PERFORMANCE OF SOYBEAN (*Glycine max* L.) VARIETIES IN POST MONSOON UNDER VARIED WEATHER CONDITIONS

BY

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PARBHANI – 431 402 (M.S.) INDIA

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DISSERTATION

Submitted to the
Vasantrao Naik Marathwada Krishi Vidyapeeth,Parbhani
in partial fulfillment of the requirement
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MASTER OF SCIENCE
(Agriculture)

IN

AGRONOMY

DEPARTMENT OF AGRONOMY,
COLLEGE OF AGRICULTURE,
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH,
PARBHANI – 431 402 (M.S.) INDIA

2018

Affectionately

Dedicated

To My

Beloved

Parents, Mentors And

My Best Friends.

CANDIDATE'S DECLARATION

I hereby declare that this dissertation or part thereof has not been previously submitted by me for a degree to any other institution or University.

Place : PARBHANI *(SANGEKAR Y. D.)*

Date : / /2018

Dr. M. P. Jagtap
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C E R T I F I C A T E - I

This is to certify that the dissertation entitled **"PERFORMANCE OF SOYBEAN (*Glycine max* L.) VARIETIES IN POST MONSOON UNDER VARIED WEATHER CONDITIONS"** submitted by **Miss. SANGEKAR YOGESHWARI DILIP (2016A/10M)** to the Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, in partial fulfillment of the requirement of the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRONOMY** is a record of original bonafide research work prosecuted by her under my guidance and supervision. The dissertation, in my opinion is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by her for any degree, diploma or distinction to any other university/institution. The assistance and help rendered during the course of investigation and sources of literature have been duly acknowledged.

Place :PARBHANI **M. P. JAGTAP**

Date : / /2018 **(Research Guide)**

C E R T I F I C A T E - I I

This is to certify that the dissertation entitled **''PERFORMANCE OF SOYBEAN (*Glycine max* L.) VARIETIES IN POST MONSOON UNDER VARIED WEATHER CONDITIONS"** submitted by Miss SANGEKAR YOGESHWARI DILIP to the Vasantrao Naik Marathwada Agricultural University, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRONOMY** has been approved by the student's advisory committee after *viva-voce* examination in collaboration with the external examiner.

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"When you focus on being a blessing, God makes sure that you are always blessed in abundance. -Joel Osteen

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Place : Parbhani

Date : / /2018 ***(SANGEKAR Y.D.)***

CONTENT

ABBREVIATIONS

/	:	per
@	:	At the rate of
^{0}C	:	Degree Celsius
CD at 5%	:	Critical difference at 5 per cent
cm	:	Centimeter (s)
DAS	:	Days after sowing
et al.	:	*et alli* (and others)
Fig.	:	Figure
g	:	Gram (s)
G.M.	:	General Mean
ha	:	Hectare
hrs.	:	Hours
i.e.	:	*ld est* (that is)
kg	:	Kilogram (s)
m	:	Meter
M.W.	:	Meteorological Week
max	:	Maximum
min	:	Minimum
mm	:	Millimeter
N	:	Nitrogen
N.S.	:	Non-significant
No.	:	Number
P or P_2O_5	:	Phosphorus
pH	:	Pussance de hydrogen
RDF	:	Recommended dose of fertilizer
Rs	:	Rupees
S.E.	:	Standard error
t	:	Tonne (s)
viz.	:	*Vedelicet*

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Introduction

CHAPTER-I

INTRODUCTION

Soybean is a leguminous crop and belongs to family Leguminoceae. Soybean is originated in China. It is basically a pulse crop but it is gaining importance as an oilseed crop. The soybean has established itself as a rich source of protein (40-42%), Oil (20%) and nutrients, besides having curative properties against chronic human diseases (Singh 1985). The protein contain of meat, fish, eggs and pulses are acid producing while that of soybean are alkalizing in their effects which makes it a desirable constituent of human diet (Kale, 1985). Soybean protein is rich in lysine (5%) which is deficient in most of the cereals. Specially omega-6 and omega-3 fatty acids, 6-7% total minerals, 5-6% crude fiber and 17-19% carbohydrates.

Soybean is finding its place in policy agenda of industrial, medical and food sector of India due to wide spectrum of its chemical composition. The dry seed of soybean is rich source of phosphorus, potassium, sulphur, iron and vit. A, D, E, K and oil in unsaturated fatty acid with the anticholesterol principle. While its sprout contains appreciable amount of vit.C which is generally obtained from fresh fruits and vegetables due to its high protein content (Singh, 1985).

Soybean is the only major crop that has witnessed on impressive expansion in acreage and production of the global level. The area is increasing in every successive year mainly due to its multi-advantages. It has easy marketing stability and gives good economic returns in short period compared to widely grown pulses like gram and black gram. Major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Gujarat. India rank 5^{th} in area and production of soybean after USA, Brazil, China and Argentina. Maharashtra ranks second in terms of production of soybean after Madhya Pradesh in the country. In India area under soybean in *kharif* 2016 was 109.71 lakh hectares with production of 108.78 lakh metric tonnes. In Maharashtra

soybean production during *kharif* 2016 was 36.05 lakh metric tonnes from area of 35.80 lakh hectares with the productivity of 1007 kg ha^{-1} (Anonymous, 2016).

Now a day, there is vast scope for soybean production due to high nutritional quality, more production and short duration (90 – 110 days), tolerate long dry spell and being leguminous crop help in improving the fertility and productivity of soil. Hence, it is known as "Gold of soil". Soybean varieties selected for drought tolerance have the potential of improving agricultural productivity and hence livelihoods if adopted by farmers (Chianu, 2006).

Soybean is generally processed for its oil, protein and lecithin as a whole bean or partially/fully defatted cake meal. Enriching cereal flour with soybean improves its nutritive quality and soya flour can also be used in making baked products (Chapattis, bread, biscuits, bun, runk and cake) thus, it is a multipurpose crop used for making soya-milk, soya-pannier, soya-yogurt, soya-ice cream etc, soya flour, soya fortified for stuffs and biscuits have good acceptability among the people because of economical and nutritional advantages. Moreover, it is widely used in oil production in India. Out of the total soybean produced, about 85 per cent is utilized for oil extraction, 10 per cent for seed and 5 per cent for food purpose.

Apart from its high nutritive value, it has manifold use in agriculture, i.e. soybean adds large amount of organic matter in soil and thereby improving physical and chemical as well as biological properties of soil and resulted in significant improvement in productivity. Besides this it can very well fit in different cropping systems under rainfed and irrigated farming. Soybean has occupied third place in oilseed crops of India.

In Maharashtra, cultivation of soybean is mainly as rainfed crop. The adverse climatic conditions especially rainfall, higher humidity etc. reduces the seed yield and seed quality in *Kharif* season as crop become more prone to insect and disease incidence. Planting date is an important factor affecting the

soybean growth, development and yield (Zhang *et al*, 2010), and seed quality (Rehman *et al*, 2005).

Soybean is widely cultivated in tropical, subtropical and temperate region of the world. Soybean grows well in warm and moist climate. A temperature range of 26.5 to 30^{o}C appears to be the optimum for most of the genotypes. Soil temperatures of 15.5^{o}C or above favour rapid germination and vigorous seedling growth. The minimum temperature for effective growth is about 10^{o}C (Gadekar, 2001). Day length is the key factor in most of the soybean genotypes as they are short day plants and are sensitive to photoperiod. Photoperiod affects soybean growth and development through its life cycle. Photoperiod along with other environmental factors and all interactivities involved contributes to the control of the ratio of the crops vegetative to the reproductive components (Zang, 2006).

The higher relative humidity during flowering phase might have to help in proper seed setting by overcoming the pollen desiccation and thereby in good seed yield and lower temperature during flowering period increased productivity of soybean (Anil Kumar *et al*, 2008). Most of the soybean genotypes will flower and mature quickly if grown under condition where the day length is less than 14 hr. provided that temperature are also favourable and well drained and fertile loam soils with pH between 6.0 – 7.5 are most suitable for cultivation of soybean.

Timely sowing, availability of high yielding genotypes, recommended fertilizer dose, optimum seed rate and need based plant protection are the most important aspects for increasing the productivity of soybean. The work of varietal development has got fast momentum in India and every year new genotypes are being recommended for cultivation. The performance of these new genotypes is necessarily to be ascertained in comparison with the check.

The varieties of soybean differ in their plant types, maturity period, may be tall or may be branched of unbranched, may be shattering or shattering resistance and present new varieties of extra-early nature (65-75 days) like MAUS-71, JS-9560 have been developed. Due to this variation in plant type, it becomes necessary to study the behavior of the soybean genotypes under various planting dates or agro-eco environments.

The agro-climatic conditions of *kharif* season are found suitable to soybean as commercial crop. However, climatic conditions may cause the adverse effect on seed production of different soybean varieties in *kharif* season. Soybean seed with high germination and vigour could be obtained by sowing during November to December in *rabi* season and August to September in *kharif-II* season (Rehman *et al.* 2013).

The adverse climatic conditions especially rainfall, higher humidity, etc. reduce the seed yield and seed quality in *kharif* season as the crop becomes more prone to insect, pest and disease incidence. These unfavourable environment conditions not only cause the reduction in yield but also affect the germination per centage of *kharif* seed production. Late harvesting due to constant rains may also lead to shattering of grains and deterioration of seed quality.

To overcome these problems and to become self sufficient in the availability of quality seed to the farming community, it becomes essential to ascertain whether the sowing of soybean can be extended up to post monsoon season by treating newly developed varieties of different duration during this extended period of sowing for seed yield and quality. If the seed production of soybean becomes successful in post monsoon, the same seed can be made available for succeeding summer and *kharif* season also. The varieties, MAUS-71, MAUS-612, MAUS-162 and JS-9560 were therefore proposed for testing during post monsoon with sowing span of 38^{th} MW (17^{th} - 23^{th} Sept.) to 40^{th} MW (01^{th} - 07^{th} Oct.)

In view of above, it was felt necessary to plan a field experiment entitled **"Performance of soybean (*Glycine max* L.) varieties in post monsoon under varied weather conditions."** at experimental farm, Department of Agronomy, Parbhani (M.S.) India with the following objectives:

Objectives :

1. To find out suitable sowing time for post monsoon soybean.
2. To evaluate the performance of different soybean varieties in post monsoon season.
3. To study the interaction effect between sowing time and varieties in post monsoon soybean.

Review of Literature

CHEPTAR-II

REVIEW OF LITERATURE

Several scientific studies carried out on the crop dates of sowing and varieties and their effects on crop growth and yield. Their findings are used as the base for present investigation entitled "Performance of soybean (*Glycine max* L.) varieties in post monsoon under varied weather conditions".

2.1 Effect of sowing time on growth of soybean:

2.1.1 Crop emergence

Rahman *et al*. (1995) conducted a field experiment at Galipur (Bangladesh) with two soybean cultivars sown from 15th June to 15th August. They noted that cultivar PK-472 gave higher seeding emergence than cultivar Bragg. Thirum treated seeds gave higher seedling emergence than untreated seeds irrespective of sowing dates.

Nath *et al*. (2017) studied the crop weather relationship of soybean and to optimize the sowing date with different soybean varieties. The data revealed that different sowing dates and varieties had no effect on initial and final plant stand and plant population was not a variable factor due to favourable weather condition during complete July month (from 27th MW to 30th MW) which resulted into uniform emergence and its persistence throughout the crop growth period.

2.1.2 Plant height

Anil Kumar *et al*. (2008) found that plant height significantly differed due to times of sowing from 16th September to 16th October (D_1, D_2 and D_3). Earliest sown crop (16th September) resulted in significantly taller plants. Plant height decreased with delay in sowings from D_1 to D_4.

Hari Ram *et al*. (2010) conducted an experiment at Punjab Agricultural University, Ludhiana during *kharif* 2008 and 2009 to study the time of sowing on the performance of soybean. Among the nine treatments with three sowing dates (June 5, June 15 and June 25) as main plot treatments and three genotypes

of soybean as sub plot treatments and replicated 4 times. The data recorded at harvest revealed that June 5 sowing had tallest plant which was significantly higher than June 25 but statistically at par with June 15 sowing date in 2008.

Sree Rekha (2010) found that there was significant influence of sowing time on plant height, number of pods plant^{-1} and seed yield both in *rabi* and summer season was conducted on vertisols at Adilabad, Andhra Pradesh.

Akter *et al.* (2016) found significant result in plant height of soybean by the sowing date at different growth stages. Plant height decreased significantly with delay in planting. The greater plant height recorded in 30th December was probably due to comparatively longer growing period along with the optimum environmental conditions.

Astha and Singh (2016) showed that p`lant height was significantly influenced by different sowing dates. Crop sown during 1st and 2nd week of June produced taller plants at 60 and 30 days after sowing, respectively.

Shah *et al.* (2017) carried out experiment to figure out the time of sowing for diverse cultivars of soybean in the agroecological environment of Charsadda, Khyberpakhtunkhwa with planting windows (14th March, 21st March, 28th March, 4th April and 11th April) and two varieties (Swat-84 and Williams-82). He observed that the height of the plant has been considerably affected by different planting windows. March 21 plantation produced significantly taller plants (97.23) cm than all other treatments.

2.1.3 Number of branches

Ramani *et al*. (1996) reported that soybean crop sown on 7th July recorded significantly higher seed yield than 22nd July and 6th August sown crop. The higher seed with 7th July sowing was due to more branching.

Chavan *et al*. (1998) revealed that the soybean crop sown on 31st January

and 1st February recorded higher value of number of branches compared to earlier sown crop of 5th and 15th January.

Astha and Singh (2016) observed significantly higher leaf area index, leaf area duration, net assimilation rate, primary branches per plant, when it was sown either during last week of May or 1st week of June and at either of the two inter-row spacings.

2.1.4 Number of leaves

Lodh (1994) reported that 19th September sowing produced maximum number of leaves plant^{-1} as compared to subsequent sowing date at Parbhani.

2.1.5 Leaf area

Hatum and Jamro (1989) conducted a field experiment at Peshawar with soybean cultivars, Lee, Essex and Williams sown at 15 days intervals from 1st April to 15th July to determine patterns of vertical leaf area development. They observed that the total leaf area decreased with late planting.

Bonari *et al*. (1989) reported in lysimeter trial near Pisa with soybean cv. Evans sown on 28th June (early sowing) after winter barley crop or 8th July after wheat (late sowing) that leaf area duration for total dry matter and seed production decreased with late sowing to early sowing.

Sultana *et al.* (2017) reported that leaf area plant^{-1} was significantly affected by sowing dates at all the growth stages. At 20, 40 and 60 DAS higher leaf area was recorded for August 1st week sowing (77.72, 758.01 and 1053.02 cm^2, respectively) while, it was recorded lower for August 4th week sowing (57.65, 358.64 and 481.93 cm^2, respectively).

2.1.6. Growth constants

Astha and Singh (2016) studied the effect of sowing date and row spacing on new genotype of soybean during *kharif* season of 2015 at CSKHPKV, Palampur. The treatments comprising of 3 dates of sowing (last week of May, 1*st* week of June and 2*nd* week of June) and that soybean sown during last week of May followed by 1st week of June resulted in significantly higher dry matter accumulation, leaf area index, leaf area duration, leaf area ratio, crop growth rate, relative growth rate and net assimilation rate.

2.1.7 Dry matter

Asewar *et al*. (2015) found that the date of sowing D_1 (MW 25) recorded significantly highest total dry matter plant^{-1} which was significantly superior over the dates of sowing D_3 (MW 27), D_4 (MW 28) and D_5 (MW 29) at all the growth stages of crop but was found at par with D_2 (MW 26) at all the growth stages of soybean crop.

2.2. Effect of sowing dates on yield attributes

2.2.1 Number of pods plant^{-1}

Barik and sahoo (1989) conducted a field experiment at Regional Research Station, Bhawanipant (Oryssa) on soybean sown on 25th June, 10th July and 25th July. They observed that pods plant^{-1} were significantly more in 10th July sowing date over other sowing dates.

Jasani *et al*. (1994) conducted an experiment where crop was sown on 23rd June, 8th July, 23rd July and 7th Aug. They observed that number of pods plant^{-1} and test weight decreased with each delay in sowing whereas, seed yield and seed protein content was the highest with early sowing. It was observed that delay in sowing reduced oil content in seeds and seed yield.

Reduced light intensity recorded decrease in number of flowers and number of pods (minimum at anthesis stage) resulting in decrease in yield (Sharma and Walia, 1995).

Pramila Rani and Kodanda (1999) conducted a field experiment at Guntur (A.P) with 9 sowing dates from 15th June to 15th October with 1days interval and found that number of pods plant^{-1} were decreased with delay in sowing.

Raj Singh *et al.* (2010) found that yield attributes like pods plant^{-1}, number of seeds pod^{-1} and 1000 seed weight decreased with subsequent delay in sowing from 7th June onwards during both the seasons (*Kharif* 2006 and 2007).

Delayed sowing generally shifts reproductive growth into less favourable conditions with shorted days, lower radiation and temperature (Egli and Bruening, 2002).

Rehman *et al.* (2011) revealed that higher number of pods per plant and number of seeds per plant were produced by 28th January and Faisal soybean. Similarly, maximum seed yield (1647.10 kg ha^{-1} and 1440.23 kg ha^{-1}) were also produced by 28th January, Faisal soybean and 21st January, Faisal soybean, respectively. Thus, 28th January planting was the best for high yield of spring soybean.

Jaybhay *et al.* (2015) studied the response of soyabean to sowing dates and spacing under rainfed condition. He reported that significantly the highest number of pods was observed in 25th MW sowing than other dates of sowing. At 75 days, 25th MW sowing found to be at par with 26th MW and significantly superior over other stages.

Shah *et al*. (2017) conducted an experiment decide the time of sowing for diverse cultivars of soybean in the agroecological environment of Charsadda, Khyberpakhtunkhwa. The results declared that a larger number of pods per plant and the number of seeds per plant were produced by 21 March and Williams-82. Therefore, 21th March plantation was the outstanding for elevated yield of soybean.

Sultana *et al*. (2017) observed that the highest number of pods plant^{-1} (65.90) was recorded from July 2nd week sowing followed by July 1st week (56.9) and were significantly different from other sowing dates.

2.2.2 Number of seeds pod^{-1}

Sakai and Hattori (1990) conducted a field experiment at Fukisima (Japan) with soybean sown between 31th May and 6th July with plant density of 89000-265000 plants ha^{-1}. They observed that the number of seeds pod^{-1} varied little with sowing dates but were lower near the base of plant.

Calvino *et al*. (2003) studied the development, growth and yield of late-sown soybean in the Southern Pampas with sowing dates (mid December and early January) and reported that the decline in crop biomass, harvest index, seed number and individual seed weight with delayed sowing can be attributed to shorter season length, slow growth rate associated with short days and low temperature and radiation.

Pederson and Lauer (2004) assessed the effect of management system and planting date on soybean yield components and their development for environment typical of the upper mid-west. Early planting produced higher seed number, pod number and harvest index but lower seed number pod^{-1} than the late planting date. This concluded that, differences in yield components and their development emphasized the complexity of plant compensation in response to management system.

Naidu *et al*. (2017) found significant decrease in number of seeds pod^{-1} with each successive delay in sowing from 16th September (D_1) to 1st November (D_4). Earliest sown crop (D_1) had significantly more number of seeds pod^{-1}.

Singh (2015) revealed that the number of seeds per pod significantly affected due to different sowing dates and fertility levels. The maximum number of seeds per pod was recorded when the crop sown on 1st

July (D_1) and this sowing date proved significantly superior over rest of the other date of sowing during both the years. However the second best sowing date was 10th July (D_2) than 20th July (D_3). The number of seeds declined with delayed sowing up to 30th July (D_4).

2.2.3 Test weight

Barik and Sahoo (1989) recorded the highest seed yield in 10th July sowing followed by 25th June and the lowest seed yield from 25th July sowing. They were significantly different from each other. Yield of straw gradually decreased with each delay in sowing date and the harvest index increased significantly from 25th June to 10th July sowing, while the latter was on par with that of 25th July. It was indicated that delayed sowing resulted in higher harvest index up to 10th July.

Ehsanullah and Hatam (1989) conducted a trial with 20 cultivars sown on 7th April and 19th May. It was observed that test weight was significantly affected by sowing date and cultivar and were higher with 19th May sowing.

Naidu *et al*. (2017) reported that the 16th September (D_1) sown crop recorded highest hundred seed weight, which was significantly higher than 16th October and 1st November sowings but, 1st October (D_2) was statistically at par with 16th September sowing.

Singh (2015) reported that the crop sown on 1st July (D_1) gave maximum test weight, which was significantly higher to 20th July (D_3) and (30th July) (D_4) in both the years, but when compared to 10th July (D_2) sown crop it was significantly higher only in the first year.

2.2.4 Seed yield

Sahoo *et al*. (1991) reported that sowing dates had significant effect on seed yield. Maximum seed yield of soybean obtained from 20th and 30th June sowings, which were at par between themselves but were superior to

subsequent sowings. The seed yield decreased by5, 13, 34 and 35% when sown on 30th June, 10th, 20th and 30th July, respectively.

Singh and Bajpai (1992) conducted an experiment under Naga land condition and revealed that the highest seed yield of soybean (Cv.Bragg) was obtained when the crop was sown on 31st May as compared to 15th June, 30th June and 15th July. Delay in sowing beyond 31st May resulted in gradual decrease in seed yield.

Singh and Arya (1994) conducted an experiment during 1988-9 at Ranichauri (U.P.) where Cv. Bragg and Shilajeet were sown on 10th, 20th and 30th June. Delayed sowing after 10th June decreased seed yield and Shilajeet produced higher seed yield than Bragg. Accumulated heat units decreased with delay in sowing. A significant and positive relationship was observed between heat units and seed and straw yields, plant height, branches and seed weight plant^{-1}.

Sarma (1994) reported from Diphu (Assam) that yield of soybean cv. JS-2 sown between10th May and 10th August was the highest from sowing on 10th June or 25th May. Maturity decreased from 153 days when sown on 10th May to 83 days when sown on 10th August.

Chandel and Gupta (1995) conducted filed studies at Palampur (H.P) and reported that advanced sowing recorded the highest yield of soybean, whereas, delay in sowing reduced soybean yields significantly.

Karmarkar and Bhtnagar (1995) reported from their study that the existence of genotypic variability to suit varied growing conditions including sowing. They conducted that for normal sowing (up to 3oth June), PK-472 was the most suitable variety for higher seed yield and for late sowing resulted in significant reduction in seed yield of soybean.

Chavan and Patil (1997) carried out a failed experiment during *Kharif* season of 1994 and 1995 at Agricultural Resarch Station, Palghar, Dist. Thane with four varieties *viz.*, MACS 13,MACS 58 MACS 124 and PKV 1 and

three times of sowing as 27th , 29th and 31th MW and observed the reduction in yield of soybean due to delay in sowing. Early sowing of soybean in 27th MW produced maximum and significantly higher seed yield over its delayed sowings of 29th and 31th MW.

Pawar (1998) conducted a field trial during semi-*rabi* and *rabi* season with eight sowing dates (Aug. 15, Sept. 1, Sept.15, Oct.15, Nov.1, Nov.15 and Dec. 1) and noticed reduction in soybean (PK 471) grain yield due to delay in sowing. During semi *rabi* season, the sowing done on Aug.15 produced significantly more yield (1527 kg ha^{-1}) over other sowing dates. During *rabi*, sowing of October 31 gave significantly higher yield (1071kg ha^{-1}) over sowing done on Oct. 15 (595 kg ha^{-1}) and December 1 (595 kg ha^{-1}).

Bhatia *et al*. (1999) conducted an experiment with 12 different soybean cultivars which were sown on five dates between 20th June and 30th July. Significant difference in yield and most of the yield components, among sowing dates and cultivars were observed. It was also observed that yield decreased with delay in sowing, while JS-335, NRC-2 and JS-71-05 recorded the highest yield.

Rajput and Shrivastav (1999) conducted a field experiment with soybean cultivars JS71-05, JS 335, PK472 and revealed that maximum seed yield was obtained when the crop was sown on 11th July (1533 kg ha^{-1}). There was significant reduction in yield in delayed sowing which ve the lowest seed yield with 31th July (853 kg ha^{-1}).

Billoe *et al.* (2002) observed that sowing of the soybean cultivars in the first week of July gave significantly higher yield than sowing in the fourth week of July (2031 kg ha^{-1}).

Billore *et al,* (2002) Conducted a field experiment for two years (1994-95) in rainy season to evaluate the performance of soybean (*Glycine max* (L.) Merril.) genotypes under 5 sowing dates and 2 row spacings. The average

soybean seed yield decreased linearly by 181.77 kg/ha for every 5 days delay in sowing from the normal date (25 June).

Calvino *et al*. (2003) studied the development, growth and yield of late-sown soybean in the Southern Pampas and reported that delayed sowing reduced yield at a rate about 2% d-1 from mid December.

Shaikh *et al*. (2005) from the investigation revealed that soybean sown on 15th June gave better yield than sowing on 30th June or 15th July. The yields obtained due to sowing of soybean on 15th June and 30th June was at par after pooling. However, both dates of sowing were significantly superior over sowing of soybean on 15th July. The late sown crop might have caught in rains during flowering and ultimately it hampered the soybean yield.

Pramila *et al*. (2008) studied the performance of soybean varieties under different sowing dates during *rabi* in vertisol. Result revealed that soybean sown around 15th September and 25th September gave significantly higher seed yield as compared with two October sowings.

The seed yields are generally greater from earlier planted soybean was due to longer duration of vegetative and reproductive stages (Chain and Wiatrak, 2010).

Ngalamu *et al.* (2012) reported that seed yield and some yield components like number of productive pods per plant, number of branches per plant and leaf area declined from the first sowing date to the last (fifth) sowing date. These results suggested that early sowing dates, around early to mid July gave the highest seed yield and could be recommended as the optimum planting time for soybean in Sennar State of Sudan.

Samia and Hamed (2013) conducted an experiment with sowing dates and genotypes of soybean. The results of season 2010/11 showed significant differences for number of pods/plant, number of seeds/pod and highly significant difference was obtained in weight of pods/plant, weight of

seeds/plant, 100 seed weight, yield and harvest index. The S_3 (16-June) mid June, produced the highest values and S_5 (30- June) gave the lowest values of the above parameters.

Khan *et al*. (2014) observed significant differences in seed yield in planting dates (D), varieties (V) and D x V interaction for the two years average. Maximum seed yield (1459 kg ha^{-1}) was given by April planted crop. There was no significant difference in seed yield of April and May planted crop but significant reduction in the seed yield observed when planting was delayed up to June and July.

Rehman *et al*. (2014) reported that higher number of pods per plant and number of seeds per plant were produced by 28th January and Faisal soybean. Similarly, maximum seed yield (1647.10 kg ha^{-1} and 1440.23 kg ha^{-1}) were also produced by 28th January, Faisal soybean and 21st January, Faisal soybean, respectively. Thus, 28th January planting was the best for high yield of spring soybean.

Asewar *et al.* (2015) conducted an experiment with two varieties i.e. MAUS-71 (V_1), MAUS-81 (V_2) and five dates of sowing i.e. D_1 (MW 25), D_2 (MW 26), D_3 (MW 27), D_4 (MW 28) and D_5 (MW 29). In case of dates of sowing, D_1 (MW 25) recorded the highest seed yield ha^{-1} and was significantly superior over rest of delayed sowing dates.

Jaybhaye *et al.* (2015) showed that there was significant reduction in yield with each delay in sowing. Soybean sown on 25th MW (1087.0 Kg ha^{-1}) out yielded later sowing dates, it was on par with 26th MW (1043.63 kg ha^{-1}) and gave 4.21% more grain yield over 26th MW and 50.09% over 28th MW. Delayed sowing adversely affected the grain production.

Singh (2015) concluded that the seed yield per plant of soybean differed significantly among them due to dates of sowing during both the years. The 1st July sowing date recorded significantly higher seed yield (8.77 and 8.36 g $plant^{-1}$ in 2013 and 2014, respectively) as compared to other dates of sowing.

Akter *et al.* (2016) reported that sowing date had significant effect on seed yield of soybean. The maximum seed yield was obtained from sowing date 2nd January and the lowest was found out from 1st February. In late planting, due to the loss of suitable time for the growth.

