing labour	5	1000

Market Price of Input

Rent of tractor	500/hour
Labour charge	200/labour
Rate of seed	55/kg
Rate of fertilizer	
DAP	2439/q
MOP	1782/q
Zipsum	@ 373/q
Rate of Thirum+Carboxin	200/100 g
Thiomethocxam	95 /100g
Rhizobium	13/150 Packet
PSB	16 /250 Packet
Pendimethalin	360 /ha
Chloropyriphos	275/L
Thiomethacxam	430/100 g
Indoxacarb	3000/L
Rate of grain	3200 /q
Rate of straw	250/q

VITA

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Forther partial fulfillment of the degree she was allotted the research problem entitled **"Effect of Sowing Dates on Growth, Yield Attributes and Productivity of Soybean [*Glycine max* (L.) Merrill] Genotypes Under Rainfed Condition"** which is duly completed by her and is presented in the form of thesis.

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