Jaybhay *et al*. (2016) reported that seed yield of crop sown on 20th June (3,143 kg ha^{-1}) and 5th July (2,936 kg ha^{-1}) was significantly higher than that sown on 20th July (2,452 kg ha^{-1}). Per cent increase in yield over 20th July sowing was 28.18 per cent and 19.74 per cent, respectively for 20th June and 5th July sowing, respectively.

Kandel *et al.* (2016) concluded that soybean yield declined sharply when crop were planted after last week of May regardless of seed treatments and cultivars.

Naidu *et al.* (2017) studied the response of soybean varieties to different sowing times during *rabi* season. Results revealed that the seed yield in 16th September (D_1) and 1st October (D_2) sown crop was at par however, significantly higher than 16th October (D_3) and 1st November (D_4) sowings. The higher seed yield in 16th September (D_1) and 1st October (D_2) sowings might be due to ideal weather for crop growth and development.

Nath *et al*. (2017) studied the crop weather relationship of soybean and to optimize the sowing date with different soybean varieties. The results revealed that soybean crop sown up to 27th MW recorded significantly higher seed (839 kg ha^{-1}) and biological yields (2773 kg ha^{-1}). Later sowings i.e. 30th MW sowing caused decreased amount of rainfall and increased maximum temperature regime across the total growing period with consequently lower seed yield (530 kg ha^{-1}).

Sultana *et al.* (2017) reported that higher seed yield (22 q ha^{-1}) was recorded in July 2nd week sowing followed by July 1st week sowing (16.95 q ha^{-1}). Significantly higher yield from July 2nd week sowing was realized due

to enhanced expression of yield attributing characters such as higher number of pods plant^{-1} (65.9), seed yield plant^{-1} (13.41 g) and test weight (11.52 g).

2.2.5 Harvest index

Billore *et al*. (2002) observed that sowing on June 25th recorded significantly the highest harvest index than July 5th, July 10th, July 15th and July 20th sowings. Among the varieties, JS-335 recorded the maximum harvest index (29.41) followed by JS-9305 (27.91 %) and TAMS 98-21 (27.44 %).

Anil kumar *et al.* (2008) concluded that early sowings (16th September and 1st October) recorded significantly the highest harvest index and was at par compared with the later sowings (16th October and 1st November). Latest sown crop (1st November (D_4)) recorded lower harvest index compared to the crop sown on 16th October (D_3).

Hari Ram *et al.* (2010) reported that timely planting of soybean recorded higher harvest index than the late sown crop.

2.3 Effect of date of sowing on seed quality of soybean:

2.3.1 Oil and Protein content

Jasni *et al.* (1994) concluded that number of pods plant^{-1} and test weight decreased with delay in sowing. Seed yield was greatest at the early sowing dates with high sowing rates. Seed protein content was the highest from the early sowing rates. Seed protein content was the highest from the early sowings. Maximum seed protein content (40.16%) was obtained with the lowest sowing rates. Delay in sowing reduced seed oil content and yield. Sowing on June 23rd at a rate of 60 kg^{-1} provides optimum conditions for seed, protein and oil yields.(P.S.R)

Minranda *et al* .(1998) reported that oil content of soybean seed is a polygenic and complex trial that is responsive to environmental effect that occur during plant development. Therefore studies were conducted to investigate seed oil content of soybean developed under divers photoperiod and

temperature conditions. Results indicates the significant difference in oil content due to sowing dates. Seed oil content increase from September to October and decreased from October to December sowing in all materials.

Rehman *et al*. (2014) revealed that protein concentration and oil percentage of soybean seeds was significantly affected by planting times. Early planted soybean (T_1- 21st January) produced seeds with lower protein percentage of 31.65%. However, the protein percentage was increased with delayed planting as late planted (T_4) crop gave maximum protein percentage of 33.53%. Delay in sowing decreased concentration of oil and seeds harvested from T_5 gave minimum oil percentage of 18.92% statistically similar with T_4. The seeds harvested from early sowing developed and matured at high temperature which resulted in maximum oil percentage as compared to late planted crop.

Singh (2015) concluded that the protein yield was deviated significantly due to sowing date and fertility levels. Crop sown on 1st July gave significantly higher protein yield compared to other sowing dates. The lowest protein yield was obtained with 30th July sown crop,

Shah *et al*. (2017) studied the yield and quality traits of soybean cultivars in response to different planting windows. The results in terms of the percentage of oil and protein in soybean revealed that there was significant difference between the effects of the different planting windows on this attribute. Delay in the planting diminish in the concentration of oil and the seeds harvested from T_5 produced the lowest percentage of oil 19.92% statistically at T_4. Again showed that untimely planted soybeans (T_1-14th March) generated the seed with low protein content of 32.65%. On the other hand, the protein content was augmented with late sowing as delayed planted (T_4) crop has given 34.53 utmost protein percentage which was analogous with T_5 (34.32%).

2.3.2 Germination %

Avila *et al*. (2003) evaluated the influence of sowing dates on the physiological and sanitary quality of seeds with five soybean cultivars. Results revealed that cultivars BRS 134 and BRS 133, which were sown during the period from 10/15 to 11/30, produced seeds that had higher percentages of normal seedlings in the germination and accelerated aging tests.

Rehman *et al*. (2013) reported that November and December sowing produced seeds with higher germination and vigour for all the cultivars in *rabi* season. On the other hand, September sowing produced seeds with high germination and vigour during *Kharif* II. The study concluded that soybean seeds having high germination and vigour could be obtained by sowing of seed during November to December and August to September in *rabi* and *Kharif*-II seasons, respectively.

Sultana *et al.* (2017) studied physiological quality of soybean as affected by sowing dates. Results revealed that seed quality parameters *viz*., germination, seedling length, seedling dry weight, field emergence and speed of germination were high for seeds harvested from July 2nd week sowing followed by July 1st week sowing throughout the storage period and maintained the seed certification standards.

2.4 Effect of varieties on growth of soybean:

2.4.1 Crop emergence

Rahman *et al*. (1995) conducted a field experiment on Gazipur (Bengladesh) with two soybean cultivars sown from 19th June to 15th August. They noted that cultivar PK 472 gave higher seed emergence than cultivar Bragg.

Crop emergence and final stand was not varied significantly due to different varieties of soybean in *Rabi* season at Parbhani, Maharashtra (Kausale, 2000).

2.4.2 Plant height

Pramila Rani (1997) conducted a field experiment during *rabi* season of 1991-92 with four soybean varieties *viz*., MACS 201, MACS 58, MACS 63 and PK 471. Maximum plant height was recorded in MACS 58(39.7) followed by MACS 201 (34.8 cm).

Koti and Chetti (1999) reported that plant height, Number of branches of soybean genotypes JS-80-21, KB-92, PK-472 have positive association with seed yield in *rabi* season only indicating the necessity of improving these characters in increasing yield potential in *rabi*.

Singh (2003) reported that among the varieties, maximum height of plant, number of branches/plant, number of pods/plant, weight of pod/plant and straw yield was recorded in JS 80-21 and JS 75-46 followed by Durga and PK-472 during both the years of experimentation but the differences were non-significant except height of the plant and straw yield during first year.

Sukalkar (2005) reported that variety MAUS 162 produced maximum number of leaves plant^{-1} at harvest followed by JS 335. Whereas, MAUS 71 showed the lowest plant height.

Anil Kumar *et al.* (2008) reported that tallest plants were obtained with JS-335 (V_4) variety which was however, on par with Basar (V_1) which were at par. Bheem (V_3) and JS-93-05 (V_2), were at par, recorded the shortest plants.

Ruhul Amin *et al*. (2009) conducted a field experiment on three soybean varieties *viz.* Shohag, Bangladesh soybean-4 and BARI soybean-5 and observed that among the three varieties, BARI soybean-5 influenced plant to

have maximum dry matter, number of leaves plant^{-1} , leaf area (cm^2), But, the maximum plant height was found the highest in Bangladesh soybean-4.

Bhangre (2010) observed that the plant height increased up to 70th days stage in variety JS 95-60 but in variety JS 97-52 plant height increased up to 90th day stage the response of varieties was significant. Variety JS 97-52 produced significantly maximum plant height (83.40 cm) than variety JS 95-60 (42.80).

Sree Rekha (2010) studied three varieties JS-335, PK-1029 and MACS-450 significantly differed in plant height, number of pods plant^{-1} and seed yield both in *rabi* and summer seasons. Significantly higher plant height was *recorded* during *rabi* with varieties JS-335 (30.6 cm) and MACS-450 (30.2 cm) over variety PK-1029 (25.7 cm).

Kandil *et al.* (2012) reported soybean attributes due to planting dates under this study were observed in early planting date on 20th May being the highest among those to other planting dates at plant height for all the studied traits and planting on 5th May for other yield and yield components.

Shah *et al.* (2017) studied the yield and quality traits of soybean cultivars in response to different planting windows. Among the two varieties, Williams-82 produced 81.83 cm statistically higher plants against significantly the shortest plants 77.16 cm for Swat-84.

2.5.3 Number of branches

Mohd. Abbas *et al*. (1994) studied the effect of various plant densities on growth parameters of soybean cultivars and reported that JS 72-44 was found superior in respect of leaf area index and number of branches plant^{-1}.

Bhangre (2010) reported that the variety JS 97-52 produced significantly higher number of branches per plant (4.94) than variety JS 95-60 (3.97).

2.5.4 Number of leaves

Asewar *et al.* (2015) studied growth and yield of soybean varieties as influenced by dates of sowing. Results revealed that the maximum number of functional leaves was produced by variety MAUS-71 (V_1) at 60 DAS. Also variety MAUS-81 (V_2) recorded higher number of functional leaves at all the growth stages.

2.4.5 Leaf area

Patodiya (1988) observed that leaf area plant^{-1} was influenced significantly due to various varieties under study at all the stage of crop growth.

Hatam and Jamro (1989) conducted a field experiment at Peshawar with soybean cultivars, Lee, Essex and Williams sown at 15 days intervals from 1st April to 15th July to determine patterns of vertical leaf area development. They observed that in cultivars Lee and Essex (determinate) leaf area decreased towards the top whereas, in cv. Williams (indeterminate) the distribution was uniform. Though the patterns remained constant, total leaf area decreased with late planting.

2.4.6 Dry matter

Ramana *et al*. (2012) studied that the varieties NRC-37 and MACS-57 showed a better performance under salinity stress, when compared to that of MAU-61 and LSB-1 which was very well correlated with their biomass contents.

Singh *et al*. (2013) observed among three soybean varieties ‘JS93 05’, ‘PK 472’ and ‘NRC 37’, variety ‘JS 9305’ recorded higher dry matter/plant, pods/plant, seed weight/plant and seed and straw yields.

Naidu *et al*. (2017) observed that JS- 335 (V_4) produced significantly higher dry matter production followed by Basar (V_1), Bheem (V_3) and JS 9305 (V_2). Difference in dry matter production between any two varieties was significant.

2.5 Effect of varieties on yield attributes

2.5.1 Number of pods plant^{-1}

Pramila Rani (1997) conducted a field experiment with four soybean varieties *viz.*, MACS 201, MACS 58, MACS 63 and PK 471 and reported that MACS 201 produced significantly higher number of pods plant^{-1} (39.4) over MACS 58 (32.2), MACS 63(35.9) and PK 471 (24.2).

Koti and Chetti (1999) reported that soybean genotypes JS-8021, KB-92, PK-472 recorded higher seed yield during *kharif, rabi* and *summer* season, respectively, and plant height, number of branches and number of pods have positive association with seed yield in *rabi* season only, indicating the necessity of improving these characters in increasing yield potential in *rabi*.

Sarawgi and Rajput (2005) reported significantly higher number of pods plant^{-1}, grains pod^{-1} and grain yield recorded in variety JS-335 over rest of the varieties except PK-472 which showed at par grains pod^{-1} during first year, however, during second year PK-472 registered significantly higher number of pods plant^{-1} and harvest index.

Bhangre (2010) observed that the variety JS 9752 produced significantly higher pods per plant (77.31) than variety JS 9560.

Tabbasum *et al*. (2015) reported that the genotype SBM-78 had the highest seed yield plant^{-1}(48.7 g), number of branches (8.5), pods (223.6),

seeds (404.7) and 100-seed weight (13.5g) among the advanced genotypes SBM-9, SBM-15, SBM-17, SBM-18, SBM-20, SBM-22, SBM-73, SBM-78, BAU-S/70 and varieties were Binasoybean-1, Binasoybean-2, Shohag, BARI Soybean-5 and BARI Soybean-6.

2.5.2 Number of seeds pod^{-1}

Khurana *et al*. (1984) reported that seeds pod^{-1} differed from variety to variety in soybean.

Anil kumar (2008) observed that among varieties tested, the highest number of seeds pod^{-1} was recorded with the variety JS-335 (V_4), which was comparable with that of Basar (V_1). Varieties Bheem (V_3) and JS-9305 (V_2) which were at par in producing lowest number of seeds pod^{-1}.

Bhangre (2010) studied the performance of soybean varieties under different seed rates and row spacings. Results revealed that the variety JS 9560 produced significantly higher seeds per pod (2.72) than variety JS 9752.

Hari Ram *et al*. (2010) revealed that variety SL-744 gave the highest yield among the varieties and the oil content was the highest in SL-525.

2.5.3 Number of seeds plant^{-1}

Ngalamu *et al*. (2012) reported that the elevated number of seeds per plant (59.72) has been noted in the Williams-82. There was also a lot of variance between the size and the weight of the seeds at the early and delayed planting.

2.5.4 Test weight

Pramila Rani (1997) conducted a field experiment with four soybean varieties MACS 201, MACS 58, MACS 63 and PK 471 and found that PK 471 gave significantly more 100 seed weight over rest of the varieties.

Niaz *et al*. (2018) revealed that soybean varieties performed differently in case of 1000-grain weight. Kharif-93 gave statistically the highest 1000-grain weight as compared to Malakand-96.

2.5.5 Seed yield

Ishida *et al.* (1980) found that seed yield of soybean was varied from variety to variety (1.7 to 3.0 t ha^{-1}).

Parlawar *et al*. (1992) reported that seed yield was 2.01, 2.02, 2.06, 1.88, 1.85 and 1.16 t ha^{-1} in MACS -25, Monetta , MACS-13, JS -2 , JS -72-44 and Black (local), respectively.

Singh *et al*. (1993) reported from the experiment conducted in rainy season at Hisser (Haryana) that PK-416 gave the highest seed yield (2.31 t ha^{-1}) followed by PK-1024 (2.09 t ha^{-1}), respectively.

Soybean cultivars JS 7981 and JS 7841 were grown and observed that the highest seed index was in JS 7981 than JS 7841 (Kurmvanshi *et al*., 1996).

Rajput *et al*. (1999) conducted an experiment with soybean varieties JS 7105, JS 335 and PK 472 and revealed that variety JS 7105 gave significantly more yield (1213 kg ha^{-1}) over PK 472 and was on par with JS 335 (1173 kg ha^{-1}).

Billore *et al*. (2002) conducted a field experiment was conducted for two years (1994-95) in rainy season to evaluate the performance of soybean (*Glycine max* (L.) Merrill.) genotypes under 5 sowing dates and 2 row spacings. The maximum reduction in seed yield was recorded in 'JS 7105' followed by 'Ahilya 3','JS 335', 'Ahilya 1' and 'PK 472' as evidenced from the regressionequations. However, genotype 'Ahilya 3' sustained higher yield levels over sowing dates.

Singh (2003) observed significant variation among the different varieties during both the years. Maximum grain yield (19.81 q ha^{-1}) was recorded in JS 80-21 and minimum in PK-472 (16.73 q ha^{-1}).

Anil Kumar *et al*. (2008) reported that varieties of soybean do differ in seed yields. High soybean yields of the varieties JS-335 (V_4) and Basar (V1) might be due to better growth, higher tolerance to insect pests and diseases, adequate crop duration.

Bhangre (2010) studied the performance of soybean varieties under different seed rates and row spacings. Results revealed that the variety JS 9560 produced significantly higher grain yield (2331 kg ha^{-1}) than variety JS 9752.

Zang *et al.* (2010) reported that the highest marketable yield of 7688, 6572 and 8661 kg ha^{-1} was obtained on May 22 for cultivars Zhongke 57, Zhongmei 52 and Dongdou 26, respectively. While the highest marketable yield of 6349 kg/ha was obtained at sowing date of July 5 for cultivar Dongdou 24.

Jadhav *et al*. (2011) evaluated the response of soybean hybrids to fertilizer levels at Farm of Department of Agronomy, College of Agriculture, Latur (M.S.) under rainfed condition. The results of experiment revealed that the hybrid MAUS-71 recorded significantly maximum growth attributes, yield and consequently resulted in the highest monetary gain over rest of the cultivars, while MAUS-81 variety found to be at par on it in respect of seed yield and gross returns.

Meena and Meena (2013) revealed that the soybean variety JS 9560 took minimum number of days for attaining maturity, whereas, variety JS 9305 took 13 days more. The variety JS 9560 gave the maximum yield of 21.3

q ha^{-1} with an average yield of 17.5 q ha^{-1}), whereas, variety JS 9305 recorded the highest average yield (18.2 q ha^{-1}).

Rehman *et al*. (2013) conducted an experiment to investigate the effect of row spacing and cultivars on the growth and yield of soybean with three soybean cultivars: (1) Bangladesh Soybean -4 (G_2), (2) BARI soybean -5 (BS-5) and (3) Shohag (PB-1)Among cultivars the highest yield was given by cultivar BS-5 (151.24 g m-2) followed by PB-1. He concluded that the soybean cultivars BS-5 and PB-1 could be selected for sowing in *Kharif*-II season.

Singh *et al*. (2013) studied the effect of integrated nutrient management on growth, yield and nutrient uptake by three soybean varieties JS 9305, PK 472 and NRC 37.Across years and nutrient management treatments, cultivar 'JS 9305' recorded higher dry matter/plant, pods/plant, seed weight $plant^{-1}$ and seed and straw yields.

Asewar *et al.* (2015) reported that variety MAUS-71 (V_1) recorded the highest seed yield which was superior over the variety MAUS-81 (V_2). This might be due to of higher seed yield $plant^{-1}$ which occurred from increased pod number and pod weight $plant^{-1}$ and number of seed pod^{-1}.

Tabassum *et al*. (2015) reported that the highest yield (2.50 t ha^{-1}) was produced by BARI Soybean-5 followed by SBM-78 (2.39 t ha^{-1}), SBM-22 (2.32 t ha^{-1}) and BARI Soybean-6 (2.28 t ha^{-1}) whereas the lowest yield (1.26 t ha^{-1}) was recordrd in genotype SBM-17 but it was statistically similar to SBM-73, SBM-15, Binasoybean-2 and SBM-9.

Shah *et al.* (2017) reported that the cultivars Williams-82 have produced significantly more seed yield of 1229 kg ha^{-1} compared to Swat-84 1122.9 kg ha^{-1}.

2.5.6 Harvest index

Bhangre (2010) reported that variety JS 9560 gave significantly higher harvest index (53.57) compared to variety JS 9752 (31.63).

Rehman *et al*. (2013) studied the effect of row spacing and cultivar on the growth and seed yield of soybean in *Kharif*-II season. Results revealed that the highest (47.72%) harvest index was found in cultivar BS-5 and the lowest in cultivar G-2.

2.6 Effect of varieties on seed quality of soybean:

2.6.1 Oil and protein content

Saxena and Pandey (1971) compared thirteen USA cultivars and three Indian cultivars from different maturity groups at Pantnagar and observed that among the early maturity cultivars, seed protein was varied from 39.5 to 43 per cent. USA cultivars were higher than those of Indian cultivars in respect of oil content.

Lal *et al.* (1973) observed considerable difference in protein and oil content among different varieties of soybean.

Drikis (1999) conducted a field experiment on yield and quality of 30 soybean vaieties and reported that the highest yield of oil was obtained from variety IYAR 78/13 (20.12%).

Billore *et al.* (2000) examined the performance of soybean (*Glycine max* (L.) Merril.) genotypes under 5 sowing dates and 2 row spacings. The maximum oil and protein content was recorded in Ahilya 3 and JS 335, respectively.

Pawar *et al.* (2000) studied quality characteristics of 4 varieties and recorded that protein content of variety Pooja (39.46%) was higher than other varieties.

Saldivar *et al*. (2011) examined the compositional change of five specialty soybean genotypes along with two commercial cultivars, Jack and Ozark, during seed development and maturation. Although there were significant differences among the seven soybean genotypes in their chemical compositions, some compositional changes followed similar trends. Protein content decreased during the first 3-5 weeks after flowering and then gradually increased. Oil was accumulated rapidly during the early stages.

2.6.2 Germination %

Avila *et al*. (2003) evaluated the influence of sowing dates on the physiological and sanitary quality of seeds with five soybean cultivars. Results revealed that cultivars BRS 134 and BRS 133 sown during the period from 10/15 to 11/30 produced seeds that had higher percentages of normal seedlings in the germination and accelerated aging tests.

Rehman *et al*. (2013) reported that the germination and vigour of soybean seed is influenced by the cultivar and their time of sowing. Among the three varieties, cultivar G-2 showed higher germination and vigour than cultivar PB-1 or BS-5 during both *rabi* and *kharif* seasons.

Material and Methods

CHEPTER-III

MATERIALS AND METHODS

The field experiment was conducted to study the "Performance of soybean (*glycine max* L .) varieties in post monsoon under varied weather conditions." at Experimental farm, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth (V.N.M.K.V.), Parbhani. The details of the material used and methods adopted during the investigation are presented in this chapter under appropriate headings.

3.1 General Description

3.1.1 Location of Experimental Site

The field experiment was conducted at Experimental farm, Department of Agronomy, College of agriculture, V.N.M.K.V., Parbhani (M.S.) India. The Laboratory works were done in the Department of Agronomy, V.N.M.K.V., Parbhani and Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidaypeeth Agricultural University, Parbhani (M.S.) India.

3.1.2 Climatic and weather Conditions

Geographically Parbhani is situated at $19^0 16^{'}$ North latitude and $76^0 47^{'}$ East longitude and at 409 altitudes above mean sea level and has a semi-arid climate. The weekly meteorological data pertaining to rainfall, temperature and relative humidity prevailed during crop growth period September 2017 to January 2018 was recorded at Agricultural Meteorological Observatory, V.N.M.K.V., Parbhani and is presented in Table 1.

Total rainfall received during the crop growth period was 189.20 mm over 10 rainy days. During this period, average monthly maximum rainfall 170.2 mm was received in the month of October and no rainfall was received in the month of November, December and January resulted in long dry spell. The

average monthly maximum temperature of 32.3 ^{0}C was recorded in October and minimum of 10.2 ^{0}C was in the month of January. Sowing operation was completed in 38th MW, 39th MW and 40th MW. The rain showers received during 38th to 41st MW helped for proper establishment of the crop.

Table 1: Weekly weather data during crop season (2017-2018) recorded at Agro meteorological observatory V.N.M.K.V. Parbhani

MW	Period	RF (mm)	Rainy days (No.)	Temperature ^{o}C		Humidity (%)		EVP (mm)	BSS (Hrs.)
				Max	Min	RH1	RHII		
37	10-16 Sep	79.2	3.0	30.5	22.7	87	72	2.8	4.9
38	17-23 Sep	6.6	1.0	31.5	22.3	87	61	4.6	6.0
39	24-30 Sep	0.0	0.0	34.2	22.5	77	48	6.2	8.5
40	01-07 Oct	57.6	2.0	33.2	21.6	82	65	5.4	7.0
41	08-14 Oct.	111.2	3.0	31.2	22.2	89	69	3.3	5.3
42	15-21 Oct.	1.4	1.0	32.6	20.2	79	46	4.7	6.5
43	22-28 Oct.	0.0	0.0	32.6	16.4	77	32	4.3	8.9
44	29-04 Nov.	0.0	0.0	30.9	14.5	78	31	4.5	9.2
45	05-11 Nov.	0.0	0.0	30.8	12.2	79	31	4.8	9.6
46	12-18 Nov.	0.0	0.0	31.4	14.4	76	32	4.7	8.7
47	19-25 Nov.	0.0	0.0	32.0	17.0	77	42	4.5	7.4
48	26-02 Dec.	0.0	0.0	29.9	10.2	77	31	3.9	9.2
49	03-09 Dec.	0.0	0.0	30.4	14.4	75	42	4.5	7.4
50	10-16 Dec.	0.0	0.0	31.0	12.5	78	31	4.7	8.6
51	17-23 Dec.	0.0	0.0	29.3	7.9	75	27	4.0	8.4
52	24-30 Dec	0.0	0.0	25.6	6.1	67	19	3.4	8.3
01	01-06 Jan.	0.0	0.0	29.6	9.2	76.1	31.6	3.9	8.6
02	07-13 Jan.	0.0	0.0	30.3	11.5	76.1	29.7	4.5	8.7
03	14-20 Jan.	0.0	0.0	31.0	11.8	75.0	25.7	5.1	9.2
04	21-26 Jan.	0.0	0.0	29.9	8.7	77.7	24.9	4.5	9.4
Average		**189.2**	**10.0**	**30.9**	**14.9**	**78.2**	**39.5**	**4.4**	**8.0**

3.1.3 Soil type of the experimental site

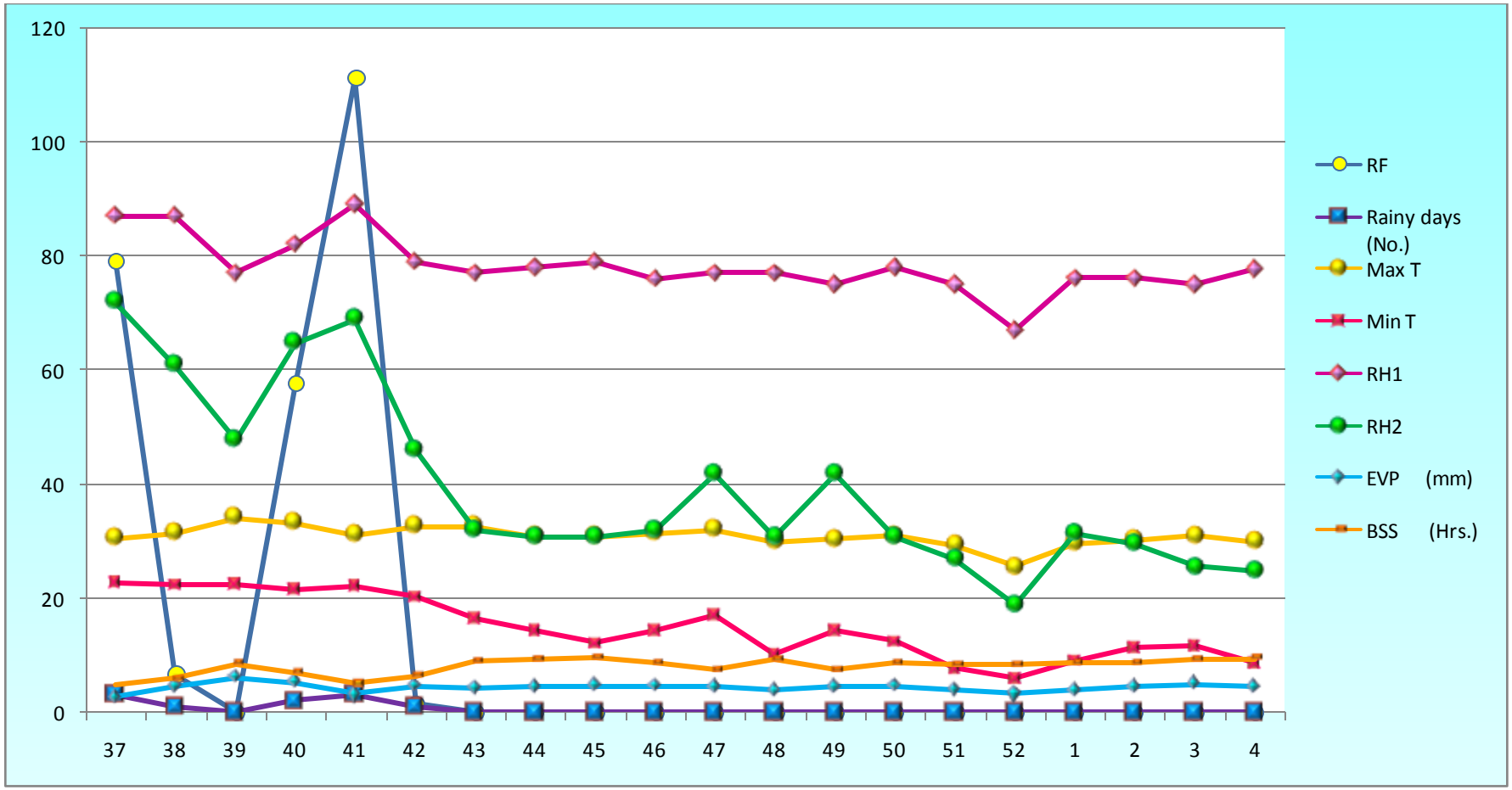


Fig. 1: Climatic variabilities at Parbhani during 2017-2018.

Before sowing of experiment the soil samples from each replication were drawn from 0-30 cm soil depth from experimental area and finally one representative sample was prepared for finding out physical and chemical properties of soil.

Table 2: Physical and chemical properties of soil of experimental field.

Sr. No.	Particulars	Content	Method adopted
A	**Mechanical composition**		
1	Coarse sand (%)	6.60	International pipette method (Piper, 1966)
2	Fine sand (%)	15.65	
3	Silt (%)	24.35	
4	Clay (%)	53.60	
B	**Chemical composition**		
1	Organic carbon (%)	0.58	Walkely and Black method (Jackson, 1967)
2	Available nitrogen (kg ha^{-1})	186.50	Alkaline permagnate method (Subbiah and Asija,1956)
3	Available phosphorus (kg ha^{-1})	12.90	Olsens method (Olsen *et al*., 1954)
4	Available potassium (kg ha^{-1})	518.70	Flame photometer method (Piper, 1966)
6	Soil PH	7.8	1:2 soil water suspension by glass electrode pH meter (Jackson, 1967)
7	Electrical conductivity (mm hos cm^{-3} at 25^0C)	0.256	Electrical conductivity bridge (Jackson, 1967)

3.1.4 Seed source

The seed of soybean variety JS-9560 (V_1), MAUS-612 (V_2), MAUS-162 (V_3) and MAUS-71 (V_4) were obtained from the AICRP on Soybean, Vasantrao Naik Marathwada Krishi Vidyapeeth Agricultural University, Parbhani .

3.1.5 Previous crop history

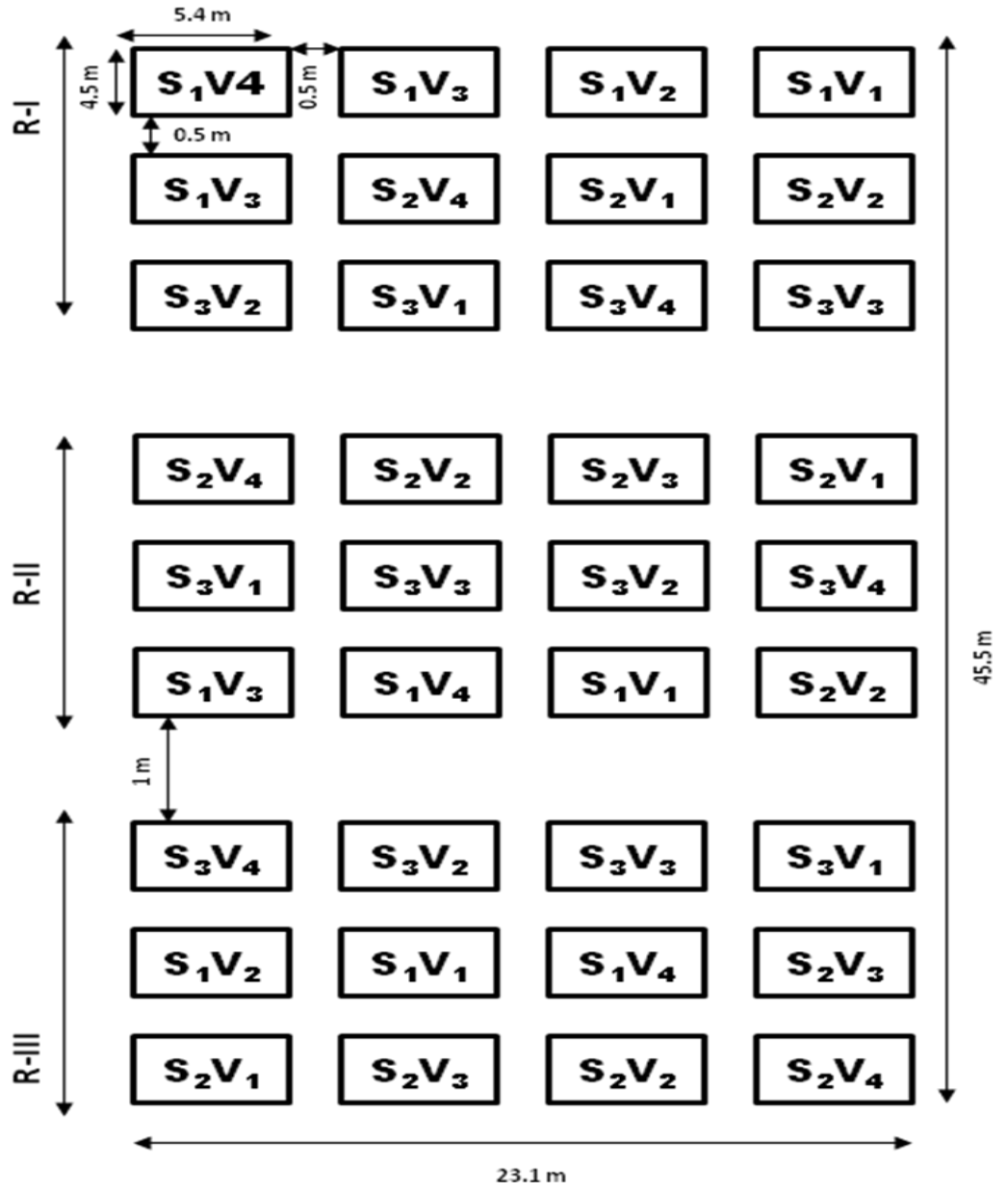
The cropping pattern followed in the experimental plot during preceding four years and present experiment is shown in Table 3.

Table 3: Previous Cropping history of the experimental plot.

Sr. No.	Year	Season		
		Kharif	***Rabi***	**Summer**
1.	2014-2015	Cotton	Soybean	Groundnut
2.	2015-2016	Red gram	Fallow	Fallow
3.	2016-2017	Niger	Fallow	Fallow
4.	2017-2018	Fallow	Present Experiment	-

3.2 Experimental details

The present experiment entitled “Performance of soybean (*glycine max* L.) varieties in post monsoon under varied weather conditions” was laid out in split plot design with three replications. The gross plot size was 5.4 m x 4.5 m and net plot size was 4.5 m x 4.2 m. The main plot consist of three dates of sowing i.e. S_1 (MW 38) 22th September, S_2 (MW 39) 29th September, S_3 (MW 40) 06th October and the sub plot was comprised of four varieties i.e. JS-9560(V_1), MAUS-612(V_2), MAUS-162(V_3) and MAUS-71(V_4). The twelve treatments combinations of three dates and four varieties were randomly allotted in each replication.



Design	: Split plot design
Replications	: Three
Treatments	: 12
Plot Size	: Gross: 5.4 m x 4.5 m
	Net : 4.5 m x 4.3 m

Fig. 1. Plan of Layout

3.2.1 Treatment details are as follows

A} Main plots (Sowing Dates)

1. S_1 – MW 38 (17^{th} - 23^{th} September)
2. S_2 – MW 39 (24^{th} – 30^{th} September)
3. S_3 – MW 40 (01^{th} – 07^{th} October)

B} Sub plots (Varieties)

1. V_1 – JS - 9560
2. V_2 – MAUS - 612
3. V_3 – MAUS - 162
4. V_4 – MAUS - 71

3.2.2 Experimental details

Design	: Split plot design
Plot size	: Gross – 5.4 m x 4.5 m
	: Net – 4.5 m x 4.2 m
Replications	: Three (3)
No. treatment combinations	: 12
No. plots	: 36
Crop	: Soybean
Season	: *Post monsoon* 2017
Method of sowing	: Dibbling
Spacing	: 45 cm x 5 cm

3.3 Cultural practices

3.3.1 Land preparation

The land is brought to the fine tilth with one deep ploughing and two harrowing. The residues of the previous crop and weeds were removed from the experimental area. The land was leveled with plank. The schedule of

Plate 1: General view of Experimental plot of soybean at emergence

Plate 2: General view of Experimental plot of soybean 30 DAS

Plate 3: General view of Experimental plot of soybean at maturity

Plate 4 : View of treatment combination S_1V_1

Plate 5 : View of treatment combination S_1V_2

important cultural operations carried out in the field of experiment during the post monsoon season 2017 is given in Table 4.

3.3.2 Manures and fertilizer application

Recommended dose of fertilizer incorporated at the time of sowing of the crop. Recommended fertilizer dose of 30 kg N, 60 kg P_2O_5 and 30 kg K_2O per hectare was applied in the form of urea, diammonium phosphate and muriate of potash, respectively.

3.3. 3 Seeds and sowing

Seeds of soybean were obtained from the AICRP on Soybean, V.N.M.K.V, Parbhani. The seeds were treated with *Rhizobium japonicum* @ 3g kg^{-1} of seed each. Seeds were sown by dibbling method with the spacing of 5 cm between seeds and 45 cm between rows. Soybean crop was sown on different dates S_1 (38 MW), S_2 (MW 39) and S_3 (MW 40).

The emergence of seed was started from 7 days after sowing and completed by 15 days.

3.3. 4 Intercultural operations

One hoeing and two hand weeding were done at 20 and 30 days after sowing to control weeds in experimental fields.

3.3.5 Harvesting and threshing

The crop was harvested treatment wise at physiological maturity based on visual observations (yellowing of pods and leaves). The harvested plants from each plot were sun dried separately and threshed manually by beating with wooden stick. The seeds were cleaned and sun dried to moisture content of approximately 8 %. Seed, straw and biological yields were recorded separately for each net plot.

Table 4: Schedule of cultural operations which was done in the experimental plot.

Sr. No.	Particulars	Frequency	Dates
A)	**Pre sowing operations**		
1	Ploughing	1	29-08-2017
2	Harrowing (Cris cross)	2	05-09-2017 and 10-09-2017
3	Layout of Experiment	1	21-09-2017
B)	**Sowing**	3	22-09-2017 29-09-2017 06-10-2017
C)	**Fertilizer application**		
1.	NPK	1	At respective sowing dates
D)	**Post sowing operations**		
1.	Gap filling	3	03-10-2017 09-10-2017 14-10-2017
2.	Thinning	1	10-10-2017
3.	Weeding	3	09-10-2017 01-11-2017 12-11-2017
4.	Spraying of insecticide	1	02-12-2017
5.	Hoeing	1	24-08-2017
E)	**Irrigation**	3	20-10-2017 28-10-2017 04-11-2017
H)	**Harvesting**	4	13-12-2017 22-12-2017 27-12-2017 05-01- 2017
G)	**Threshing**	2	20-01-2017 09-01-2017

3.4 Collection of Experimental Data or Biometric observations

Data on important biometric observations were collected on fixed five randomly selected plants in each plot throughout the crop life.

3.4.1 Pre-harvest studies

3.4.1.1 Emergence count

Emergence count was taken on 10 and 21 days after sowing and final plant stand from each net plot was recorded.

The field emergence was calculated by following formula:

$$\text{Emergence (\%)} = \frac{\text{Number of seedling emerged at } 10^{th} \text{ and } 21^{st} \text{ days}}{\text{Total number of seeds sown}} \times 100$$

3.4.1.2 Final plant stand

The number of plants net^{-1} plot were recorded one day before harvesting.

3.4.1.3 Plant height (cm)

The plant height on five randomly selected and tagged plants were measured from the base of the plant to the tip of the shoot apex (growing point) at15, 30, 45, 60, 75 DAS and at harvest. The average height of five plants was worked out and expressed in centimeters (cm).

3.4.1.4 Number of branches plant^{-1}

The number of branches arising on the main stem in the five randomly selected and tagged plants were recorded at 15 days interval from 15 DAS. The mean number of branches plant^{-1} was worked out and expressed in number plant^{-1}.

3.4.1.5 Number of leaves plant^{-1}

Progressive number of functional leaves and fully opened green leaves present in each of the five randomly selected and tagged plants were counted at 15 days interval from 15 DAS. The mean number of leaves plant^{-1} was worked out and expressed in number plant^{-1}.

3.4.1.6 Leaf area plant^{-1} (dm^2)

Leaf area was calculated by using the plant samples taken for the dry matter studies from each net plot. The leaves were aerated into leaflets and grouped into three groups *viz*., small, medium and large. The maximum length and breadth of five leaflets from each group was measured and the mean leaf area per plant worked out by following formula.

$$A = \sum_{i=0}^{n=3} (LXB)K$$

Where,

A : Leaf area in cm2 under particular group.

L : Length of leaflet in cm

B : Maximum breadth of leaflet in cm.

K : Leaf area constant for soybean (K = 0.6889, Pawar, 1978).

N : Number of leaflets under a particular group

∑ : Summation

n : Number of leaflets in trifoliate leaves `

3.4.1.7 Number of pods plant^{-1}

The number of pods arising from branches of each five selected plants was counted after 45 days till harvesting and expressed in number of pods plant^{-1}.

3.4.1.8 Total dry matter accumulation plant^{-1} (g)

Five representative plants from each net plot was selected randomly and uprooted at every growth stage i.e. 15, 30, 45, 60, 75, DAS and five tagged plants at harvest for dry matter studies. Roots were discarded for dry matter studies. Plants were air dried in hot air oven at 65^{0}C until their constant weight was obtained.

3.4.2 Plant growth analysis

The data on growth characters *viz*. LAI, AGR for height and AGR for dry matter and RGR plant^{-1} were further analyzed for the growth function. Data on these growth functions were not statistically analyzed. Inferences were drawn on mean value.

3.4.2.1 Leaf area index

Leaf area index was worked out by dividing the leaf area plant^{-1} by land area occupied by that plant (Watson, 1952).

$$LAI = \frac{\text{Leaf area plant}^{-1}\ (\text{cm}^2)}{\text{Land area occupied by the plant}\ (\text{cm}^2)}$$

3.4.2.2 Absolute Growth Rate (AGR)

AGR of growth variable *viz*. plant height and total dry matter per plant were worked out by formula (Hunt, 1980) and expressed as cm day^{-1} and g day^{-1}, respectively.

$$\text{AGR for plant height} = \frac{h_2 - h_1}{t_2 - t_1}\ (\text{cm day}^{-1})$$

$$\text{AGR for dry matter} = \frac{w_2 - w_1}{t_2 - t_1}\ (\text{g day}^{-1})$$

Where,

H_1, H_2 and W_1, W_2 refers to the plant height (cm) and dry matter weight (g) at the time t_1 and t_2, respectively.

Absolute growth rate is the total gain in height and weight by plant within a stipulated time interval.

3.4.2.3 Relative Growth rate (RGR)

The relative growth at which a plant adds new material into its substance is measured by relative growth rate (RGR) of height.

Blackman (1919) pointed out that increase in the height of the plant is continuous process of compound interest where the increment at any interval adds to the capital for subsequent growth. The rate of increment was called as relative growth rate. It was computed by using following formula and expressed in cm day^{-1} $plant^{-1}$.

$$RGR = \frac{\log_e w_2 - \log_e w_1}{t_2 - t_1} \quad (g\ g^{-1}\ day^{-1})$$

Where,

W_1 = Dry matter weight (g) at time t_1

W_2 = Dry matter weight (g) at time t_2

t_1 = Initial time of observation

t_2 = Final time of observation

Log_e = Natural logarithms (logarithms to the base of 2.3026)

RGR = Increase in plant height in g g^{-1} day^{-1} $plant^{-1}$.

3.4.3 Post harvest studies

3.4.3.1 Number of pods $plant^{-1}$

The number of pods harvested from five randomly selected and tagged plants in each treatment was counted and average was worked out and expressed as number of pods $plant^{-1}$.

The schedule of biometric observations and post harvest observations recorded plot wise in experimental field is presented in Table 5.

Table 5: Schedule of biometric observations and post harvest observations recorded plot wise in experimental field.

Sr. No.	Name of the observation	Frequency	DAS	No. of plants to be observed
A	**Pre –harvest studies**			
1	Emergence count	1	15	All plants
2	Height of plant (cm)	5	30, 45, 60, 75 & at harvest	Five plants/Net plot
3	No. of functional leaves/plant	5	30, 45, 60, 75 & at harvest	Five plants/Net plot
4	No. of branches/plant	5	30, 45, 60, 75 & at harvest	Five plants/Net plot
5	No. of pods/plant	4	45, 60, 75 & at harvest	Five plants/Net plot
6	Leaf area(dm^2)/plant	5	30, 45, 60, 75 & at harvest	Five plants/Net plot
7	Leaf area index(LAI)/plant	4	45, 60, 75 & at harvest	Five plants/Net plot
8	Dry matter weight of leaves/plant(g)	4	45, 60, 75 & at harvest	Five plants/Net plot
9	Dry matter weight of stem/plant(g)	5	30, 45, 60, 75& at harvest	Five plants/Net plot
10	Dry matter weight of pods/plant(g)	3	60, 75 & at harvest	Five plants/Net plot
11	Total dry matter/plant(g)	5	30, 45, 60, 75 & at harvest	Five plants/Net plot
12	Final plant stand	1	At harvest	Five plants/Net plot
B	**Post harvest studies**			
1	No. of developed pods/plant	1	At harvest	Five plants/Net plot
2	Pod weight/plant	1	At harvest	Five plants/Net plot

3	No. of seed/pod	1	At harvest	Five plants/Net plot
4	Seed weight/plant (g)	1	At harvest	Five plants/Net plot
5	No of seeds/plant	1	At harvest	Five plants/Net plot
6	Biological yield/plot(kg)	1	At harvest	All plants
7	Pod weight/plot(kg)	1	At harvest	All plants
C	**Seed quality aspects**			
1	Seed germination	1	At harvest	100 seeds/plot
2	Test weight	1	At harvest	1000 seeds/plot
3	Protein content	1	At harvest	100 (g)/plot

3.4.3.2 Pods weight plant^{-1}(g)

The weight of pods from five randomly selected and tagged plants in each treatment was taken after threshing and expressed as pods weight plant^{-1} in grams.

3.4.3.3 Number of seeds pod^{-1}

The number of seeds from the pods of five randomly selected and tagged plants in each treatment was counted and the average was worked out and expressed as number of seeds pod^{-1}.

3.4.3.4 Number of seeds plant^{-1}

The number of seeds from five randomly selected and tagged plants in each treatment was counted and the average was worked out and expressed as number of seeds plant^{-1}.

3.4.3.5 Test weight (1000 seed weight) g

Thousands seeds from each treatment were counted manually and recorded. The average thousands seeds weight was recorded in grams.

3.4.3.6 Seed weight plant^{-1} (g)

The matured pods harvested from five randomly selected and tagged plants in each treatment were sun dried and the seeds were separated. The average yield of seeds was worked out and expressed as seed yield plant^{-1} in grams.

3.4.3.7 Biological yield (kg ha^{-1})

The weight of whole dried produce harvested from net plot, before threshing was recorded as a biological yield and multiplied with hectare factor and expressed as biological yield hectare^{-1}.

3.4.3.8 Seed yield (kg ha^{-1})

After separation of straw from the biological yield, remaining material (seeds) was considered as a seed yield and its final weight was recorded and multiplied with hectare factor and expressed as seed yield hectare^{-1}.

3.4.3.9 Straw yield (kg ha^{-1})

After separation of seeds from the biological yield, remaining material was considered as a straw yield and its final weight was recorded and multiplied with hectare factor and expressed as straw yield hectare^{-1}.

3.4.3.10 Harvest index (%)

It is the per cent ratio of the economic yield to the total biological yield. Harvest index reflects the proportion of assimilate distribution between economic and total biomass. It is computed by the following formula.

$$\text{Harvest index} = \frac{\text{Economic yield (kg)}}{\text{Biological yield (kg)}} \times 100$$

3.5 Economics

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

The gross monetary returns (Rs.ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product, by product and crop residues during the experimental year.

$$GMR\ (ha^{-1}) = \text{Total output of crop} \times \text{Price of unit output}$$

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

The cost of cultivation (Rs.ha^{-1}) of each treatment was worked out by considering the price of inputs, charges for cultivation, labour, land and other charges.

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

The net monetary returns (Rs.ha^{-1}) of each treatment were worked out by deducting the mean cost of cultivation (Rs.ha^{-1}) of each treatment from the gross monetary returns (Rs.ha^{-1}) gained from the respective treatments.

$$NMR = GMR - \text{Cost of cultivation}$$

3.5.4 Benefit : cost ratio

The benefit: cost ratio of each treatment was calculated by dividing the gross monetary returns by the mean cost of cultivation.

$$B{:}C = \frac{\text{Gross monetory returns}}{\text{Total cost of cultivation}}$$

3.6 Seed quality parameters

3.6.1 Protein content (%)

Seed samples from each treatment were ground into fine powder. The 0.2 g ground seed material was taken for estimation of nitrogen by the Micro Kjeldhal's method. The total protein in the sample was calculated by multiplying nitrogen content in the seed with conversion factor 6.25 and then expressed in percentage.

3.6.2 Oil content (%)

The 60 g clean seeds samples of soybean was taken treatment wise from all replications and oil content was estimated by using Nuclear Magnetic Resonance (NMR) method at All India Coordinated Research Project on Safflower (AICRP on safflower),V.N.M.K., Parbhani.

3.6.3 Germination (%)

Germination test was conducted in three replications of 100 seeds each by adopting between paper method as described by ISTA rules (Anonymous, 1999). The temperature of 25 ± 1°C and RH of 95 per cent was maintained during the germination test. The first and final germination counts were recorded on fifth and eighth day of germination test respectively for normal seedlings and germination was expressed in percentage.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

3.7 Statistical Analysis

The experimental data was analyzed by Fisher's method of analysis of variance (Panse and Sukhatme, 1978). Critical differences were calculated at probability of 5 % wherever F value was significant.

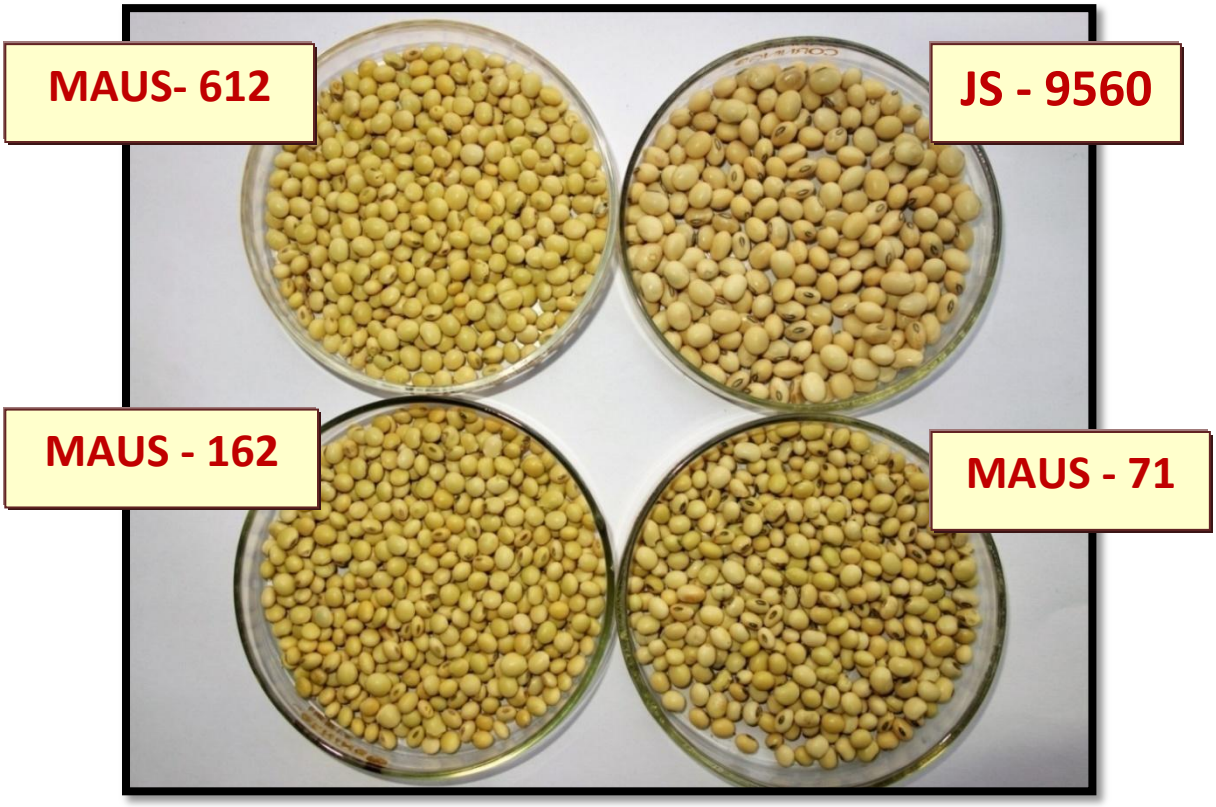


Plate 6: View of seeds of different varieties

Table 6: Distinguishing characters of four soybean genotypes under study.

Sr. No.	Characters	Soybean varieties			
		JS-9560	**MAUS-612**	**MAUS - 162**	**MAUS - 71**
1.	Type/ Class	Determinate	Semi determinate	Semi determinate	Semi determinate
3.	Flower colour	Violet	Purple	Purple	Purple
4	Days to start flowering	35-40	35-40	40-45	35-40
5.	Marurity (days)	80-85	100-105	100-110	93-100
6	Seed colour	Yellow	Yellow	Yellow	Yellow
7.	Halum colour	Grey	Brown	Black	Black
8.	Days to start shattering after maturity	6-7	10-12	12-15	10-12
9.	Yield potential (q/ha)	20-25	30-35	25- 30	25-30

Experimental Findings

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EXPERIMENTAL FINDINGS

The important findings in the form of summarized data on growth, yield attributes, yield statistical parameters and critically interpreted results of the present investigation are presented in this chapter under appropriate heads.

4.1 Mean emergence count and final plant stand (%)

The data on emergence count was recorded at 15 days after sowing, whereas final plant stand was recorded at the time of harvest in each net plot were counted and converted into per cent and arcsine and data obtained is furnished in Table 7.

Table 7: Emergence count and final plant stand (Arcsine and per cent values) as influenced by different treatments

Treatment	Emergence count	Final plant stand
Dates of sowing		
S_1 - MW 38	67.21 (84.99)	63.98 (80.76)
S_2 - MW 39	63.83 (80.55)	62.91 79.26)
S_3 - MW 40	63.11 (79.54)	61.18 76.76)
S.E. m ±	1.61	1.90
C.D. at 5 %	NS	NS
Varieties		
V_1 – JS – 9560	66.25 (83.78)	62.26 (78.33)
V_2 – MAUS-612	63.50 (80.09)	62.28 (78.36)
V_3 – MAUS-162	65.11 (82.28)	62.73 (79.00)
V_4 – MAUS-71	63.87 (80.61)	63.43 (80.00)
S.E. m ±	1.58	1.41
C.D. at 5%	NS	NS
Interaction (SXV)		
S.E. m ±	2.74	2.44
C.D. at 5 %	NS	NS
General mean	**64.67 (81.69)**	**62.67 (78.92)**

***** Figures in parenthis are arcsine value.

The data presented in Table 7 indicated that the emergence count was not influenced significantly by different dates of sowing and varieties and their interaction. Similarly, final plant stand at harvest was apparently uniform indicating that the variations obtained in the different parameters under study were the real effect of treatments.

4.1 Growth attributes

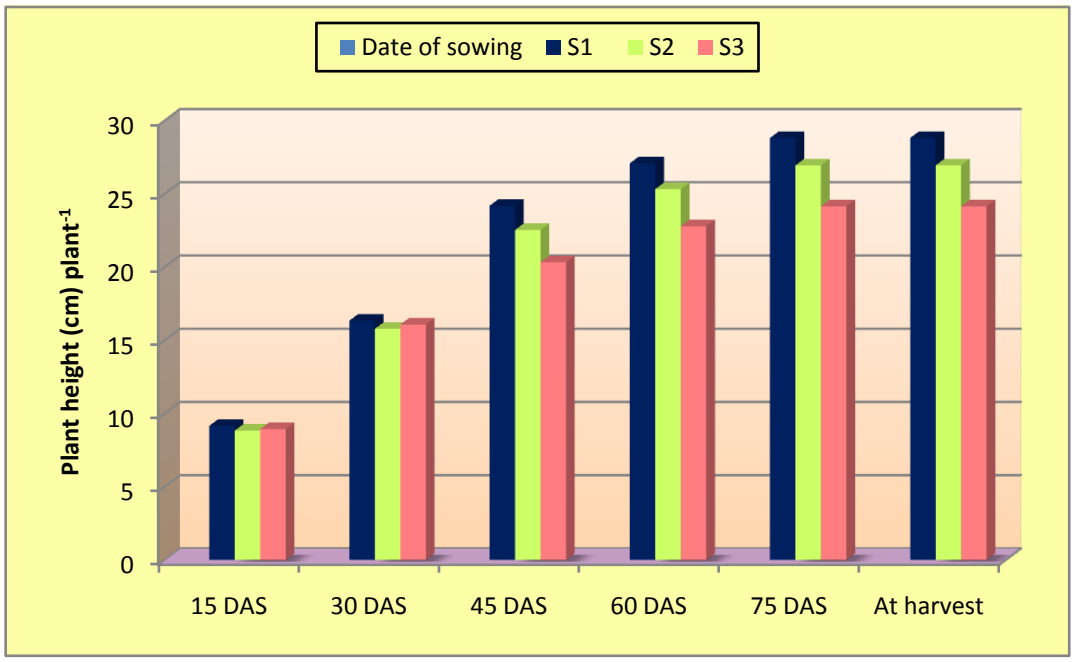
4.2.1 Plant height (cm)

The mean plant height plant^{-1} (cm) as influenced by different varieties and dates of sowing at various stages of crop growth are presented in Table 8 and graphically depicted in fig.3 .

The data presented in Table 8 indicated that the mean plant height plant^{-1} (cm) of soybean was increased continuously from emergence to the harvest of crop. The increase in plant height was rapid up to 45 days and later on the rate of increase in plant height was increased with decreasing rate.

Table 8: Mean plant height (cm) as influenced periodically by different treatments of soybean

Treatment	Days after sowing					
	15	30	45	60	75	At harvest
Date of sowing						
S_1 –MW 38	9.15	16.34	24.18	27.08	28.81	28.81
S_2 –MW 39	8.83	15.78	22.53	25.32	26.94	26.94
S_3 –MW 40	8.93	16.07	20.33	22.78	24.14	24.14
SE ±	0.26	0.33	0.51	0.63	0.67	0.67
CD at 5 %	NS	NS	2.00	2.48	2.64	2.64
Varieties						
V_1 – JS-9560	8.77	15.86	20.02	21.85	23.12	23.12
V_2 – MAUS-612	9.51	16.57	23.84	27.63	29.40	29.40
V_3 – MAUS-162	9.43	16.61	24.73	29.63	31.52	31.52
V_4 – MAUS-71	8.16	15.21	20.53	21.14	22.49	22.49
SE ±	0.39	0.40	0.52	0.50	0.56	0.56
C.D. at 5 %	NS	NS	1.55	1.48	1.65	1.65
Interaction(SxV)						
SE ±	0.68	0.69	0.90	0.86	0.96	0.96
C.D. at 5 %	NS	NS	NS	2.57	2.86	2.86
General mean	**8.97**	**16.06**	**22.28**	**25.06**	**26.63**	**26.63**



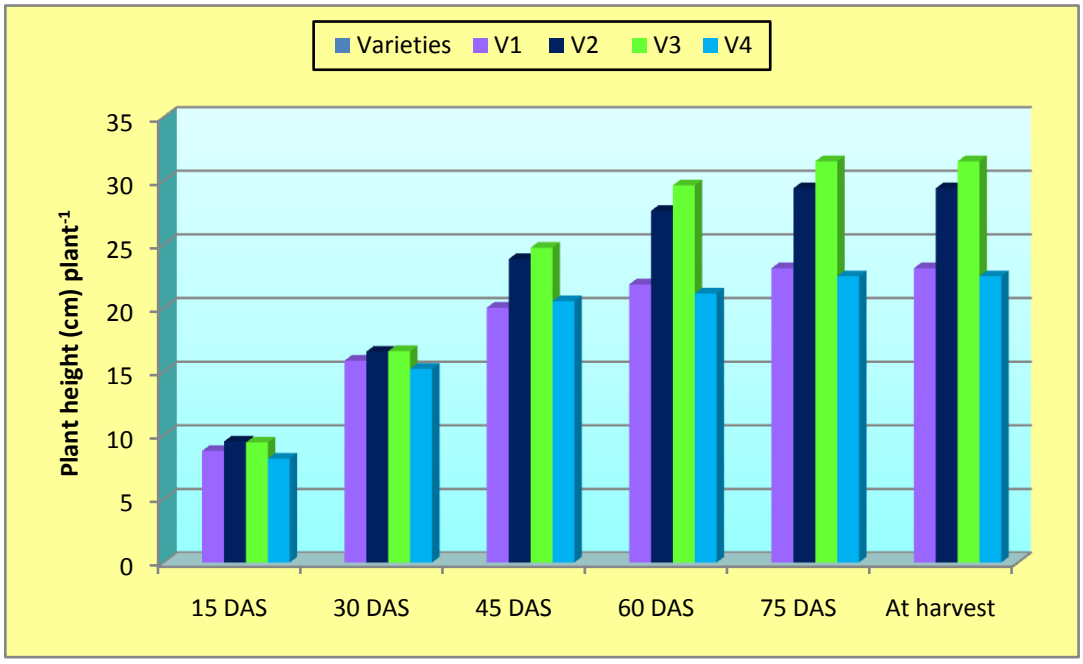


Fig. 3: Mean plant height (cm) plant^{-1} of soybean as influenced periodically by dates of sowing and varieties

4.2.1.1 Date of sowing

The data presented in Table 8 revealed that the mean plant height (cm) was influenced significantly by different dates of sowing except at 15 and 30 DAS. The soybean crop sown on S_1 (MW 38) recorded significantly heigher plant height than the rest of the sowing dates at 45, 60, 75 and harvest of crop.

4.2.1.2 Varieties

The data presented in Table 8 showed that the mean plant height (cm) was significantly influenced by varieties at all the stages of crop growth except at 15 and 30 DAS. The variety V_3 (MAUS-162) recorded maximum plant height than rest of the varieties which was significantly superior over V_1 (JS-9560), V_2 (MAUS-612) and V_4 (MAUS-71) at 45, 60, 75 DAS and at harvest of crop.

4.2.1.3 Interaction effect

The interaction effect between dates of sowing and varieties was found significant in respect of plant height at 60, 75 DAS and at harvest presented in Table 8 (a) and Table 8 (b) respectively.

When variety V_3 (MAUS-162) sown during MW 38 (S_1) recorded significantly taller plants of soybean over rest of the treatment combinations at 60, 75 DAS and at harvest.

Table 8 (a) Interaction effect between dates of sowing and varieties on plant height (cm) of soybean at 60 DAS

Varieties / Date of sowing	V_1 JS-9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	22.82	30.41	32.83	22.27
S_2 - MW 39	21.76	28.83	29.94	20.75
S_3 - MW 40	20.95	23.64	26.11	20.38
S.E. m ±	0.86			
C.D. at 5 %	2.57			

Table 8 (b) Interaction effect between dates of sowing and varieties on plant height (cm) of soybean at 75 DAS and at harvest

Varieties / Date of sowing	V_1 JS-9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	24.28	32.35	34.93	23.70
S_2 - MW 39	23.16	30.67	31.86	22.08
S_3 - MW 40	21.93	25.17	27.78	21.68
S.E. m ±	0.96			
C.D. at 5 %	2.86			

4.2.2 Mean number of functional leaves plant^{-1}

The data on mean number of functional leaves plant^{-1} recorded at various stages of crop growth is presented in Table 9 and graphically shown in Fig. 4. The mean number of functional leaves plant^{-1} was increased up to the 60 DAS; thereafter, it was decreased due to leaf senescence. The mean numbers of functional leaves plant-1 of soybean at 15, 30, 45, 60, 75, DAS and at harvest were 2.06, 4.46, 7.89, 10.65 and 6.21, respectively.

4.2.2.1 Date of sowing

The data presented in Table 8 showed that the mean number functional leaves plant^{-1} was influenced significantly by different varieties at all stages of crop growth. The functional leaves plant^{-1} were observed significantly more with S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40) at 45, 60 and 75 DAS days of observations.

4.2.2 .2 Varieties

The data presented in Table 9 showed that the mean number functional leaves plant^{-1} was influenced significantly by different varieties at all stages of crop growth except at 15 and 30 DAS. Variety V_2 (MAUS-612) recorded significantly more number of functional leaves over rest of the varieties at 45, 60 and 75 DAS of crop respectively.

Table 9: Mean number of functional leaves plant^{-1} as influenced periodically by different treatments of soybean

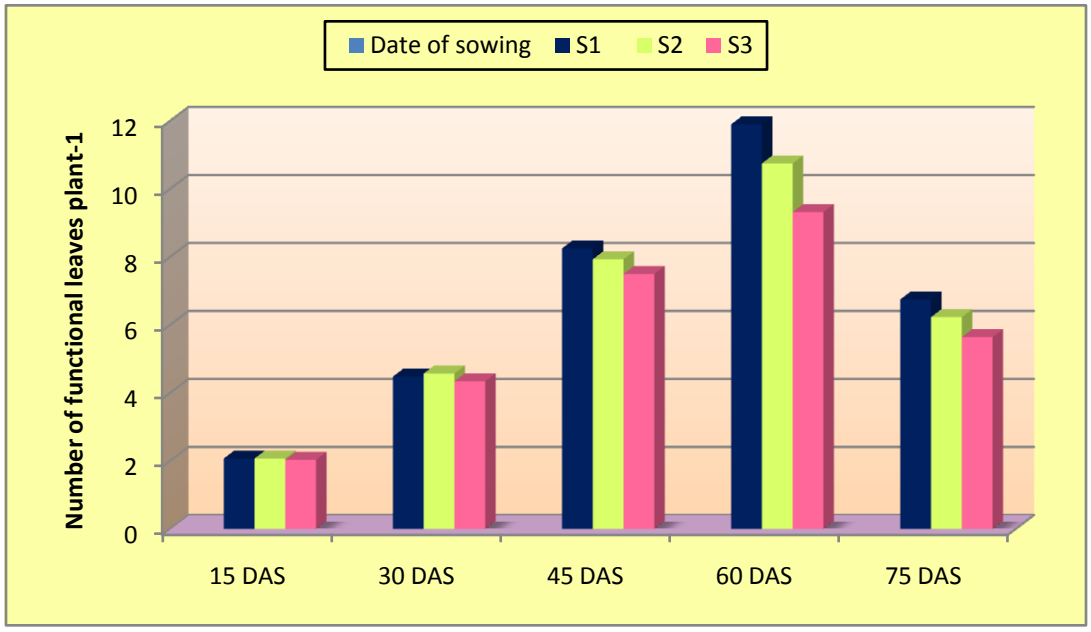
Treatment	Days after sowing				
	15	30	45	60	75
Date of sowing					
S_1 –MW 38	2.07	4.48	8.25	11.90	6.75
S_2 –MW 39	2.07	4.57	7.93	10.75	6.23
S_3 –MW 40	2.03	4.34	7.50	9.32	5.64
SE ±	0.03	0.11	0.13	0.31	0.14
CD at 5 %	NS	NS	0.51	1.20	0.54
Varieties					
V_1 – JS-9560	2.07	4.12	7.26	10.20	5.40
V_2 – MAUS-612	2.10	4.91	9.16	12.29	7.44
V_3 – MAUS-162	2.00	4.38	7.39	9.84	5.96
V_4 – MAUS-71	2.06	4.44	7.78	10.29	6.02
SE ±	0.04	0.19	0.20	0.28	0.20
C.D. at 5 %	NS	NS	0.58	0.83	0.59
Interaction (SxV)					
SE ±	0.06	0.33	0.34	0.49	0.34
C.D. at 5 %	NS	NS	NS	1.44	NS
General mean	**2.06**	**4.46**	**7.89**	**10.65**	**6.21**

4.2.3.3 Interaction effect

The interaction effects between dates of sowing and varieties were found significant in respect of number of functional leaves at 60 DAS of crop growth are presented in Table 9 (a).

Table 9 (a) Interaction effects between dates of sowing and varieties on number of functional leaves plant^{-1} of soybean at 60 DAS.

Varieties / Date of sowing	V_1 JS-9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	11.00	13.83	11.23	11.54
S_2 - MW 39	10.33	13.37	9.22	10.07
S_3 - MW 40	9.27	9.67	9.07	9.27
S.E. m ±	0.49			
C.D. at 5 %	1.44			



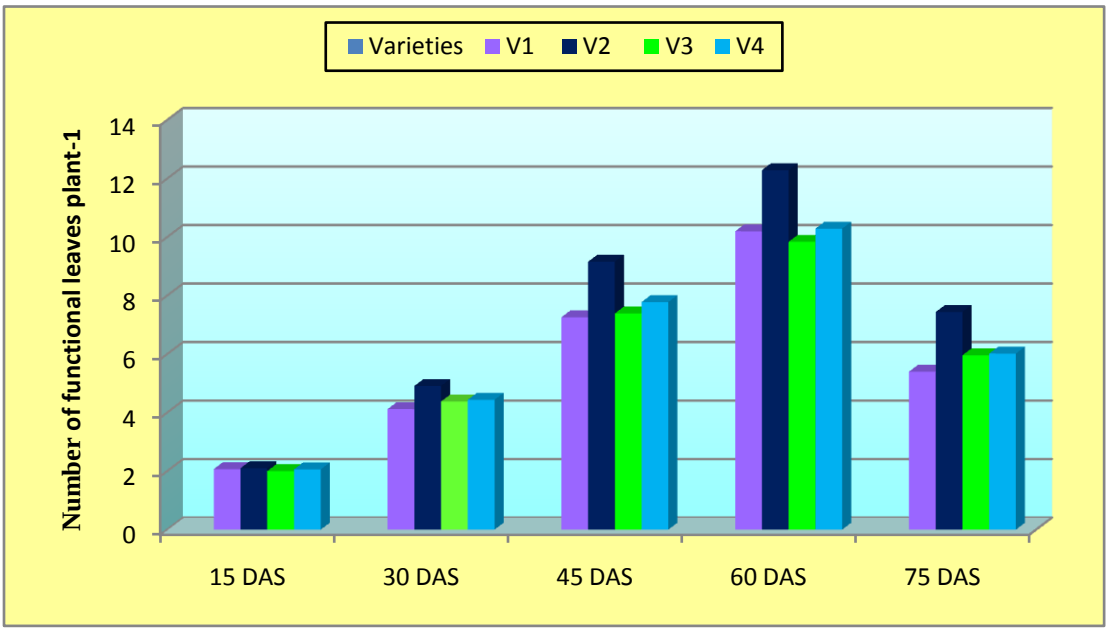


Fig. 4: Mean number of functional leaves of soybean as influenced periodically by different dates of sowing and varieties

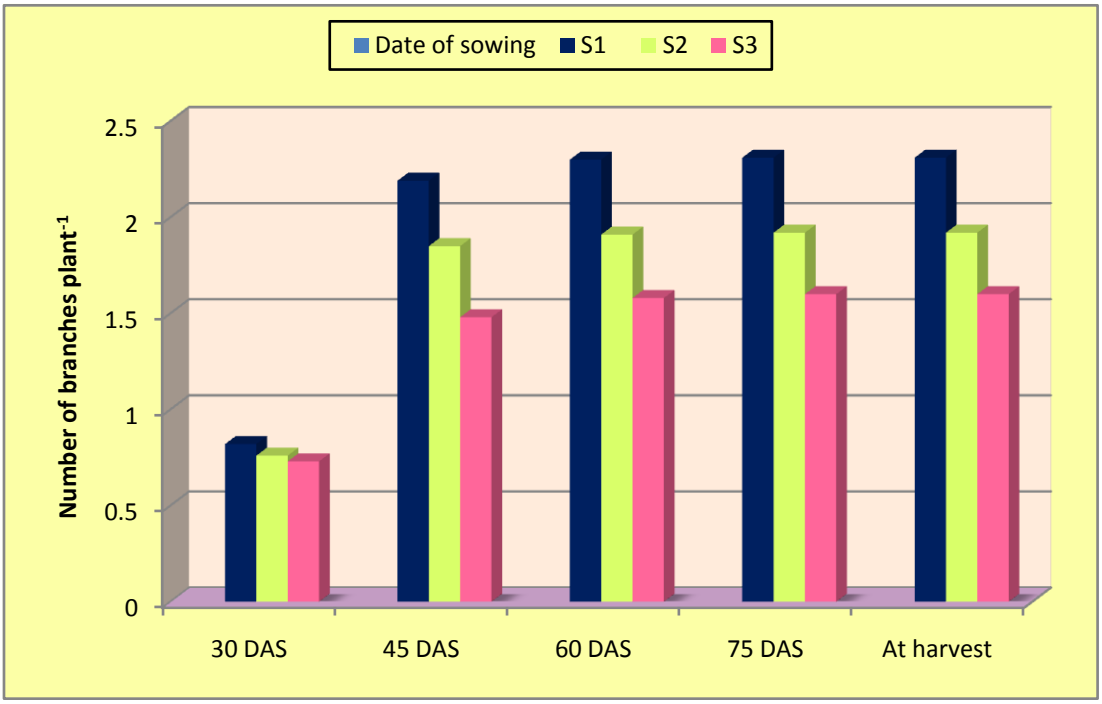
Interaction effects between date of sowing of S_1 (MW 38) with variety V_2 (MAUS-612) recorded significantly highest number of functional leaves plant^{-1} of soybean over rest of the treatment combinations at 60 DAS.

4.2.3 Mean number of branches plant^{-1}

The data on mean number of branches plant^{-1} as influenced by different varieties and dates of sowing at various stages of crop growth are shown in Table 10 and graphically represented in Fig. 5. It is observed that mean number of branches plant^{-1} was increased continuously up to 75 DAS. The mean number of branches plant^{-1} of soybean at 30, 45, 60 and 75 DAS were 0.77, 1.84, 1.93, 1.94 and 1.94 respectively.

Table 10: Mean number of branches plant^{-1} as influenced periodically by different treatments of soybean

Treatment	Days after sowing				
	30	45	60	75	At harvest
Date of sowing					
S_1 –MW 38	0.82	2.19	2.30	2.31	2.31
S_2 –MW 39	0.76	1.85	1.91	1.92	1.92
S_3 –MW 40	0.73	1.48	1.58	1.60	1.60
SE $\pm$	0.02	0.06	0.04	0.06	0.06
CD at 5 %	NS	0.25	0.16	0.23	0.23
Varieties					
V_1 – JS-9560	0.60	1.09	1.13	1.15	1.15
V_2 – MAUS-612	0.95	2.79	3.08	3.11	3.11
V_3 – MAUS-162	0.46	0.83	0.89	0.91	0.91
V_4 – MAUS-71	0.92	2.58	2.63	2.66	2.66
SE $\pm$	0.02	0.07	0.05	0.07	0.07
C.D. at 5 %	0.06	0.21	0.15	0.22	0.22
Interaction(SxV)					
SE $\pm$	0.04	0.13	0.09	0.12	0.12
C.D. at 5 %	NS	NS	NS	NS	NS
General mean	**0.77**	**1.84**	**1.93**	**1.94**	**1.94**



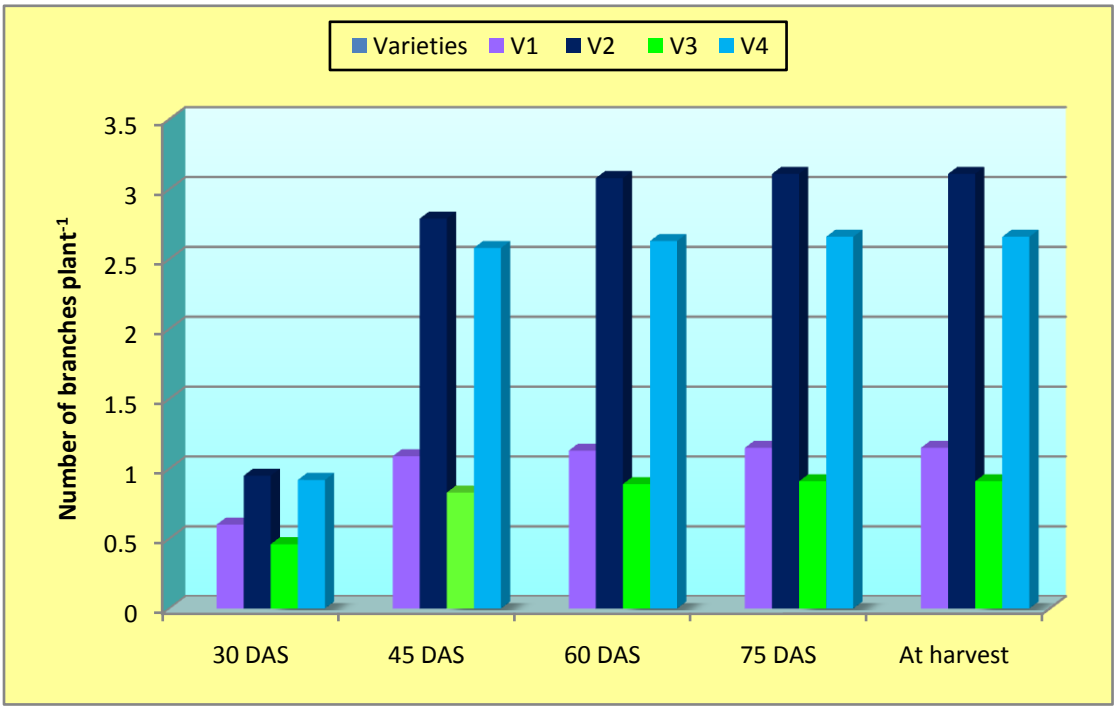


Fig. 5: Mean number of branches plant^{-1} of soybean influenced periodically by dates of sowing and varieties

4.2.3.1 Dates of sowing

The data presented in Table 10 revealed that mean number of branches plant^{-1} were influenced significantly by dates of sowing, at all stages of crop growth. The maximum number of branches was observed in S_1 (MW 38) which was significantly superior over sowing date S_2 (MW 39) and S_3 (MW 40).

4.2.3.2 Varieties

The data presented in Table 10 showed that the mean number of branches plant^{-1} was influenced significantly by different varieties at all stages of crop growth. Significantly more number of branches plant^{-1} were recorded with variety MAUS-612 (V_2) over rest of the varieties at all the stages.

4.2.3.3 Interaction effect

The interaction effect between varieties and dates of sowing was found to be not significant at all growth stages of crop.

4.2.4 Mean leaf area (dm^2)

The data on mean leaf area of soybean recorded at various growth stages of the crop are presented in Table 11 and graphically depicted in Fig. 6.

Leaf area plant^{-1} increased rapidly during 30 to 60 DAS and reached maximum at 60 DAS and decreased thereafter due to leaf senescence. The mean leaf area at 15, 30, 45, 60, and 75 DAS was 0.45, 2.34, 4.14, 5.43 and 3.26 respectively.

4.2.4.1 Dates of sowing

The data presented in Table 11 revealed that the mean leaf area plant^{-1} was influenced significantly by different dates of sowing, at different stages of crop growth. Mean leaf area plant^{-1} was significantly in S_1 (MW 38) and it was significantly superior over S_2 (MW 39) and sowing of S_3 (MW 40) at all days of observation.

4.2.4.2 Varieties

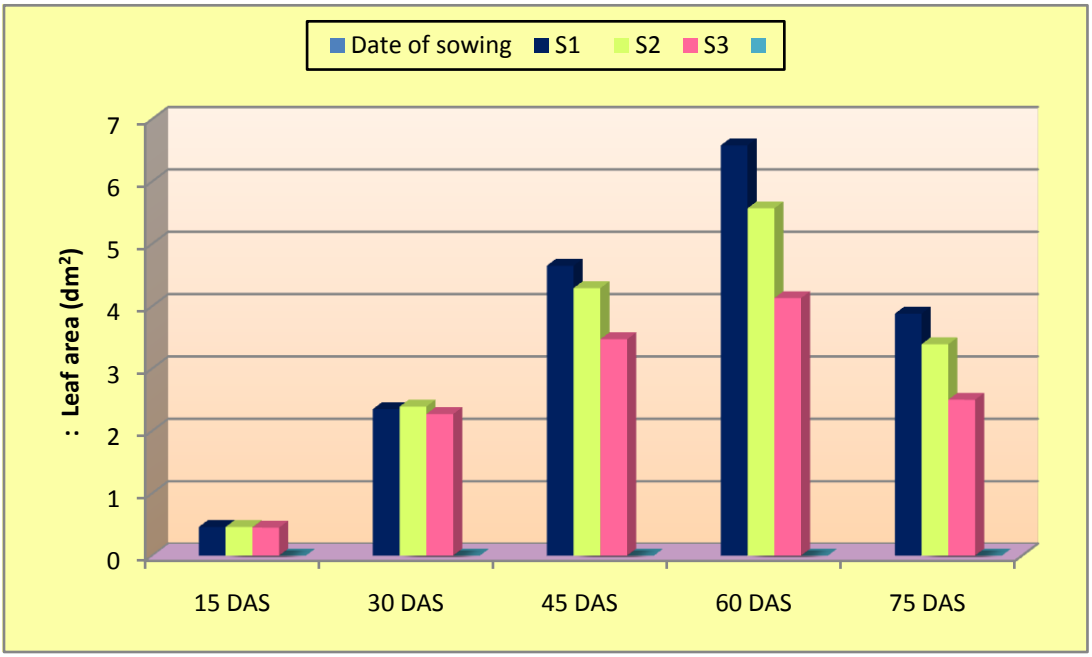
The data presented in Table 11 showed that the mean leaf area plant^{-1} (dm^2) was influenced significantly by different varieties, at all the stages of crop growth. The mean leaf area plant^{-1} was observed significantly superior in variety MAUS-612 (V_2) over rest of the varieties at 45, 60 and 75 DAS and remained at par with V_1 (JS-9560) at 45 DAS.

Table 11: Mean leaf area plant^{-1}(dm^2) as influenced periodically by different treatments of soybean

Treatment	Days after sowing				
	15	30	45	60	75
Date of sowing					
S_1 –MW 38	0.46	2.35	4.65	6.58	3.88
S_2 –MW 39	0.46	2.39	4.29	5.57	3.39
S_3 –MW 40	0.45	2.27	3.47	4.13	2.50
SE ±	0.01	0.06	0.14	0.11	0.07
CD at 5 %	NS	NS	0.57	0.44	0.25
Varieties					
V_1 – JS-9560	0.47	2.47	4.28	5.55	2.93
V_2 – MAUS-612	0.45	2.46	4.58	6.40	3.86
V_3 – MAUS-162	0.44	2.19	3.71	4.51	3.17
V_4 – MAUS-71	0.45	2.22	3.97	5.25	3.06
SE ±	0.01	0.09	0.12	0.12	0.11
C.D. at 5 %	NS	NS	0.35	0.36	0.32
Interaction(SxV)					
SE ±	0.01	0.15	0.20	0.21	0.19
C.D. at 5 %	NS	NS	NS	0.63	NS
General mean	**0.45**	**2.34**	**4.14**	**5.43**	**3.26**

4.2.4.3 Interaction effect

The interaction effects between date of sowing and variety in respect of the leaf area plant^{-1} were found to be significant at 60 DAS and presented in Table 11 (a). The date of sowing S_1 (MW 38) and variety V_2 (MAUS-612) was significantly superior over rest of the treatment combinations.



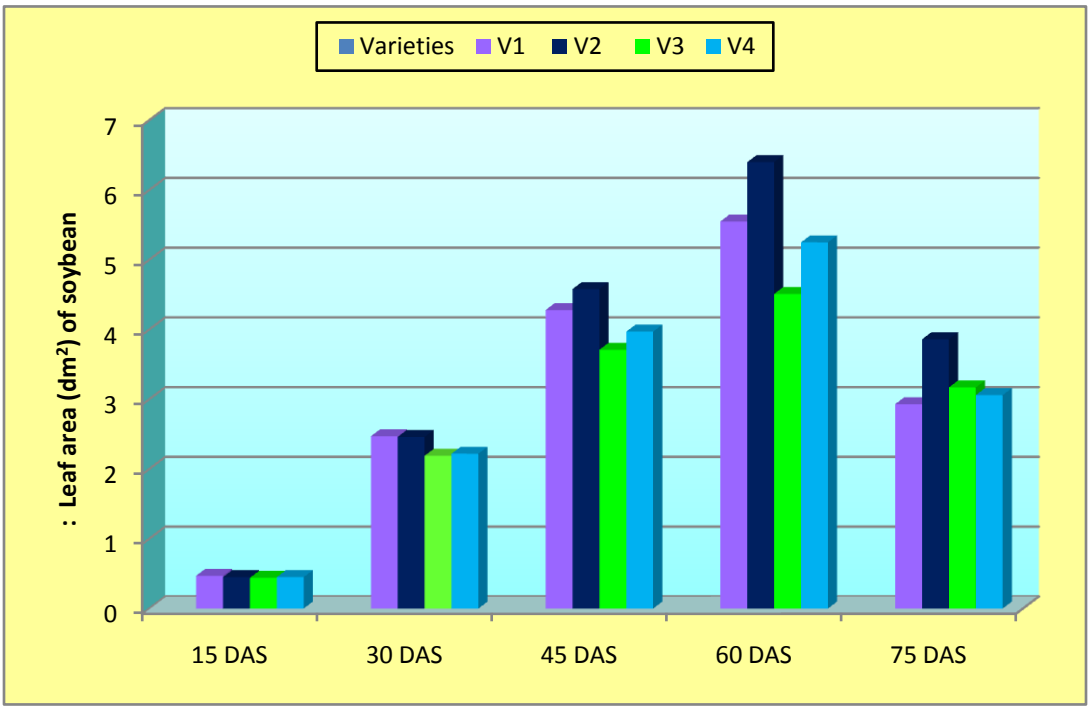


Fig. 6: Leaf area (dm^2) of soybean as influenced periodically by different dates of sowing and varieties

Table 11 (a). Interaction effects between dates of sowing and variety on mean leaf area plant^{-1} (dm^2) of soybean at 60 DAS

Variety / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	6.69	7.74	5.46	6.43
S_2 - MW 39	5.73	7.05	4.39	5.10
S_3 - MW 40	4.22	4.42	3.68	4.22
S.E. m ±	0.21			
C.D. at 5 %	0.63			

4.2.5 Number of pods plant^{-1}

The data on mean number of pods plant^{-1} recorded at various crop growth stages are presented in Table 12. The data revealed that number of pods plant^{-1} influenced significantly by different varieties and dates of sowing. The mean number of pods plant^{-1} at 45, 60, 75 DAS and at harvest were 5.16, 10.74, 14.90 and 14.90, respectively.

4.2.5.1 Dates of sowing

The data presented in Table 12 revealed that the mean number of pods plant^{-1} was influenced significantly by different dates of sowing at all the stages of crop growth. The significantly maximum number of pods plant^{-1} was recorded in S_1 (MW 38) than rest of the sowing dates at all the stages of crop growth.

4.2.5.2 Varieties

The data presented in Table 12 showed that the mean number of pods plant^{-1} was influenced significantly by different varieties at all the stages of crop growth. Variety V_1 (JS-9560) recorded significantly more number of pods plant^{-1} than V_3 (MAUS-162) and V_4 (MAUS-71), whereas, it was at par with V_2 (MAUS-612) at 60, 75 DAS and at harvest.

Table 12: Mean number of pods plant^{-1} as influenced periodically by different treatments of soybean

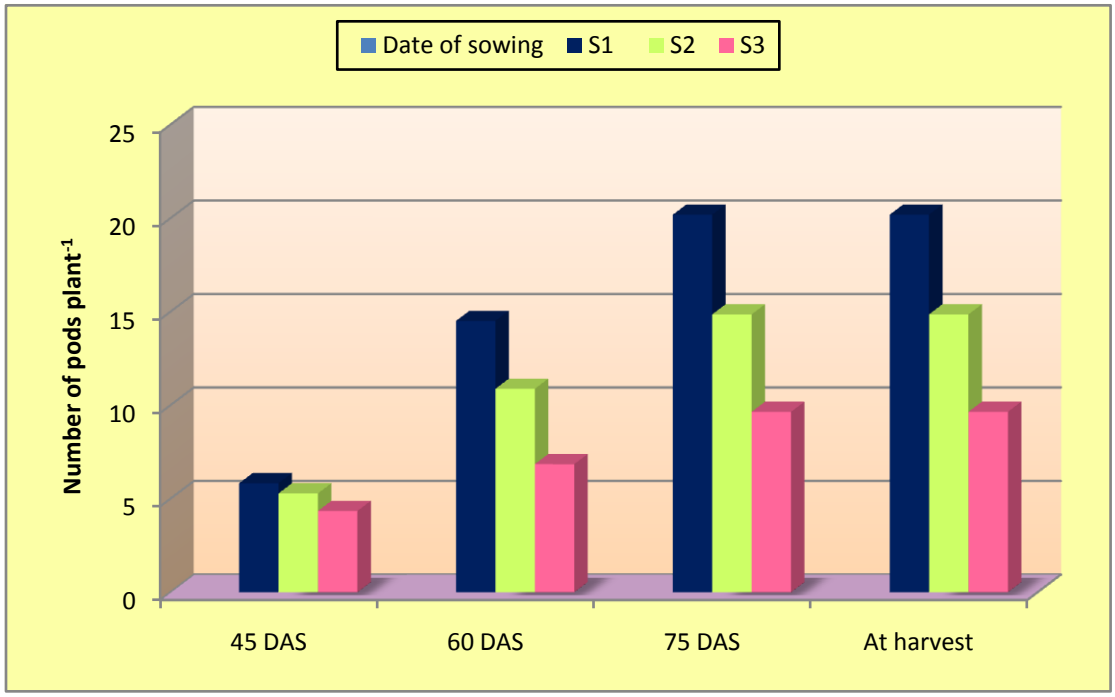
Treatment	Days after sowing			
	45	60	75	At harvest
Date of sowing				
S_1 –MW 38	5.83	14.51	20.19	20.19
S_2 –MW 39	5.29	10.88	14.86	14.86
S_3 –MW 40	4.35	6.85	9.65	9.65
SE ±	0.12	0.46	0.53	0.53
CD at 5 %	0.48	1.79	2.09	2.09
Varieties				
V_1 – JS-9560	5.89	12.84	18.14	18.14
V_2 – MAUS-612	5.08	12.12	17.04	17.04
V_3 – MAUS-162	4.97	9.38	12.84	12.84
V_4 – MAUS-71	4.69	8.64	11.57	11.57
SE ±	0.16	0.39	0.52	0.52
C.D. at 5 %	0.46	1.17	1.54	1.54
Interaction(SxV)				
SE ±	0.27	0.68	0.90	0.90
C.D. at 5 %	NS	2.03	2.67	2.67
General mean	**5.16**	**10.74**	**14.90**	**14.90**

4.2.5.3 Interaction effect

The data presented in Table 12 (a) and (b) revealed that the interaction effects of date of sowing and varieties in respect of the number of pods plant^{-1} were found to be significant at 60, 75 DAS and at harvest.

Table 12 (a) Interaction effects between dates of sowing and varieties on number of pods plant^{-1} of soybean at 60 DAS

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	16.32	15.56	13.01	13.13
S_2 - MW 39	14.24	13.78	8.64	6.85
S_3 - MW 40	7.97	7.00	6.50	5.93
S.E. m ±	0.68			
C.D. at 5 %	2.03			



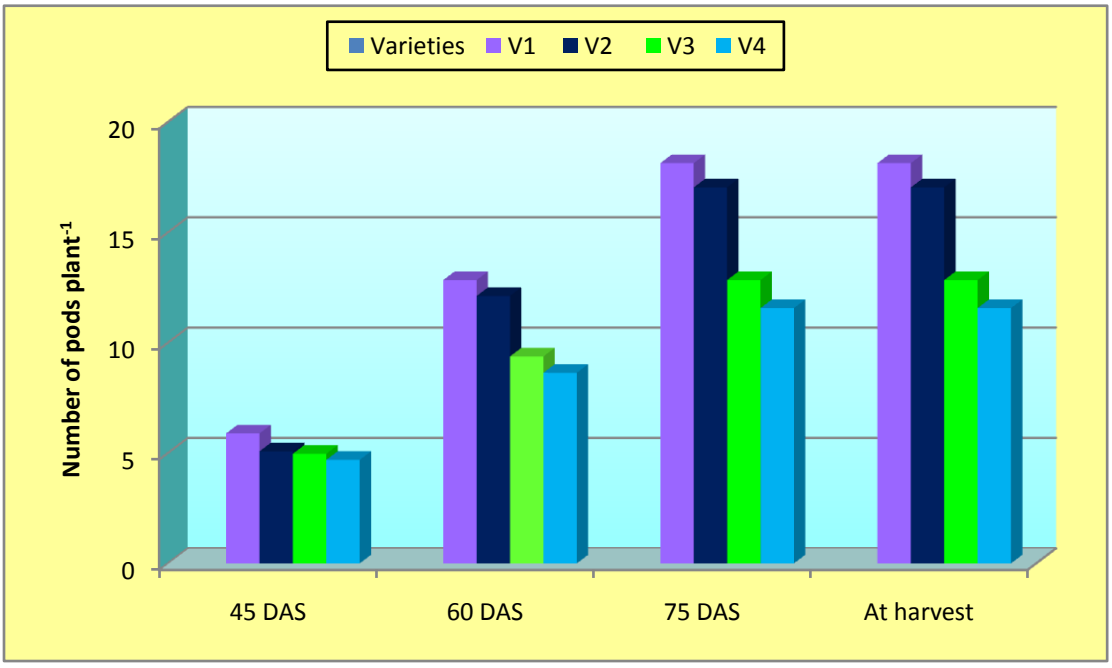


Fig. 7: Mean number of pods plant^{-1} of soybean influenced periodically by different dates of sowing and varieties

Interaction between date of sowing S_1 (MW 38) and variety V_1 (JS-9560) recorded significantly more number of pods plant^{-1} at 60 DAS over rest of the treatment combinations but was found at par with S_1V_2 (MW 38 with variety MAUS-612). Similar trend was observed at 75 and harvest.

Table 12 (b): Interaction effects between dates of sowing and varieties on number of pods plant^{-1} of soybean at 75 DAS and at harvest

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	22.42	21.74	18.70	17.87
S_2 - MW 39	19.73	18.67	11.72	9.34
S_3 - MW 40	12.28	10.72	8.10	7.50
S.E. m ±	0.90			
C.D. at 5 %	2.67			

4.2.6 Dry matter accumulation of stem plant^{-1} (g)

The data on mean dry matter accumulation of stem plant^{-1} (g) at all the growth stages of crop as influenced by different varieties and dates of sowing are presented in Table 13 and graphically represented in Fig. 8 .

The mean dry matter of stem plant^{-1} recorded at 15, 30, 45, 60, 75 DAS and at harvest were 0.65, 1.06, 2.04, 2.65, 3.18 and 3.31 (g) plant^{-1}, respectively. The data showed that dry matter of stem plant^{-1} (g) increased continuously from emergence up to harvest.

4.2.6.1 Dates of sowing

The data presented in Table 13 revealed that total dry matter accumulation plant^{-1} (g) was influenced significantly by different dates of sowing, at all the stages of crop growth. The highest total dry matter accumulation plant^{-1} (g) was recorded in S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40) at all the growth stages.

4.2.6.2 Varieties

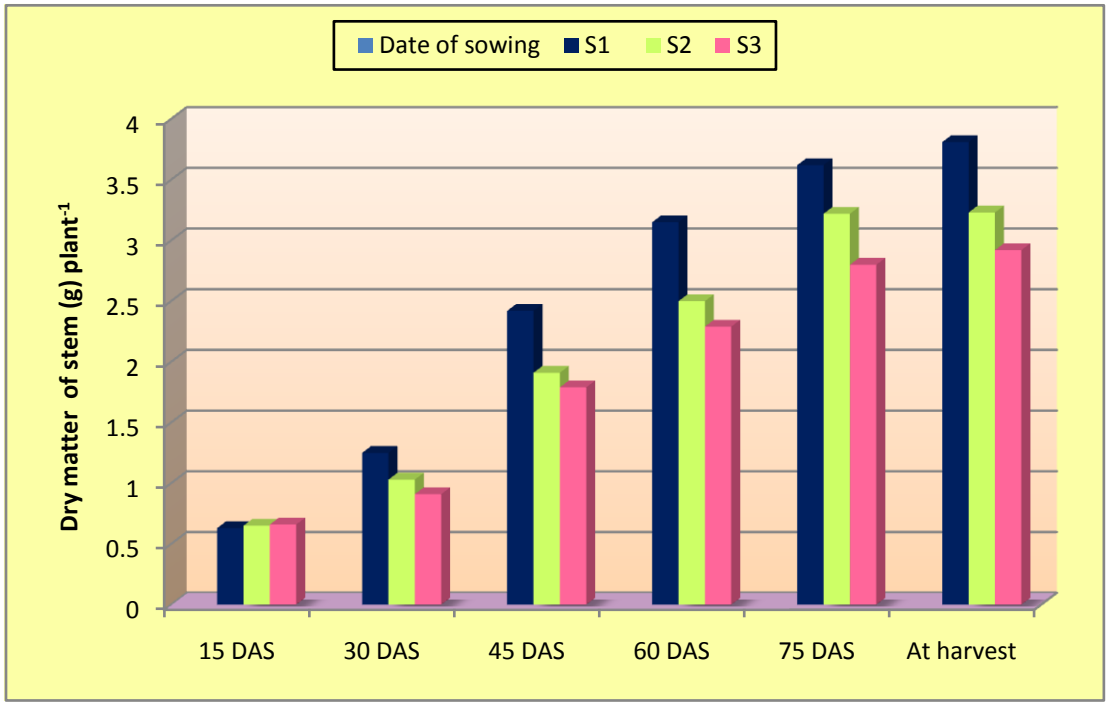
The data presented in Table 13 showed that dry matter accumulation of stem plant^{-1}(g) was influenced significantly by different varieties, at all the stages of crop growth. Variety V_2 (MAUS- 612) recorded significantly higher dry matter of stem plant^{-1} over rest of all the varieties at all the stages and remain at par with V_4 (MAUS- 71) at 30 DAS.

Table 13: Dry matter accumulation of stem plant^{-1}(g) as influenced periodically by treatments of soybean

Treatment	Days after sowing					
	15	30	45	60	75	At harvest
Date of sowing						
S_1 –MW 38	0.63	1.25	2.42	3.15	3.62	3.81
S_2 –MW 39	0.65	1.03	1.91	2.50	3.22	3.23
S_3 –MW 40	0.66	0.91	1.79	2.29	2.8	2.92
SE ±	0.03	0.03	0.05	0.06	0.06	0.05
CD at 5 %	NS	0.11	0.18	0.25	0.22	0.18
Varieties						
V_1 – JS-9560	0.66	1.13	1.94	2.52	3.17	3.18
V_2 – MAUS-612	0.65	1.11	2.23	2.88	3.58	3.74
V_3 – MAUS-162	0.64	1.00	1.97	2.52	2.96	3.10
V_4 – MAUS-71	0.64	1.02	2.05	2.68	3.17	3.24
SE ±	0.03	0.03	0.06	0.07	0.09	0.08
C.D. at 5 %	NS	0.08	0.18	0.21	0.28	0.25
Interaction(SxV)						
SE ±	0.06	0.05	0.1	0.12	0.16	0.15
C.D. at 5 %	NS	NS	NS	NS	NS	NS
General mean	**0.65**	**1.06**	**2.04**	**2.65**	**3.22**	**3.31**

4.2.6.3 Interaction effect

The interaction effect between varieties and dates of sowing was found to be not significant at all stages of crop growth.



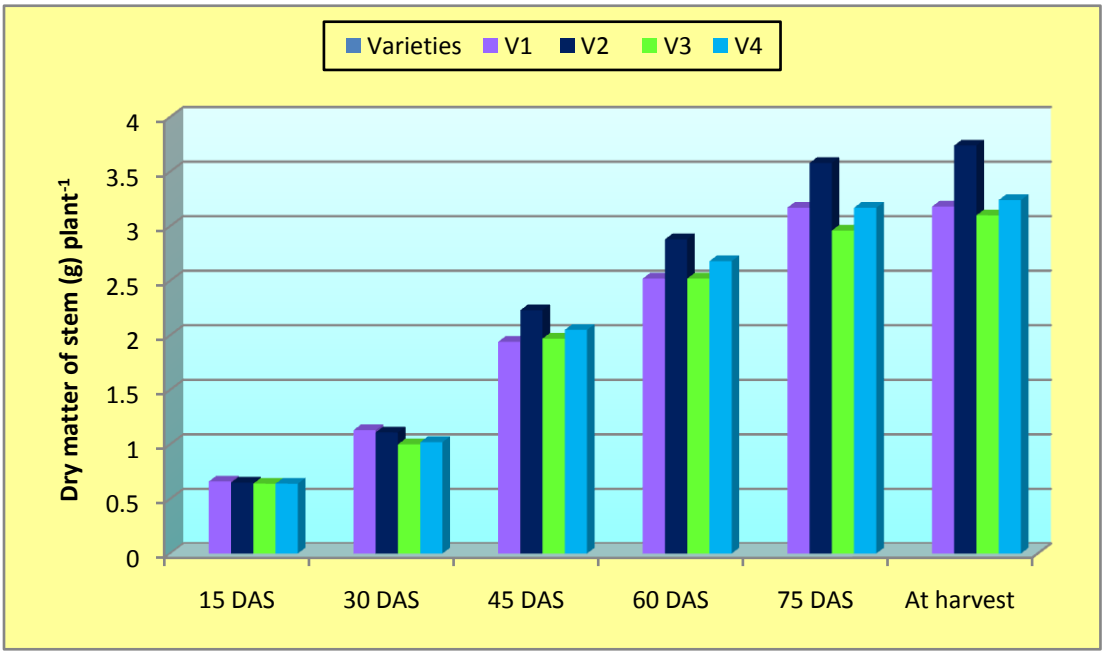


Fig. 8: Mean dry matter accumulation of stem (g) plant^{-1} of soybean influenced periodically by dates of sowing and varieties

4.2.7 Dry matter accumulation of leaves plant^{-1} (g)

The data on mean dry matter accumulation of leaves plant^{-1} (g) at all growth stages of crop as influenced by different varieties and dates of sowing are presented in Table 14 and graphically represented in Fig. 9.

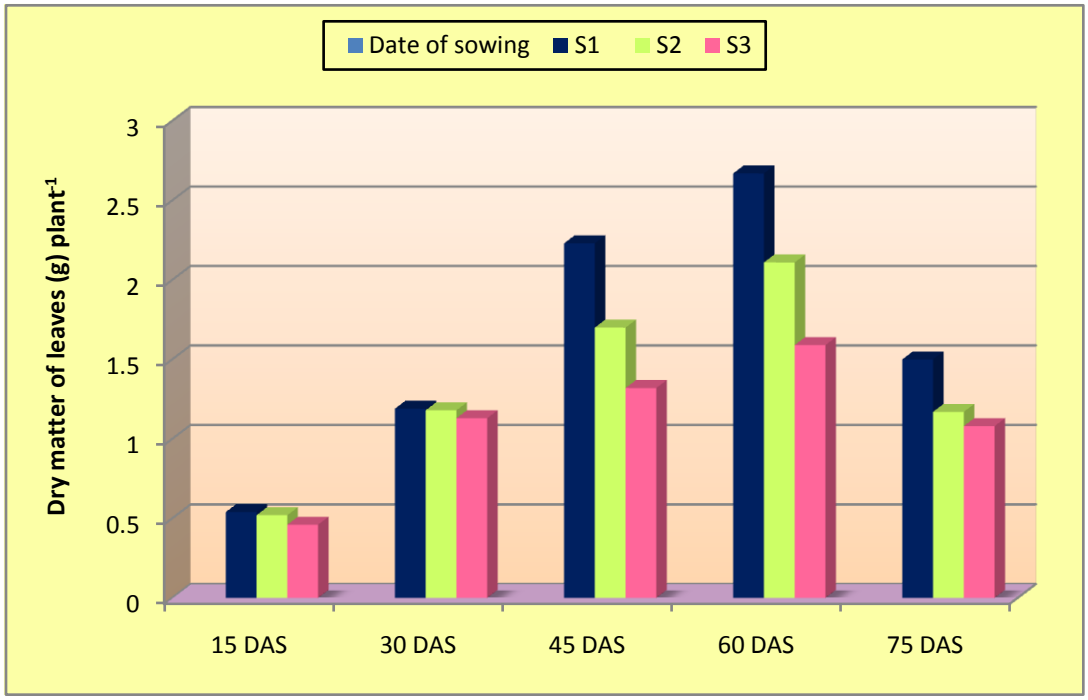
The mean dry matter of leaves plant^{-1} recorded at 15, 30, 45, 60 and 75 DAS was 0.51, 1.17, 1.75, 2.12 and 1.25 (g) plant^{-1} respectively. The data shows that dry matter of leaves plant^{-1} (g) increased continuously up to 60 DAS and decreased thereafter due to leaf senescence.

Table 14: Dry matter accumulation of leaves plant^{-1}(g) as influenced periodically by treatments of soybean

Treatment	Days after sowing				
	15	30	45	60	75
Date of sowing					
S_1 –MW 38	0.54	1.19	2.23	2.67	1.50
S_2 –MW 39	0.52	1.18	1.70	2.11	1.17
S_3 –MW 40	0.46	1.13	1.32	1.59	1.08
SE ±	0.02	0.02	0.05	0.06	0.03
CD at 5 %	NS	NS	0.19	0.24	0.11
Varieties					
V_1 – JS-9560	0.54	1.21	1.89	2.24	1.18
V_2 – MAUS-612	0.53	1.17	1.95	2.37	1.31
V_3 – MAUS-162	0.48	1.12	1.57	1.93	1.30
V_4 – MAUS-71	0.48	1.15	1.60	1.95	1.22
SE ±	0.02	0.03	0.05	0.06	0.04
C.D. at 5 %	NS	NS	0.16	0.17	0.11
Interaction(SxV)					
SE ±	0.03	0.04	0.09	0.10	0.06
C.D. at 5 %	NS	NS	NS	0.30	NS
General mean	**0.51**	**1.17**	**1.75**	**2.12**	**1.25**

4.2.7.1 Dates of sowing

The data presented in Table 14 revealed that dry matter accumulation of leaves plant^{-1} (g) was influenced significantly by different dates of sowing at all the stages of crop growth. The significantly highest dry matter



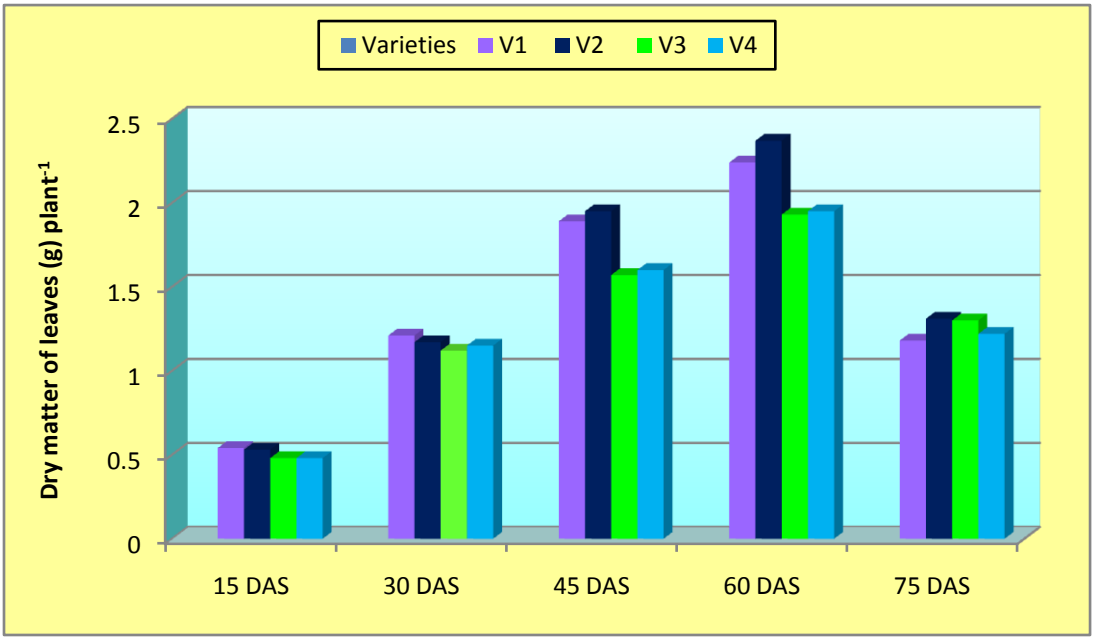


Fig. 9: Mean dry matter accumulation of leaves (g) plant^{-1} of soybean influenced periodically by dates of sowing and varieties

accumulation of leaves plant^{-1}(g) was recorded in S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40) at all the growth stages.

4.2.7.2 Varieties

The data presented in Table 14 showed that dry matter accumulation of leaves plant^{-1}(g) was influenced significantly by different varieties at all the stages of crop growth. Variety V_2 (MAUS- 612) recorded significantly higher dry matter of leaves plant^{-1} over rest of all the varieties at all the stages and remain at par with V_1 (JS- 9560) at 60 DAS and at 75 DAS it was at par with V_3 (MAUS-162).

4.2.7.3 Interaction effect

The interaction effect between dates of sowing and varieties in respect of dry matter accumulation of leaves (g) plant^{-1} was found to be significant at 60 DAS and presented in Table 14 (a).

Table 14. (a) Interaction effect between dates of sowing and varieties on dry matter accumulation of leaves (g) plant^{-1}of soybean at 60 DAS

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	2.73	2.90	2.49	2.55
S_2 - MW 39	2.11	2.20	2.00	2.10
S_3 - MW 40	1.87	2.02	1.30	1.19
S.E. m ±	0.10			
C.D. at 5 %	0.30			

Interaction between sowing of S_1 (MW 38) with variety V_2 (MAUS- 612) recorded significantly higher dry matter accumulation of leaves (g) plant^{-1} at 60 DAS over rest of the treatment combinations and it was at par with date of sowing S_1 (MW 38) with variety V_1 (JS-9560).

4.2.8 Dry matter accumulation of pods plant^{-1} (g)

The data on mean dry matter accumulation of pods plant^{-1} (g) at all growth stages of crop as influenced by different varieties and dates of sowing are presented in Table 15 and graphically represented in Fig. 10.

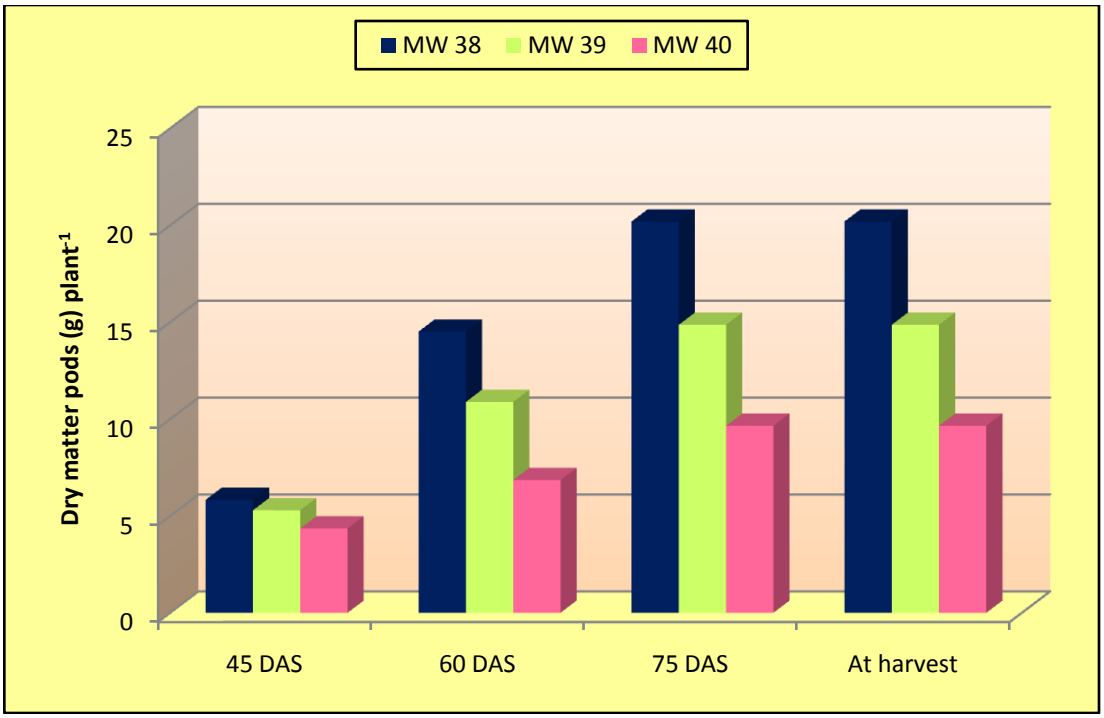
The mean dry matter of pods plant^{-1} recorded at 45, 60, 75 DAS and at harvest was 0.77, 2.59, 4.04 and 5.32 (g) plant^{-1} respectively. The data shows that dry matter of pods plant^{-1} (g) increased continuously up to harvest of crop.

Table 15: Dry matter accumulation of pods plant^{-1}(g) as influenced periodically by treatments of soybean

Treatment	Days after sowing			
	45	60	75	At harvest
Date of sowing				
S_1 –MW 38	0.90	3.16	5.10	6.60
S_2 –MW 39	0.77	2.54	4.14	5.42
S_3 –MW 40	0.65	2.08	2.86	3.94
SE ±	0.02	0.06	0.09	0.11
CD at 5 %	0.07	0.22	0.34	0.43
Varieties				
V_1 – JS-9560	0.85	2.90	4.78	6.09
V_2 – MAUS-612	0.80	2.78	4.63	5.91
V_3 – MAUS-162	0.72	2.40	3.45	4.76
V_4 – MAUS-71	0.73	2.29	3.28	4.53
SE ±	0.01	0.06	0.03	0.15
C.D. at 5 %	0.03	0.19	0.10	0.45
Interaction(SxV)				
SE ±	0.02	0.11	0.06	0.05
C.D. at 5 %	NS	NS	0.17	0.15
General mean	**0.77**	**2.59**	**4.04**	**5.32**

4.2.8.1 Dates of sowing

The data presented in Table 15 revealed that dry matter accumulation of pods plant^{-1} (g) was influenced significantly by different dates of sowing at all the stages of crop growth. The significantly highest dry matter accumulation of pod plant^{-1}(g) was recorded in S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40) at all growth stages.



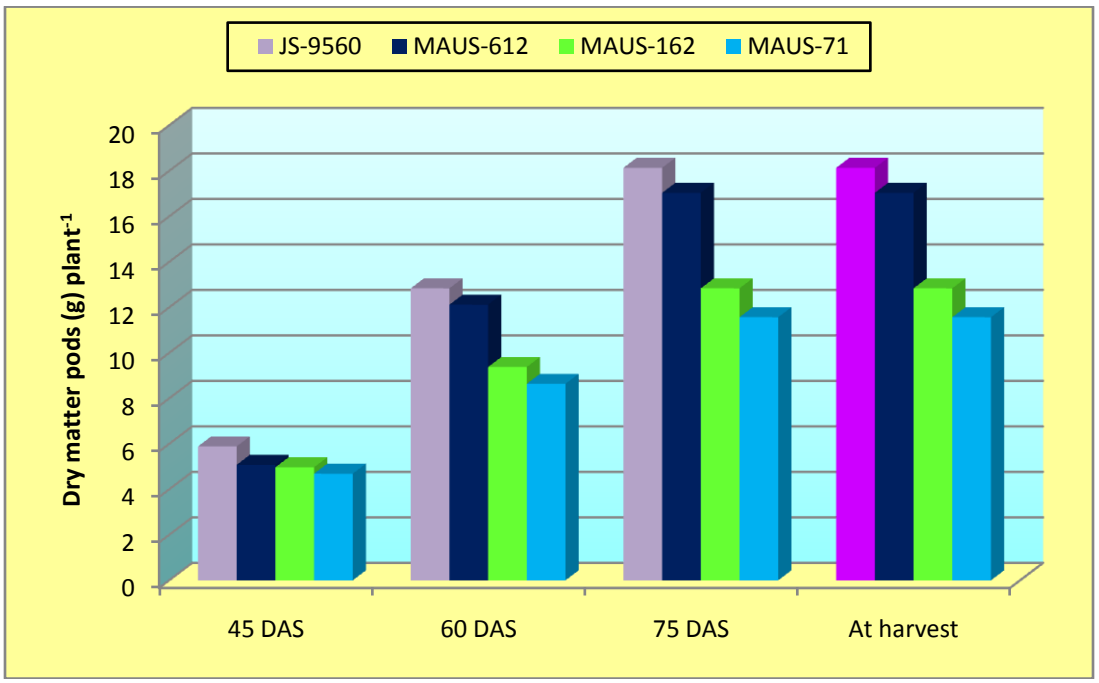


Fig. 10: Mean dry matter accumulation pods (g) plant^{-1} of soybean influenced periodically by different dates of sowing and varieties

4.2.8.2 Varieties

The data presented in Table 15 showed that dry matter accumulation of pods plant^{-1}(g) was influenced significantly by different varieties at all the stages of crop growth. Variety V_1 (JS-9560) and V_2 (MAUS- 612) recorded significantly higher dry matter of pods plant^{-1} than rest of the varieties, which was significantly superior over the V_3 (MAUS- 162) and V_4 (MAUS- 71) at all the growth stages but both V_1 (JS-9560) and V_2 (MAUS- 612) were at par with each other

4.2.8.3 Interaction effect

Interaction effect between dates of sowing and varieties on soybean dry matter accumulation of pods plant^{-1} of soybean at 75 DAS and at harvest were shown in Table number 15 (a) and 15 (b), respectively.

The interaction effects between dates of sowing and varieties were found to be significant for mean pod dry matter accumulation of pods (g) plant^{-1}at 75 DAS and at harvest. Interaction of date of sowing S_1 (MW 38) with variety V_1 (JS-9560) recorded significantly the highest dry matter of pods (g) plant^{-1} of soybean over rest of the treatment combinations and it was at par with the treatment combination of S_1V_2 at 75 DAS. Similar trend was observed at harvest.

Table 15 (a): Interaction effects between dates of sowing and varieties on dry matter of pods (g) plant^{-1} of soybean at 75 DAS

Varieties / Date of sowing	**V_1 JS – 9560**	**V_2 MAUS-612**	**V_3 MAUS-162**	**V_4 MAUS-71**
S_1 - MW 38	5.89	5.81	4.47	4.25
S_2 - MW 39	4.84	4.73	3.62	3.39
S_3 - MW 40	3.63	3.35	2.26	2.21
S.E. m ±	0.06			
C.D. at 5 %	0.17			

Table 15 (b): Interaction effects between dates of sowing and varieties on dry matter of pods (g) plant^{-1} of soybean at harvest

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	7.35	7.27	6.04	5.74
S_2 - MW 39	6.25	5.85	4.89	4.62
S_3 - MW 40	4.68	4.53	3.34	3.22
S.E. m ±	0.05			
C.D. at 5 %	0.15			

4.2.9 Total dry matter accumulation plant^{-1} (g)

The data on mean total dry matter accumulation plant^{-1} (g) at different growth stages of crop as influenced by different varieties and dates of sowing are presented in Table 16 and graphically represented in Fig. 11.

The mean total dry matter plant^{-1} recorded at 15, 30, 45, 60, 75 DAS and at harvest were 1.16, 1.92, 4.57, 7.37, 8.54 and 8.64 (g) plant^{-1}, respectively The data revealed that mean dry matter accumulation plant^{-1} was increased continuously from emergence to harvest.

4.2.9.1 Date of sowing

The data presented in Table 16 showed that total dry matter accumulation plant^{-1}(g) was influenced significantly by different varieties, at all the stages of crop growth. Mean dry matter accumulation was observed significantly superior in date of sowing S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40) at all the growth stages.

4.2.9.2 Varieties

The data presented in Table 16 showed that total dry matter accumulation plant^{-1}(g) was influenced significantly by different varieties, at all the stages of crop growth. Variety V_2 (MAUS- 612) recorded higher dry matter

accumulation plant^{-1}(g) over rest of the varieties, which was significantly superior than V_3 (MAUS- 162) and V_4 (MAUS- 71) at all the growth stages and remained at par with V_1 (JS- 9560) at 75 DAS and at harvest of the crop.

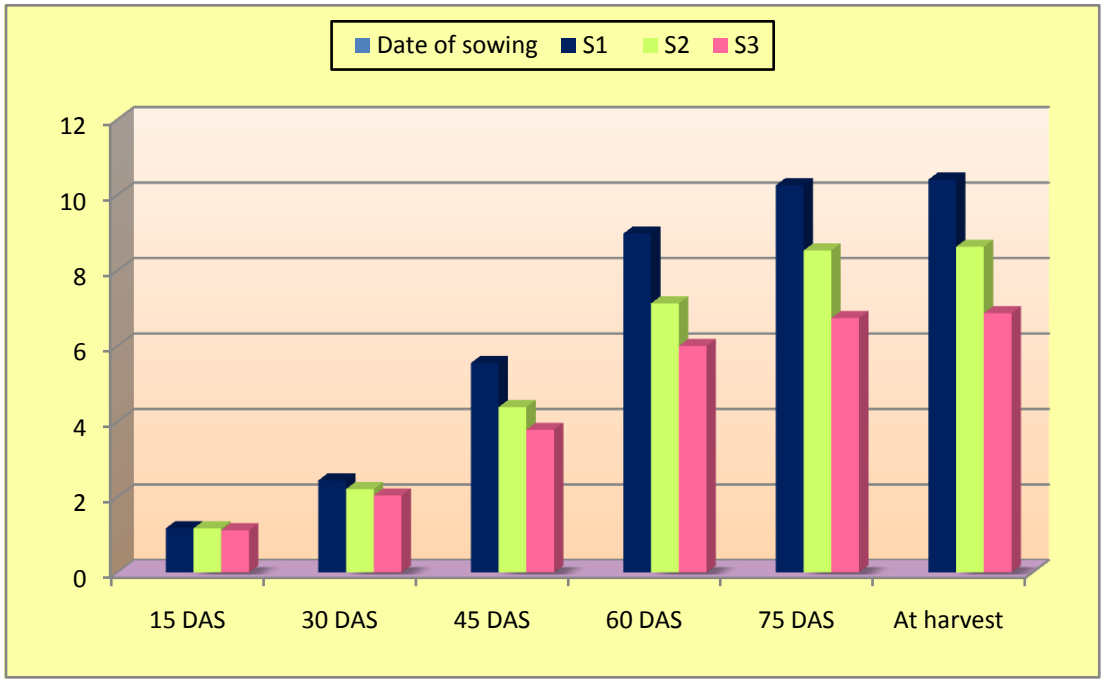
Table 16: Total dry matter accumulation plant^{-1}(g) as influenced periodically by treatments of soybean

Treatment	Days after sowing					
	15	30	45	60	75	At harvest
Date of sowing						
S_1 –MW 38	1.17	2.44	5.55	8.98	10.26	10.41
S_2 –MW 39	1.17	2.21	4.38	7.13	8.53	8.63
S_3 –MW 40	1.12	2.04	3.78	6.00	6.74	6.87
SE ±	0.03	0.08	0.04	0.13	0.09	0.13
CD at 5 %	NS	NS	0.16	0.52	0.36	0.52
Varieties						
V_1 – JS-9560	1.20	2.34	4.68	7.66	9.13	9.27
V_2 – MAUS-612	1.18	2.28	4.98	8.03	9.52	9.65
V_3 – MAUS-162	1.12	2.12	4.26	6.89	7.70	7.86
V_4 – MAUS-71	1.12	2.17	4.38	6.90	7.67	7.78
SE ±	0.02	0.06	0.09	0.09	0.09	0.08
C.D. at 5 %	0.07	NS	0.27	0.26	0.25	0.23
Interaction (SxV)						
SE ±	0.04	0.12	0.14	0.15	0.14	0.13
C.D. at 5 %	NS	NS	NS	NS	0.42	0.39
General mean	**1.15**	**1.92**	**4.54**	**7.37**	**8.51**	**8.64**

4.2.9.3 Interaction effect

The interaction effects between dates of sowing and varieties were found to be significant for mean total dry matter accumulation plant^{-1}(g) at 75 DAS and at harvest and are shown in Table number 16 (a) and 16 (b) respectively.

At 75 DAS, the variety V_2 (MAUS- 612) sown on S_1 (MW 38) recorded significantly higher dry matter plant^{-1} of soybean than all other combinations. However it was at par with variety V_1 (JS- 9560) sown on S_1 (MW 38).



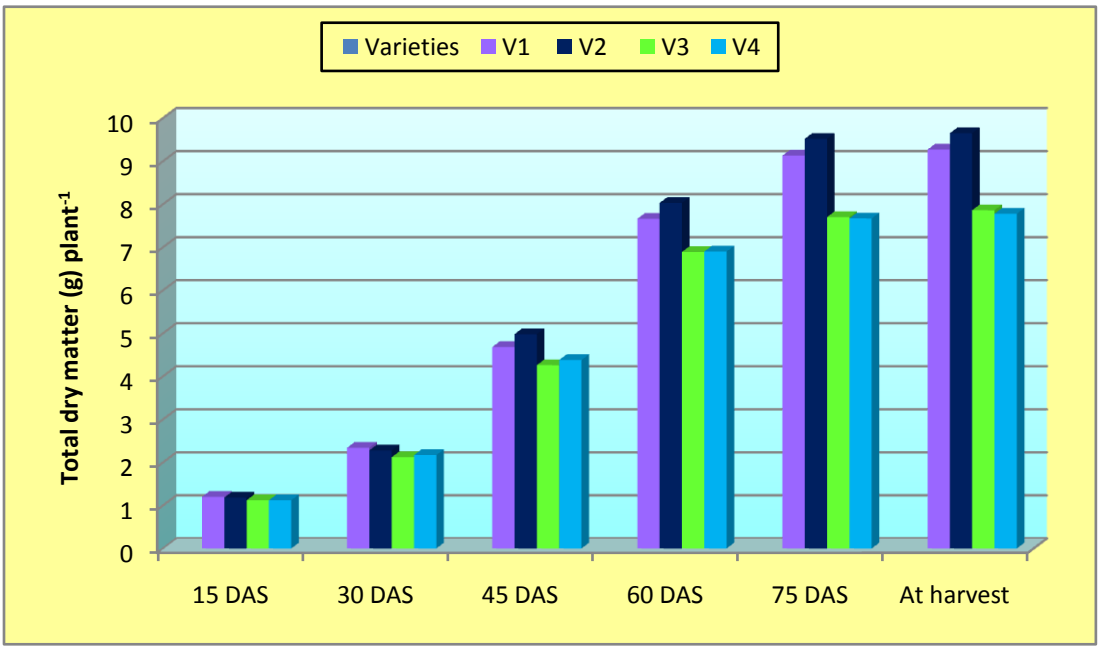


Fig. 11: Mean total dry matter accumulation (g) plant^{-1} of soybean influenced periodically by different dates of sowing and varieties

Table 16 (a): Interaction effects dates of sowing and varieties on dry matter plant^{-1} of soybean at 75 DAS.

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	10.91	11.37	9.33	9.43
S_2 - MW 39	9.24	9.76	7.65	7.45
S_3 - MW 40	7.25	7.44	6.13	6.13
S.E. m ±	0.16			
C.D. at 5 %	0.47			

Similar trend was found at harvest, the variety V_2 (MAUS- 612) sown on S_1 (MW 38) recorded significantly higher dry matter plant^{-1} of soybean than all other combinations but it was at par with the variety V_1 (JS- 9560) sown during S_1 (MW 38).

Table 16 (b) Interaction effects dates of sowing and varieties on dry matter (g) plant^{-1} of soybean at harvest.

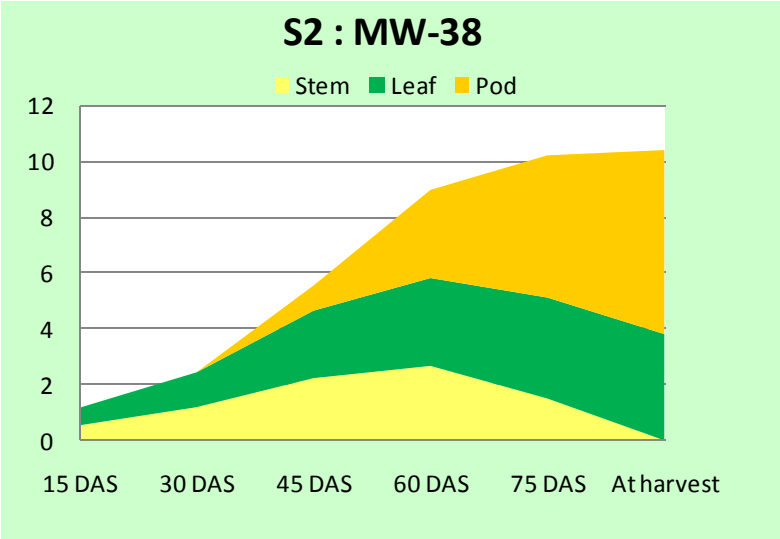
Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	11.01	11.50	9.56	9.58
S_2 - MW 39	9.29	9.89	7.78	7.57
S_3 - MW 40	7.51	7.55	6.22	6.19
S.E. m ±	0.17			
C.D. at 5 %	0.51			

4.2.10 Relative contribution of stem, leaf and pods in total dry matter plant^{-1}

The relative contribution of stem leaves and pods to the total dry matter at various growth stages was calculated and the relevant data is presented Table 17 and depicted in Fig 12.

Table : 17 Relative contribution of stem, leaf and pods to total dry matter plant^{-1}.

Treatment	Days after sowing														
	15		30		45			60			75			At harvest	
	S/T	L/T	S/T	L/T	S/T	L/T	P/T	S/T	L/T	P/T	S/T	L/T	P/T	S/T	P/T
Date of sowing															
S_1 –MW 38	0.46	0.54	0.49	0.51	0.40	0.44	0.16	0.35	0.30	0.35	0.35	0.15	0.50	0.37	0.63
S_2 –MW 39	0.44	0.56	0.53	0.47	0.39	0.44	0.18	0.35	0.30	0.36	0.38	0.14	0.49	0.37	0.63
S_3 –MW 40	0.41	0.59	0.55	0.45	0.35	0.48	0.17	0.38	0.27	0.35	0.42	0.16	0.42	0.43	0.57
Varieties															
V_1 – JS-9560	0.45	0.55	0.52	0.48	0.40	0.41	0.18	0.33	0.29	0.38	0.35	0.13	0.52	0.34	0.66
V_2 –MAUS-612	0.45	0.55	0.51	0.49	0.39	0.45	0.16	0.36	0.30	0.35	0.38	0.14	0.49	0.39	0.61
V_3 –MAUS-162	0.43	0.57	0.53	0.47	0.37	0.46	0.17	0.37	0.28	0.35	0.38	0.17	0.45	0.39	0.61
V_4 –MAUS-71	0.43	0.57	0.53	0.47	0.37	0.47	0.17	0.39	0.28	0.33	0.41	0.16	0.43	0.42	0.58
General mean	**0.44**	**0.56**	**0.52**	**0.48**	**0.38**	**0.45**	**0.17**	**0.36**	**0.29**	**0.35**	**0.38**	**0.15**	**0.47**	**0.39**	**0.61**



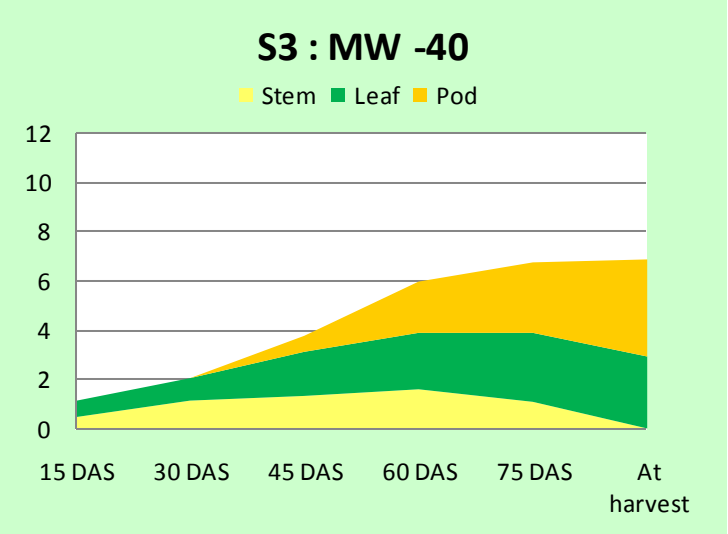


Fig. 12 :

Relative contribution of stem, leaf and pods in total dry matter plant[1] at different growth stages.

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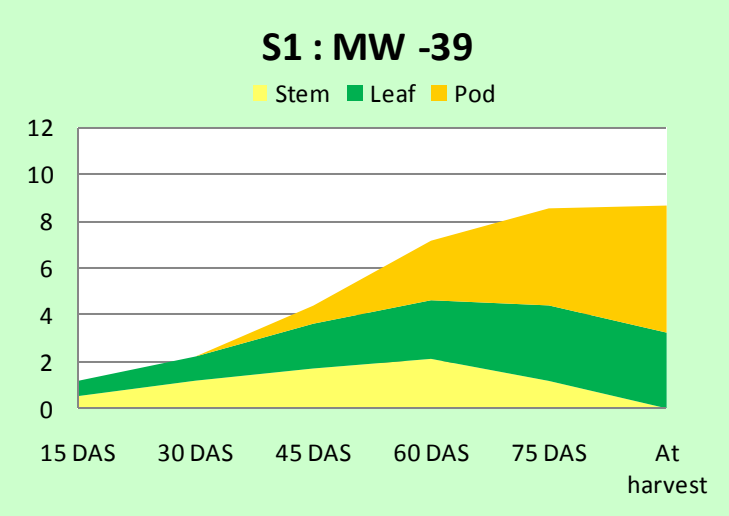
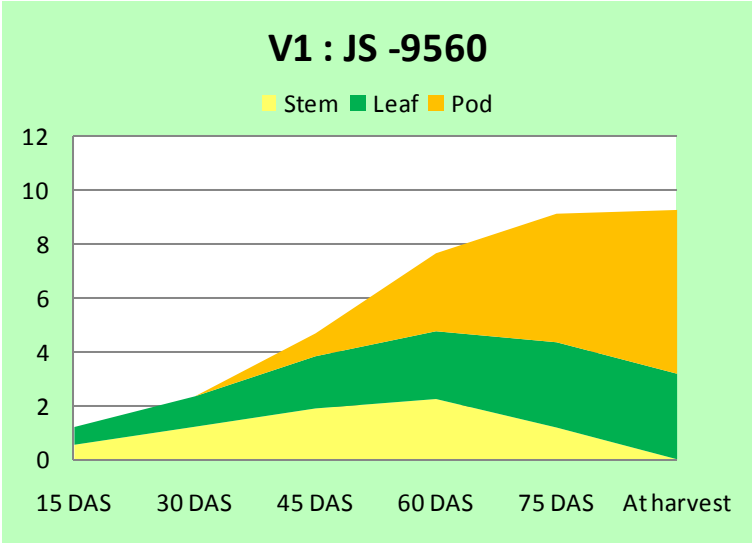
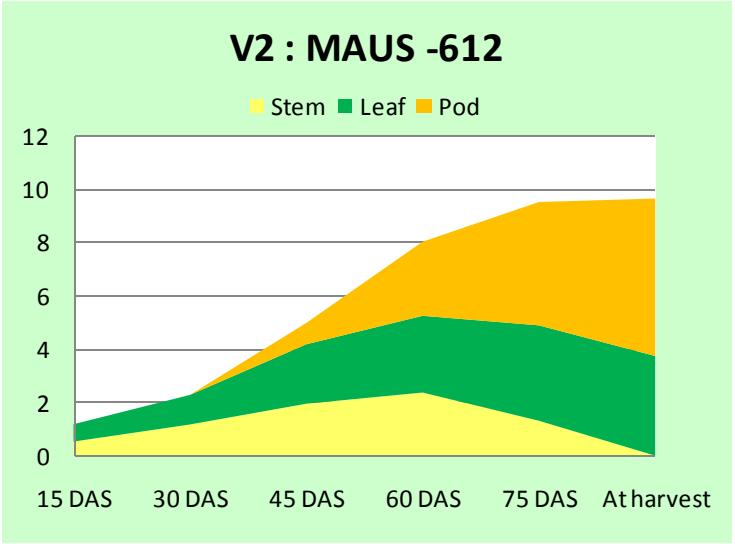
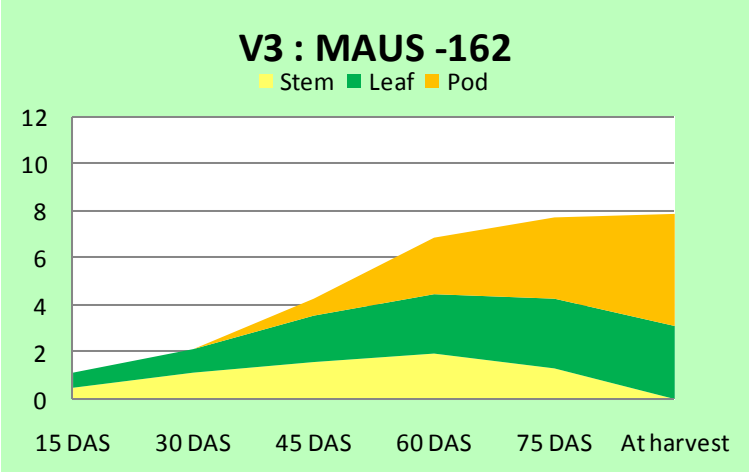
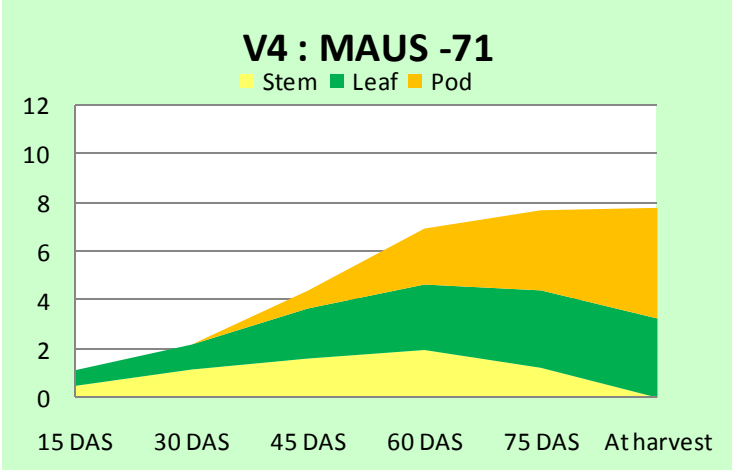



V1 : JS -9560
Stem
Leaf
Pod
12
10
8
6
4
2
0
15 DAS
30 DAS
45 DAS
60 DAS
75 DAS
At harvest


V2 : MAUS -612
Stem
Leaf
Pod
12
10
8
6
4
2
0
15 DAS
30 DAS
45 DAS
60 DAS
75 DAS
At harvest


V3 : MAUS -162
Stem
Leaf
Pod
12
10
8
6
4
2
0
15 DAS
30 DAS
45 DAS
60 DAS
75 DAS
At harvest


V4 : MAUS -71
Stem
Leaf
Pod
12
10
8
6
4
2
0
15 DAS
30 DAS
45 DAS
60 DAS
75 DAS
At harvest

The contribution of stem to total dry matter was 44 % at initial stage and it was decreased upto 38 % at 60 DAS. Thereafter, it was found increased to the tune of 39 % at harvest.

The contribution of leaves to total dry matter was 56 % in the initial stage (15 DAS). It gradually decreased at every stage thereafter. It was 45 % at pod initiation stage (45 DAS) and reduced to 15 % at 75 DAS due to leaf senescence.

Contribution of pod dry matter to total dry matter was only 17 % at 45 DAS and it was increased to about 61 % at harvest due to rapid translocation of photosynthates to the developing pods.

4.3 Growth Analysis

4.3.1 Absolute growth rate (cm day^{-1} plant^{-1}) for plant height

The mean value of absolute growth rate (AGR) for plant height (cm day^{-1} plant^{-1}) during various stages of crop growth is presented in Table 18 graphically represented in Fig. 13.

The AGR for plant height was increased at vary fast rate during 0-15 DAS than 31-45 DAS, and gradually declined thereafter up to harvest.

4.3.1.1 Date of sowing

The data furnished in Table 18 revealed that the date of sowing S_1 (MW 38) recorded numerically maximum AGR values over S_2 (MW 39) and S_3 (MW 40) at all the stages of crop growth.

4.3.1.2 Varieties

The data furnished in Table 18 revealed that the variety V_3 (MAUS-162) recorded numerically maximum AGR (cm day^{-1} plant^{-1}) values at all the stages of crop growth than rest of the varieties except at 0-15 DAS.

Table18: Mean absolute growth rate for plant height (cm day^{-1} plant^{-1}) as influenced periodically by treatments of soybean

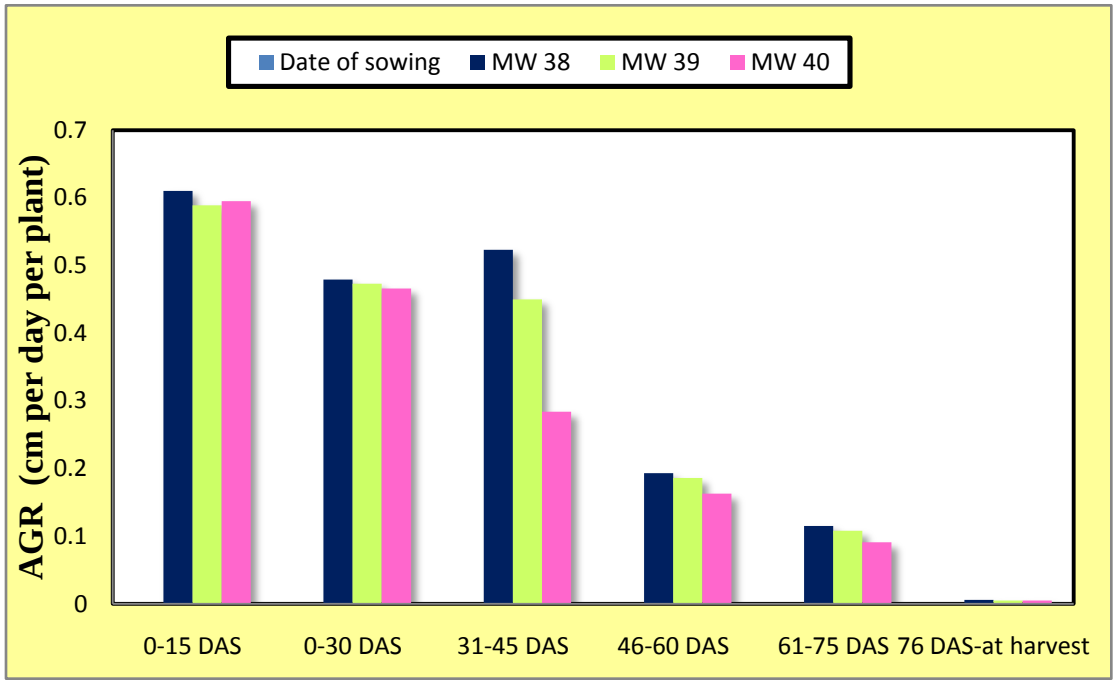
Treatment	Days in between					
	0-15	15-30	31-45	46-60	61-75	75-at harvest
Date of sowing						
S_1 –MW 38	0.610	0.479	0.523	0.193	0.115	0.006
S_2 –MW 39	0.589	0.463	0.450	0.186	0.108	0.005
S_3 –MW 40	0.595	0.476	0.284	0.163	0.091	0.005
Varieties						
V_1 – JS-9560	0.585	0.473	0.277	0.122	0.085	0.005
V_2 – MAUS-612	0.634	0.471	0.485	0.253	0.118	0.006
V_3 – MAUS-162	0.629	0.479	0.541	0.327	0.126	0.006
V_4 – MAUS-71	0.544	0.470	0.288	0.107	0.090	0.004
General mean	**0.598**	**0.473**	**0.415**	**0.185**	**0.105**	**0.005**

4.3.2 Absolute growth rate (g day^{-1} plant^{-1}) for dry matter

The data regarding mean values of AGR for dry matter accumulation expressed in g day^{-1} plant^{-1} during various growth stages are presented in Table 19 graphically represented in Fig. 12. The data revealed that the dry matter accumulation was slow up to 30 DAS, rapid between 46-60 DAS and thereafter decreased up to the harvest as depicted in Fig. 14.

4.3.2.1 Date of sowing

A remarkable mean difference was recorded in AGR (g day^{-1} plant^{-1}) values for dry matter accumulation due to various dates of sowing. The dates S_1 (MW 38) recorded numerically maximum AGR values over S_2 (MW 39) and S_3 (MW 40) at all the stages of crop growth except at 61-75 DAS. Whereas, minimum AGR values for dry matter recorded by the S_3 (MW 40) at all the stages of crop growth.



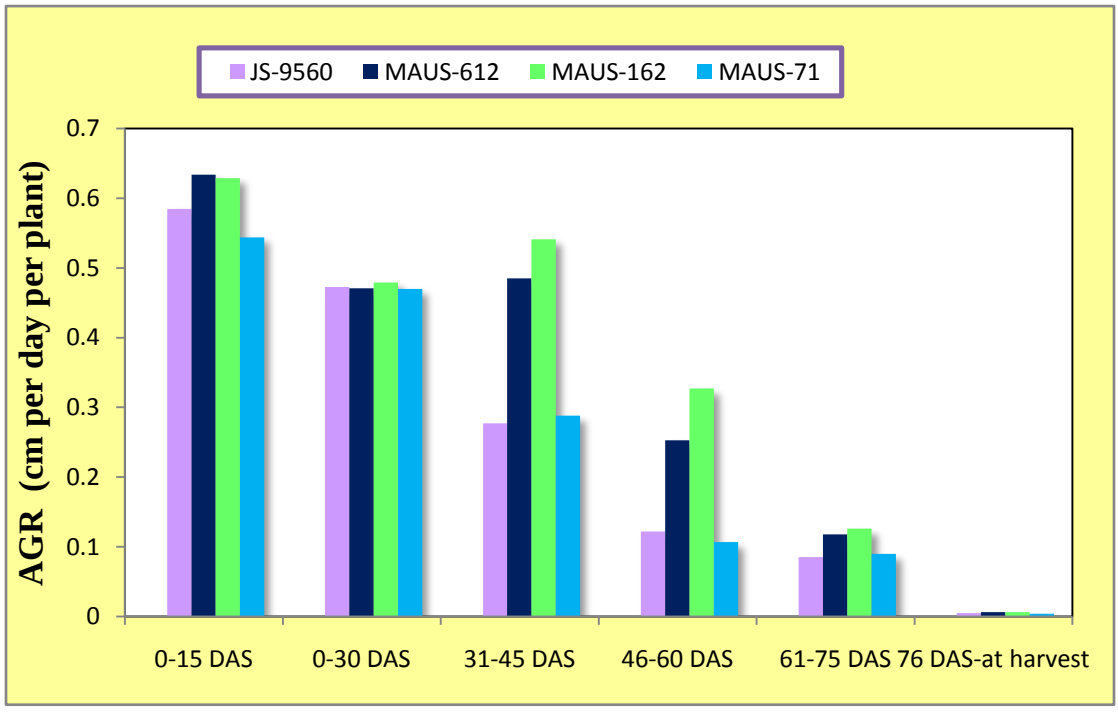


Fig. 12: AGR by plant height (cm day^{-1} plant^{-1}) of soybean influenced periodically by different dates of sowing and varieties

Table 19: Mean Absolute Growth Rate (AGR) for dry matter accumulation as influenced periodically by treatments of soybean (g day^{-1} plant^{-1}).

Treatment	Days in between					
	0-15	15-30	31-45	46-60	61-75	75-at harvest
Date of sowing						
S_1 –MW 38	0.078	0.085	0.207	0.229	0.085	0.010
S_2 –MW 39	0.078	0.069	0.145	0.183	0.093	0.007
S_3 –MW 40	0.075	0.061	0.116	0.148	0.049	0.009
Varieties						
V_1 – JS-9560	0.080	0.076	0.156	0.199	0.098	0.009
V_2 – MAUS-612	0.079	0.073	0.180	0.203	0.099	0.009
V_3 – MAUS-162	0.075	0.067	0.143	0.175	0.054	0.011
V_4 – MAUS-71	0.075	0.070	0.147	0.168	0.051	0.007
General mean	**0.077**	**0.072**	**0.156**	**0.186**	**0.076**	**0.009**

4.3.3 Mean relative growth rate (RGR) for total dry matter

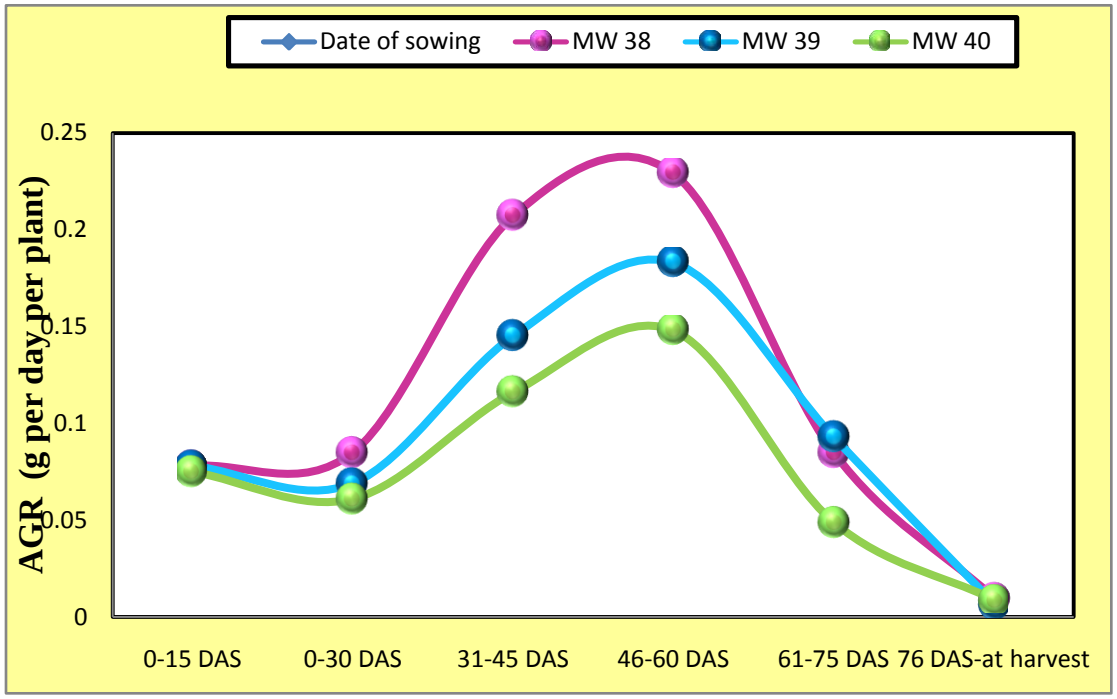
Data regarding the varieties and dates of sowing on RGR (g g^{-1}day^{-1}) at different growth stages of crop are presented in Table 20 graphically represented in Fig. 15 revealed that RGR was increased up 31-45 DAS and decreased thereafter .

4.3.3.1 Dates of sowing

The rate of increase as shown by RGR values was numerically higher in S_1 (MW 38) during all the stages of crop growth over the rest of the sowing dates.

4.3.3.2 Varieties

Variety V_1 (JS- 9560) recorded numerically higher RGR values at all the stages of crop growth except during 31-45 DAS than rest of the varieties. Whereas, during 31-45 DAS, variety V_2 (MAUS- 612) numerically higher RGR values than rest of the varieties.



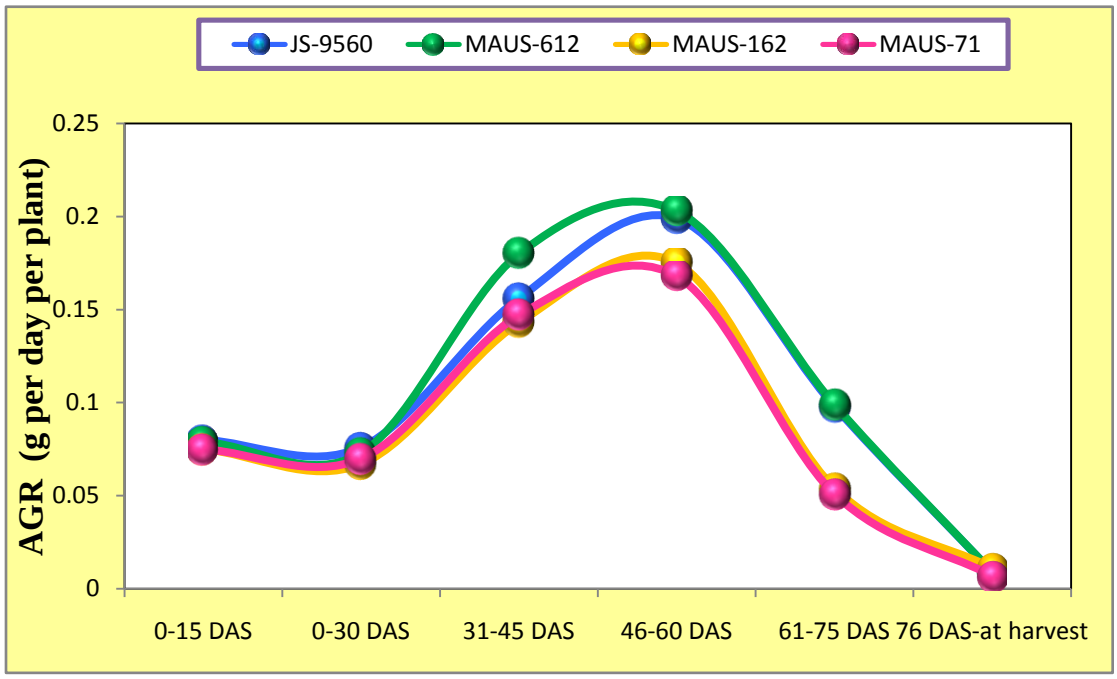


Fig. 13: AGR by dry matter (g day^{-1} plant^{-1}) of soybean influenced periodically by different dates of sowing and varieties

Table 20: Mean Relative Growth Rate (RGR) for dry matter accumulation as influenced periodically by treatments of soybean (g g^{-1} day^{-1} $plant^{-1}$).

Treatment	Days in between					
	0-15	15-30	31-45	46-60	61-75	76-at harvest
Date of sowing						
S_1 –MW 38	0.010	0.049	0.055	0.032	0.009	0.001
S_2 –MW 39	0.010	0.042	0.046	0.032	0.012	0.001
S_3 –MW 40	0.008	0.040	0.041	0.031	0.008	0.001
Varieties						
V_1 – JS-9560	0.012	0.045	0.046	0.033	0.012	0.001
V_2 – MAUS-612	0.011	0.044	0.052	0.032	0.011	0.001
V_3 – MAUS-162	0.008	0.043	0.047	0.032	0.007	0.001
V_4 – MAUS-71	0.008	0.044	0.047	0.030	0.007	0.001
General mean	**0.010**	**0.045**	**0.046**	**0.033**	**0.012**	**0.001**

4.3.4.1 Mean leaf area index (LAI)

The data pertaining to mean leaf area index as influenced by different varieties and dates of sowing are furnished in Table 21 graphically represented in Fig. 16.

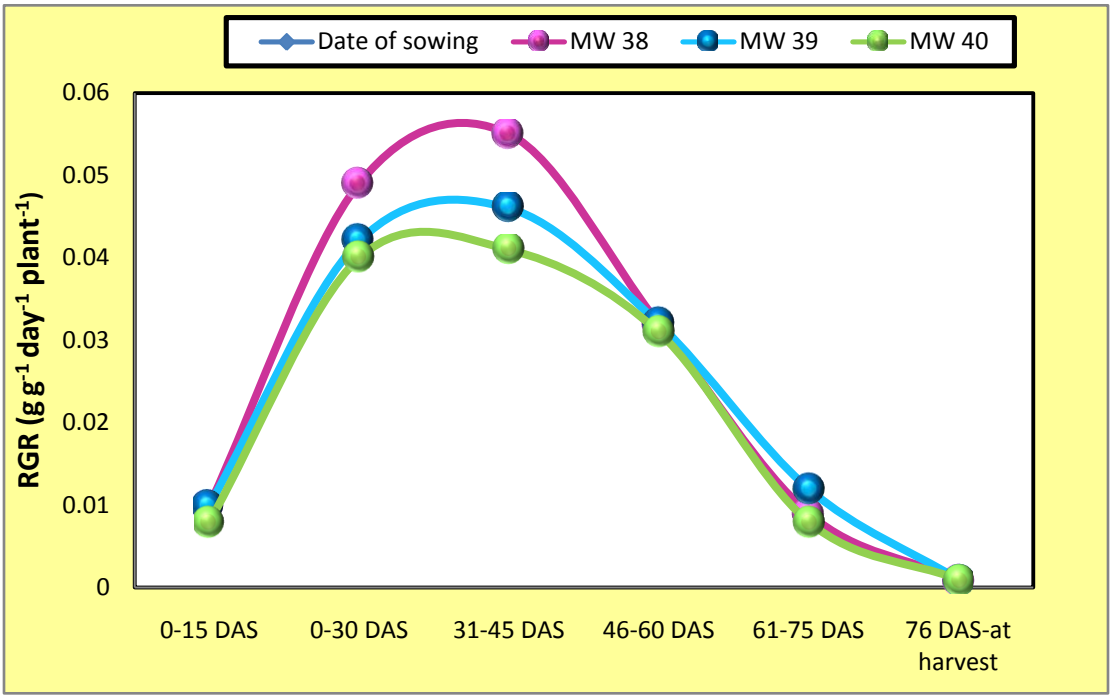
Perusal of data presented in Table 21 indicated that mean LAI increased up to 60 DAS and thereafter decreased due to leaf senescence.

4.3.4.1 Dates of sowing

A clear variation in leaf are index was observed due to different dates of sowing and it was noted that S_1 (MW 38) recorded numerically higher LAI over the rest dates of sowing. Whereas, less LAI was recorded in the S_3 (MW 40).

4.3.4.2 Varieties

The data from Table 19 illustrated that the maximum leaf area index was recorded in variety V_2 (MAUS- 612) during at all the growth stages of the crop compared to rest of the varieties.



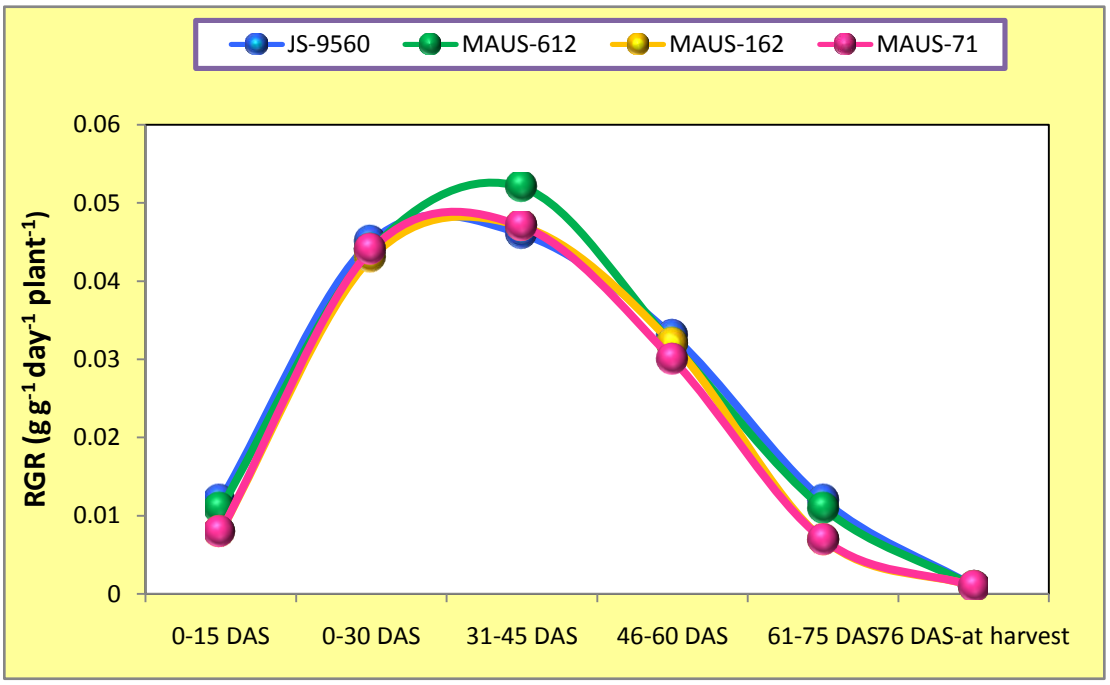


Fig. 14: RGR (g g^{-1} day^{-1} $plant^{-1}$) of soybean as influenced periodically by different dates of sowing and varieties

Table 21: Mean Leaf Area Index (LAI) of soybean as influenced periodically by different treatment

Treatment	Days in between				
	0-15	**15-30**	**31-45**	**46-60**	**61-75**
Date of sowing					
S_1 –MW 38	0.20	1.04	2.07	2.92	1.72
S_2 –MW 39	0.20	1.06	1.91	2.48	1.51
S_3 –MW 40	0.20	1.01	1.54	1.84	1.11
Varieties					
V_1 – JS-9560	0.21	1.10	1.90	2.47	1.30
V_2 – MAUS-612	0.20	1.09	2.04	2.84	1.72
V_3 – MAUS-162	0.20	0.97	1.65	2.00	1.41
V_4 – MAUS-71	0.20	0.99	1.76	2.33	1.36
General mean	**0.20**	**1.04**	**1.84**	**2.41**	**1.45**

4.4 Post harvest studies

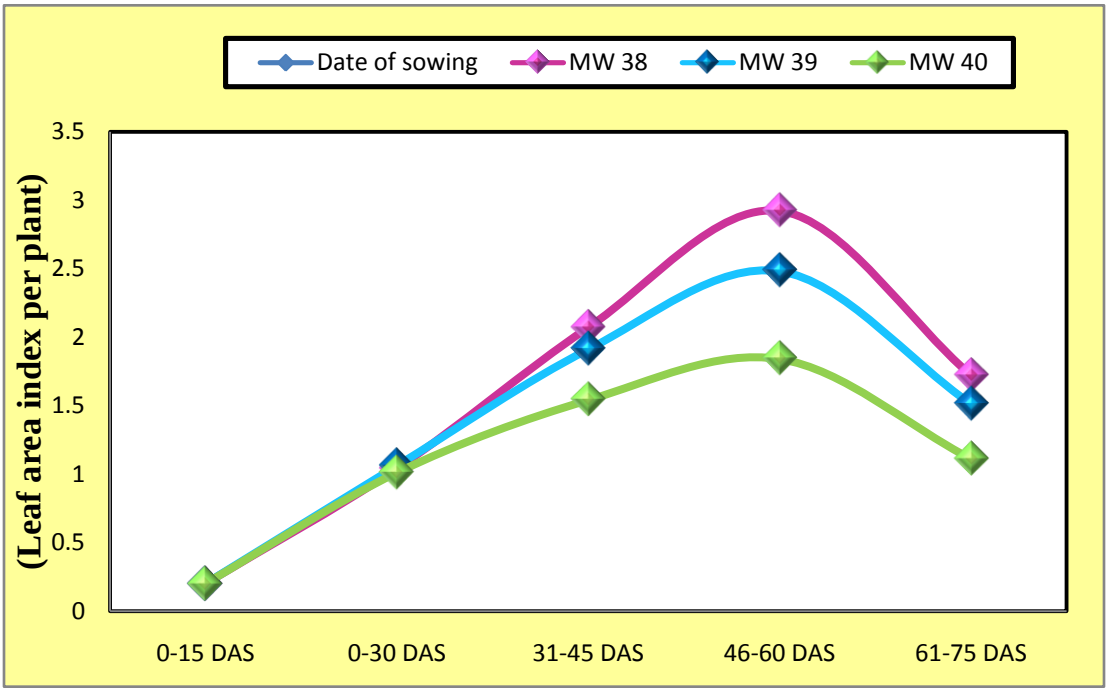
The data on mean yield contributing characters *viz*., number of developed pods, pod weight plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1} and seed weight plant^{-1} at harvest as influenced by different dates of sowing and varieties are showed in Table 22.

4.2.5 Number of developed pods plant^{-1}

The data on mean number of developed pods plant^{-1} is presented in Table 22 graphically represented in Fig. 17. The data revealed that number of developed pods plant^{-1} influenced significantly by different dates of sowing and varieties. The mean number of developed pods plant^{-1} were 14.90.

4.2.5.1 Dates of sowing

The data presented in Table 22 revealed that the mean number of developed pods plant^{-1} was influenced significantly by different dates of sowing. The significantly higher number of developed pods plant^{-1} was recorded in S_1 (MW 38) than S_2 (MW 39) and S_3 (MW 40).



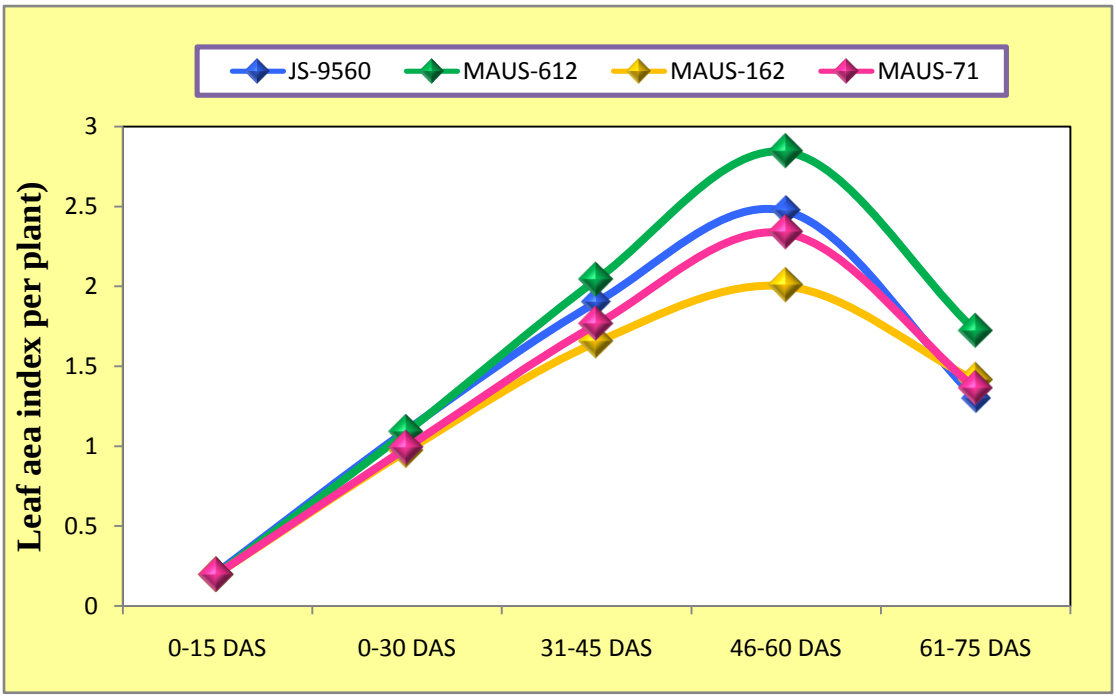


Fig. 15: Leaf area index in soybean as influenced periodically by different dates of sowing and varieties

Table 22: No. of developed pods plant^{-1}, mean pod weight plant^{-1} (g), seed weight plant^{-1} (g), number of seeds pod^{-1}and number of seeds plant-^{1} and of soybean as influenced by treatments

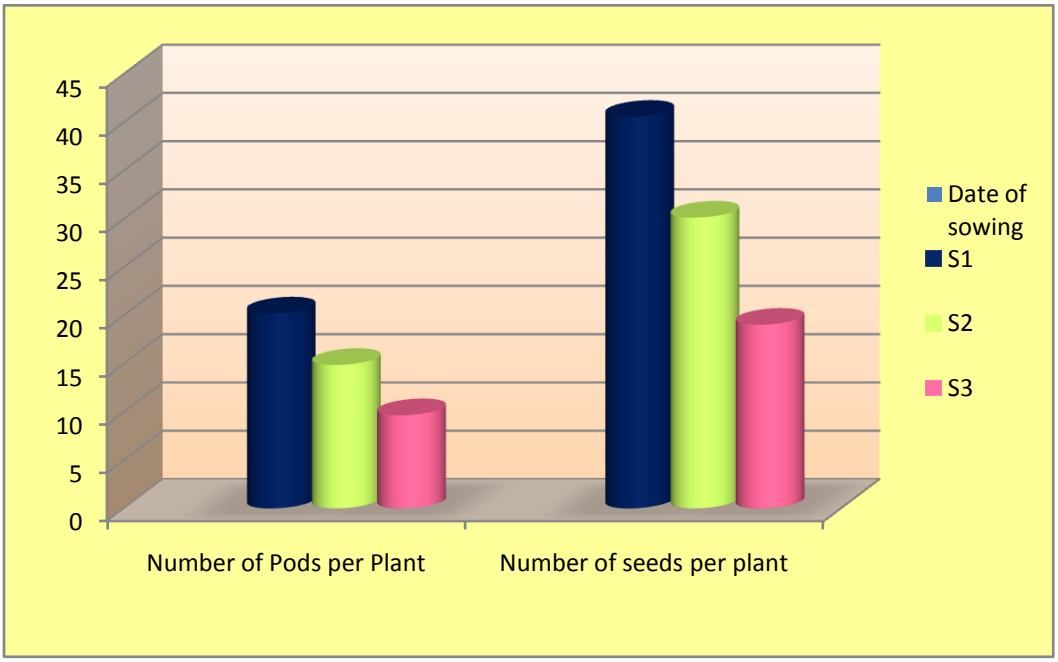
Treatment	No. of developed pods plant^{-1}	Pod weight plant^{-1} (g)	Seed weight plant^{-1} (g)	No. of seeds pod^{-1}	No. of seeds plant^{-1}
Date of sowing					
S_1 –MW 38	20.19	6.60	4.09	2.08	40.56
S_2 –MW 39	14.86	5.42	2.93	2.07	30.13
S_3 –MW 40	9.65	3.94	1.70	2.03	19.02
SE ±	0.53	0.11	0.05	0.04	1.14
CD at 5 %	2.09	0.43	0.19	NS	4.46
Varieties					
V_1 – JS-9560	18.14	6.09	3.61	1.85	32.95
V_2 – MAUS-612	17.04	5.91	3.43	2.03	33.89
V_3 – MAUS-162	12.84	4.76	2.38	2.21	28.08
V_4 – MAUS-71	11.57	4.53	2.20	2.15	24.70
SE ±	0.52	0.15	0.07	0.04	0.82
C.D. at 5 %	1.54	0.45	0.20	0.13	2.45
Interaction(SxV)					
SE ±	0.90	0.26	0.12	0.08	1.43
C.D. at 5 %	2.67	NS	0.34	NS	4.24
General mean	**14.90**	**5.32**	**2.91**	**2.06**	**29.90**

4.2.5.2 Varieties

The data presented in Table 22 showed that the mean number of developed pods plant^{-1} was influenced significantly by different varieties. Variety V_1 (JS-9560) (i.e. 18.14) recorded significantly more number of developed pods plant^{-1} than V_3 (MAUS-162) and V_4 (MAUS-71), Whereas, it was at par with V_2 (MAUS-612) (i.e. 17.04).

4.4.1.3 Interaction effect

Interaction effect between sowing dates and varieties of number of developed pods plant^{-1} of soybean is shown in Table number 22(a).



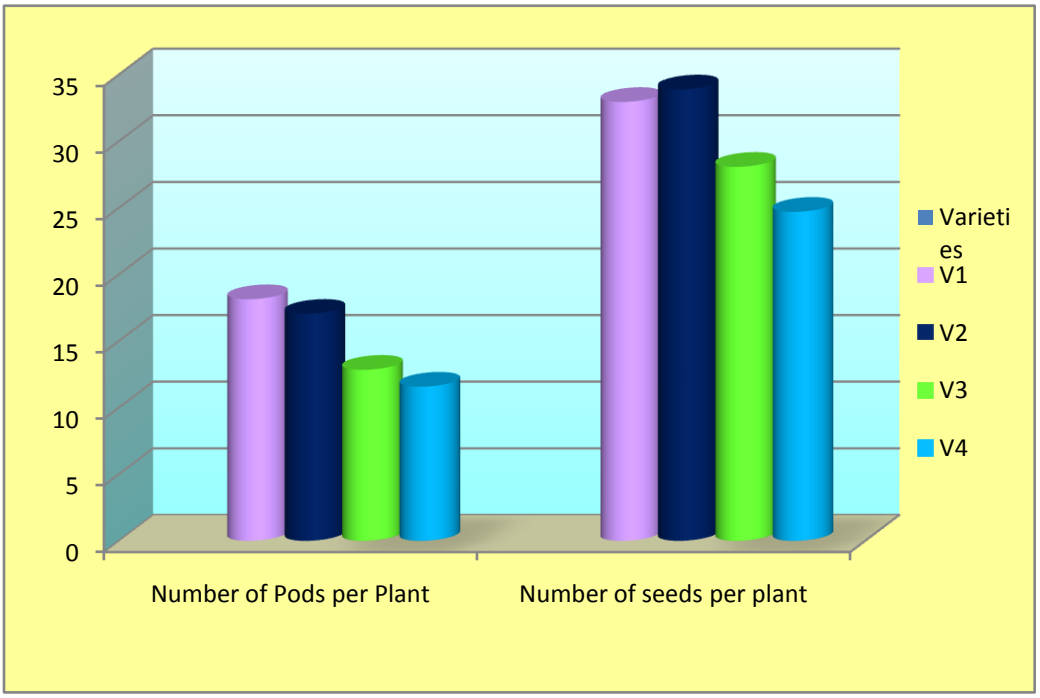


Fig.17: Number of pods plant^{-1} and number of seed plant^{-1} of soybean as influenced by different dates of sowing and varieties

Interaction between date of sowing S_1 (MW 38) and variety V_1 (JS-9560) (i.e. 22.42) recorded significantly more number of developed pods plant^{-1} over rest of the treatment combinations but was found at par with S_1V_2 (i.e. 21.74).

Table 22. (a) Interaction effects between dates of sowing and varieties on number of developed pods plant^{-1} of soybean

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	22.42	21.74	18.70	17.87
S_2 - MW 39	19.73	18.67	11.72	9.34
S_3 - MW 40	12.28	10.72	8.10	7.50
S.E. m $\pm$	0.90			
C.D. at 5 %	2.67			

4.4.1 Pod weight plant^{-1}

Data regarding weight of pods plant^{-1} affected by different varieties and dates of sowing are presented in Table 22 graphically represented in Fig. 18. The mean of pod weight plant^{-1}(g) was 5.32 g.

4.4.1.1 Dates of sowing

The data presented in Table 22 indicated that the crop sown in S_1 (MW 38) recorded higher pod weight (6.60 g plant^{-1}) and found to be significantly superior over the rest dates of sowing. Whereas, the lowest pod weight (3.94 g plant^{-1}) was recorded in S_3 (MW 40).

4.4.1.2 Varieties

Statistical analysis of soybean varieties showed significant results in respect of pod weight (g) plant^{-1} and presented in Table 22. The variety V_1 (JS-9560) recorded higher pod weight (i.e. 6.09 g plant^{-1}) and found significantly superior than variety V_3 (MAUS- 162) and V_4 (MAUS- 71) but was at par with variety V_2 (MAUS- 612) i.e. (5.91 g plant^{-1}).

4.4.1.3 Interaction effect

The interaction effect between date of sowing and varieties was found to be significant in influencing the pod weight (g) plant^{-1}.

Table 22 (b) Interaction effects between dates of sowing and varieties on weight of pods (g) plant^{-1} of soybean at harvest

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	7.35	7.27	6.04	5.74
S_2 - MW 39	6.25	5.85	4.89	4.62
S_3 - MW 40	4.68	4.53	3.34	3.22
S.E. m ±	0.05			
C.D. at 5 %	0.15			

Date of Sowing S_1 (MW 38) and variety V_1 (JS- 9560) recorded significantly the highest pod weight plant^{-1} of soybean (7.35 g) than rest of the treatment combinations and was at par with treatment combinations S_1V_2 (MW 38 and MAUS-612) (7.27 g) Table 22(b).

4.4.2 Seed weight plant^{-1}(g)

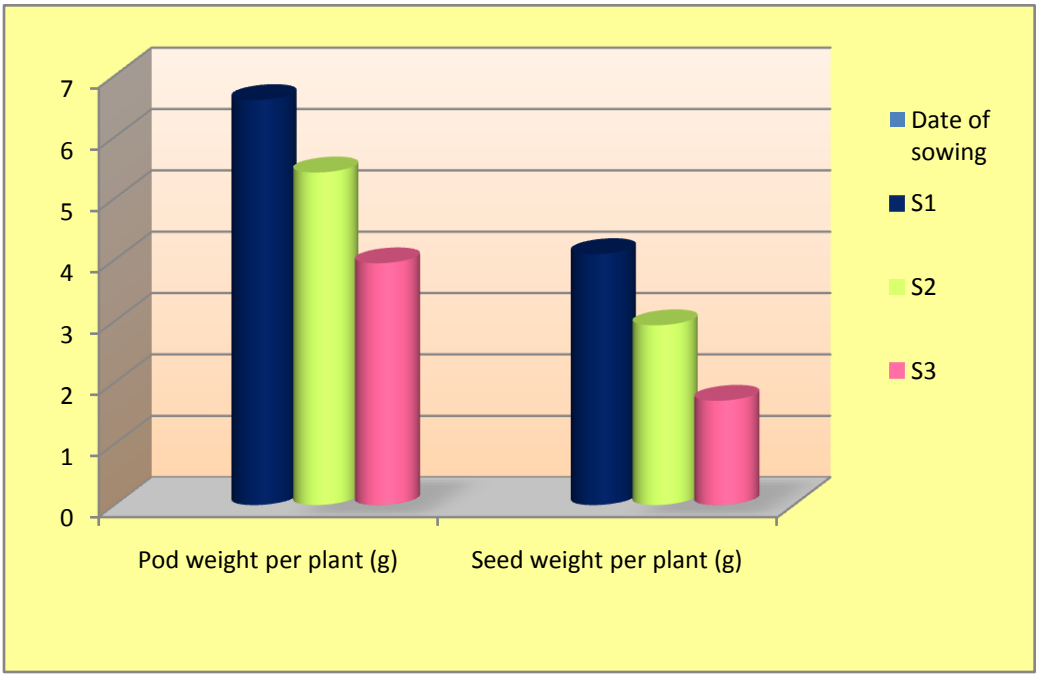
The data on weight of the seed plant^{-1} affected by different varieties and dates of sowing are presented in Table 22 graphically represented in Fig. 18. The mean seed weight plant^{-1} was 2.91 g.

4.4.2.1 Date of sowing

The data presented in Table 22 indicated that the crop sown in S_1 (MW 38) recorded higher seed weight (i.e.4.09 g) and found to be significantly superior over S_2 (MW 39) and S_3 (MW 40).

4.4.2.2 Varieties`

The data indicated that the maximum seed weight plant^{-1} (g) was noticed in variety V_1 (JS- 9560) (i.e. 3.61 g plant^{-1}) and found significantly



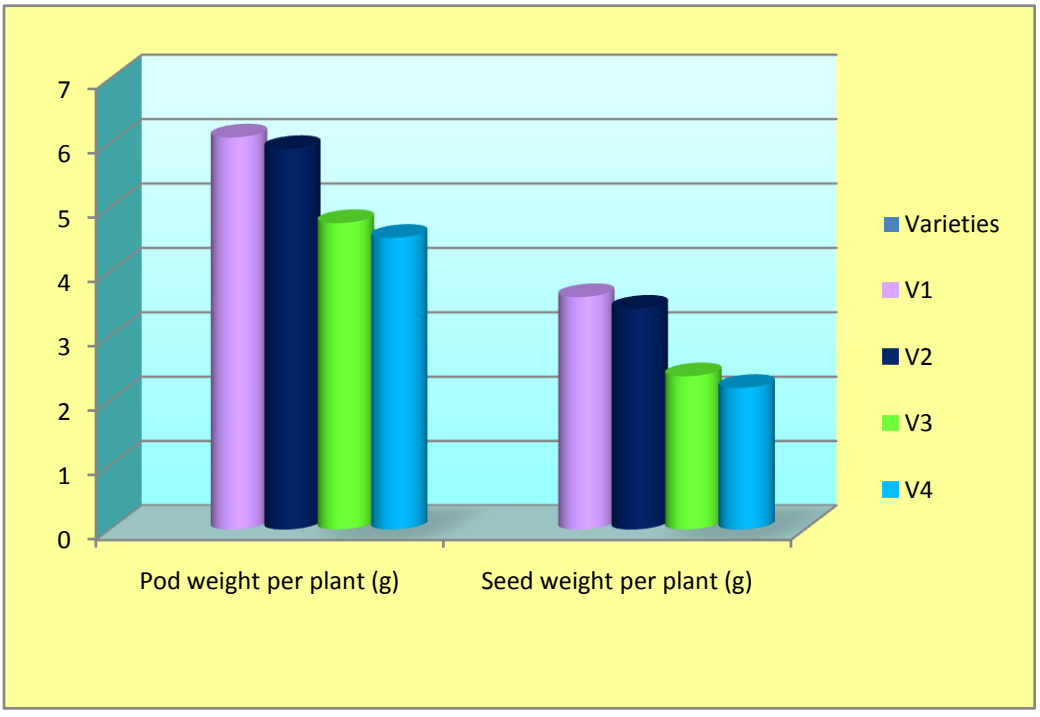


Fig.18: Pod and seed weight (g) plant^{-1} of soybean as influenced by different dates of sowing and varieties

superior than variety V_4 (MAUS- 162) and V_4 (MAUS- 71) but remain at par with variety V_2 (MAUS- 612) i.e. (3.43 g plant^{-1}).

4.4.2.3 Interaction effect

The interaction effects between date of sowing and varieties were found to be significant in influencing the seed weight plant^{-1}.

Sowing on S_1 (MW 38) with variety V_1 (JS- 9560) recorded significantly highest weight of seeds plant^{-1} (4.70 g) of soybean than rest of the treatment combinations and was at par with treatment combinations S_1V_2 (i.e. MW 38 and MAUS-612) (4.55 g) Interaction effect between sowing dates and varieties of seed weight plant^{-1} of soybean is shown in Table number 22(c).

Table 22 (c) Interaction effects between dates of sowing and varieties on weight of seed (g) plant^{-1} of soybean at harvest

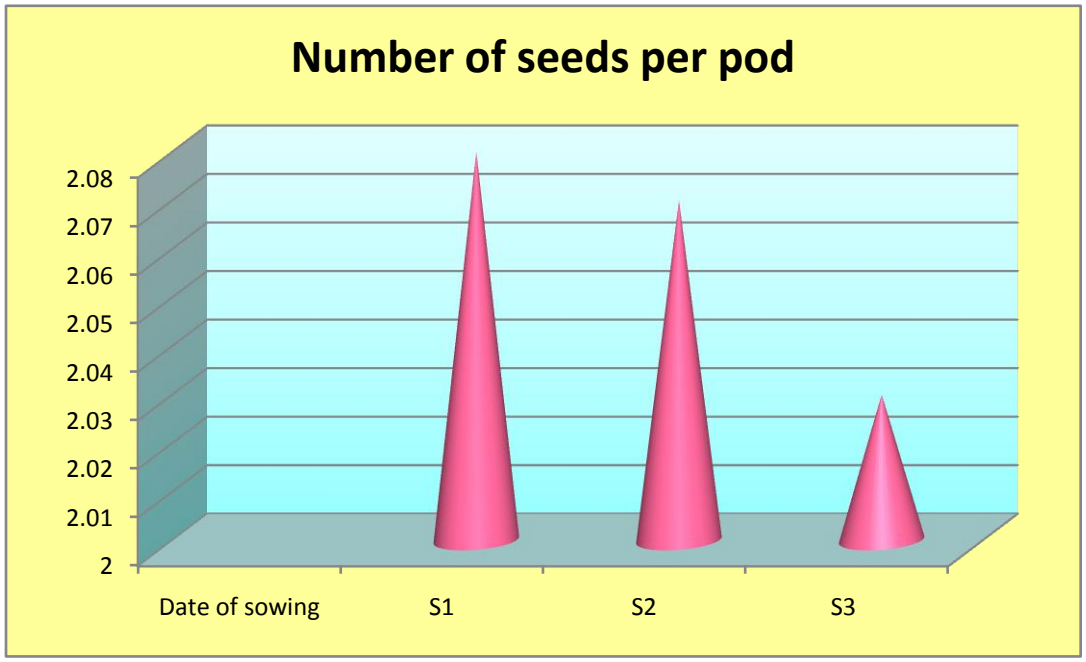
Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	4.70	4.55	3.64	3.46
S_2 - MW 39	3.97	3.82	2.12	1.80
S_3 - MW 40	2.18	1.90	1.39	1.34
S.E. m ±	0.12			
C.D. at 5 %	0.34			

4.4.3 Number of seeds pod^{-1}

The data on number of seeds pod^{-1} affected by different varieties and dates of sowing are presented in Table 22 graphically represented in Fig. 19. The mean number of seed per pods were 2.06.

4.4.3.1 Dates of sowing

The data presented in Table 20 indicated that the crop sown in S_1 (MW 38) recorded higher seed pods^{-1} (i.e.2.08) and found to be not significant in respect to dates of sowing.



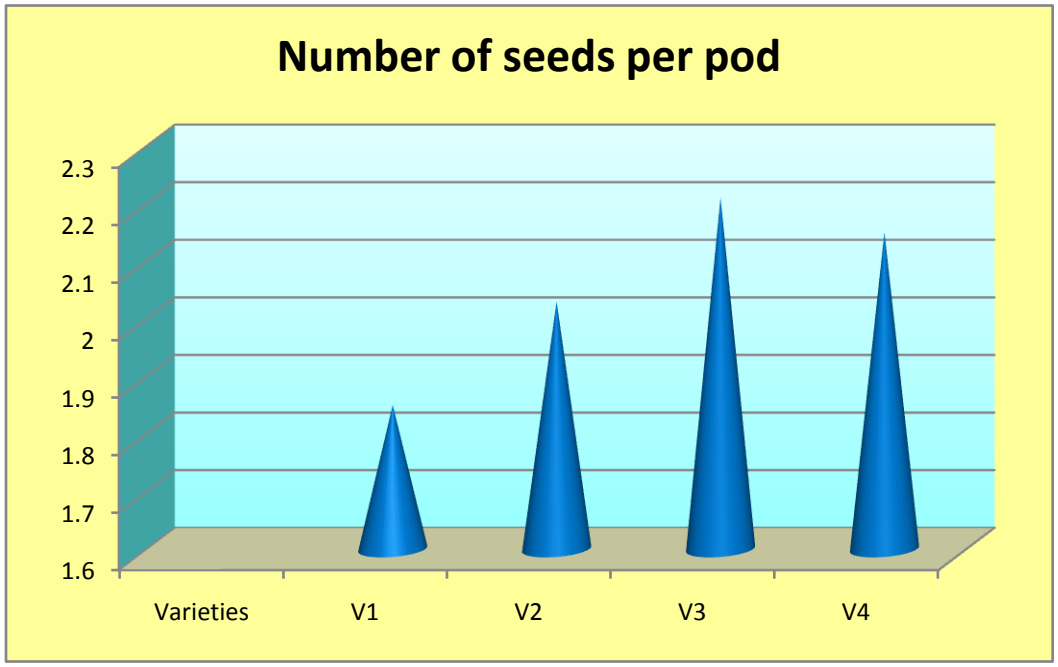


Fig.19: Number of seeds pod^{-1} of soybean as influenced by different dates of sowing and varieties

4.4.3.2 Varieties

The data revealed that the significantly maximum number of seeds pod^{-1} was noticed in variety V_3 (MAUS 162) which was at par with V_4 (MAUS- 74).

4.4.3.3 Interaction effect

The interaction effect between varieties and dates of sowing was found to be not significant.

4.4.4 Number of seeds plant^{-1}

The data on number of seed plant^{-1} affected by different varieties and dates of sowing are presented in Table 22 graphically represented in Fig. 17. The mean number of seeds plant^{-1} were 29.90.

4.4.4.1 Dates of sowing

The data presented in Table 22 indicated that the crop sown in S_1 (MW 38) recorded higher number of seeds plant^{-1} (i.e. 40.56 seed plant^{-1}) and found to be significantly superior over the rest dates of sowing.

4.4.4.2 Varieties

Data presented in Table 22 showed that variety V_2 (MAUS 612) recorded significantly maximum number of seeds plant^{-1} than V_3 (MAUS- 162) and V_4 (MAUS- 71) and remained at par with V_1 (JS- 9560) in respect to number of seeds plant^{-1}.

4.4.4.3 Interaction effect

The interaction effect between date of sowing and varieties was found to be significant in influencing the number of seeds plant^{-1}. Sowing on S_1 (MW 38) with variety V_2 (MAUS 612) recorded significantly highest number of seeds plant^{-1} (42.22) of soybean than rest of the treatment combinations and was at par with treatment combinations S_1V_3 (41.10), S_1V_1 (40.93) and S_1V_4 (37.98) Table 22(d)

Table 22 (d) Interaction effects between dates of sowing and varieties on number of seed plant^{-1} of soybean at harvest

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	40.93	42.23	41.10	37.98
S_2 - MW 39	36.17	37.78	26.32	20.26
S_3 - MW 40	21.76	21.65	16.79	15.85
S.E. m ±	1.43			
C.D. at 5 %	4.24			

4.5 Yield

Seed, straw and biological yields(kg ha^{-1}) and harvest index (%)

The data on mean seed, straw and biological yields (kg ha^{-1}) and harvest index (%) as influenced by different varieties and dates of sowing are quoted in Table 23 and graphically shown in Fig. 19.

4.5.1 Seed yield (kg ha^{-1})

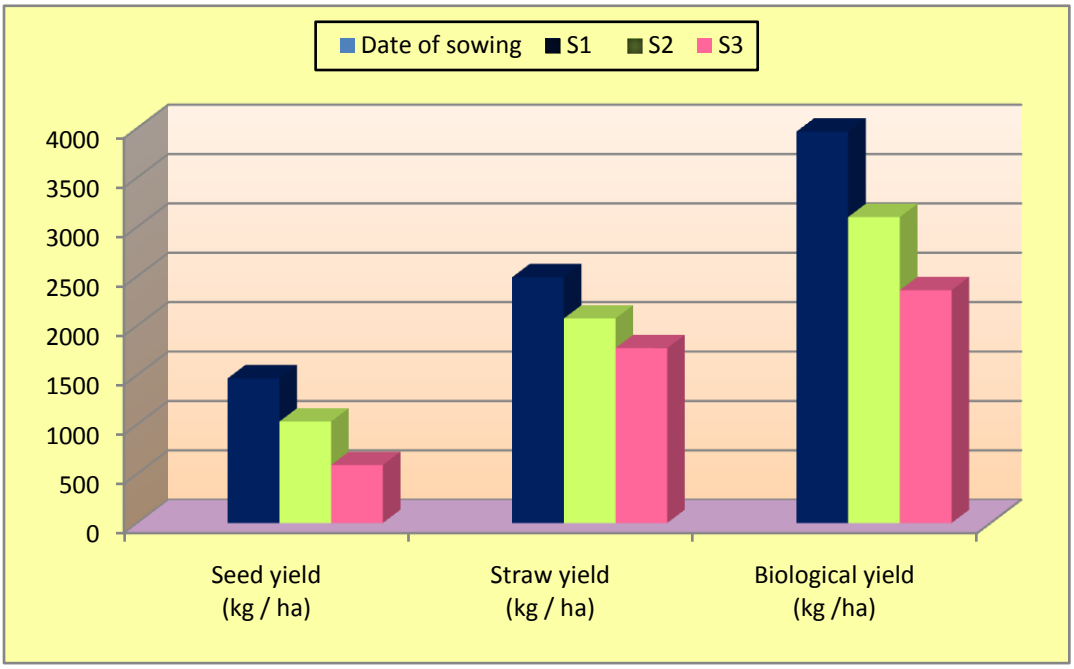
The data regarding seed yield was significantly influenced by different varieties and dates of sowing are presented in Table 23 and graphically represented in Fig. 20. The average seed yield was 1026.82 kg ha^{-1}.

4.5.1.1 Date of sowing

The data presented in Table 23 indicated crop sown in S_1 (MW 38) recorded maximum seed yield (i.e. 1465.79 kg ha^{-1}) and found to be significantly superior over S_2 (MW 39) and S_3 (MW 40).

4.5.1.2 Varieties

Statistical analysis of soybean varieties showed significant results and presented in Table 23. Variety V_1 (JS- 9560) produced higher seed yield (i.e. 1269.95 kg ha^{-1}) and found significantly superior over the variety V_3 (MAUS-



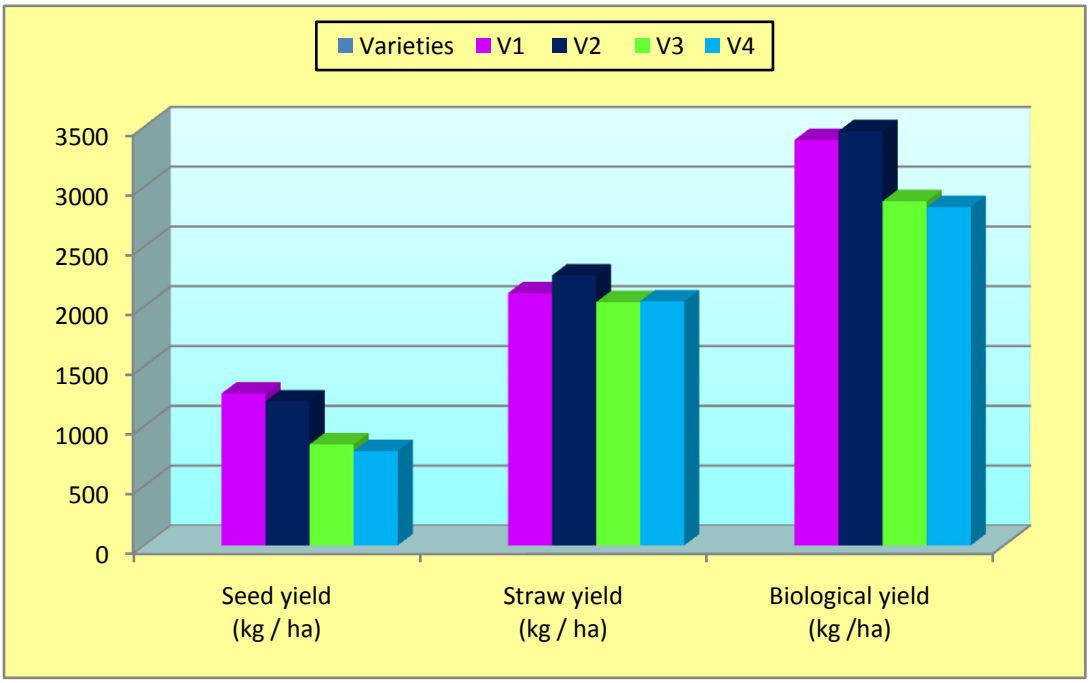


Fig.20: Seed, Straw and biological yield (kg ha^{-1}) of soybean as influenced by different dates of sowing and varieties

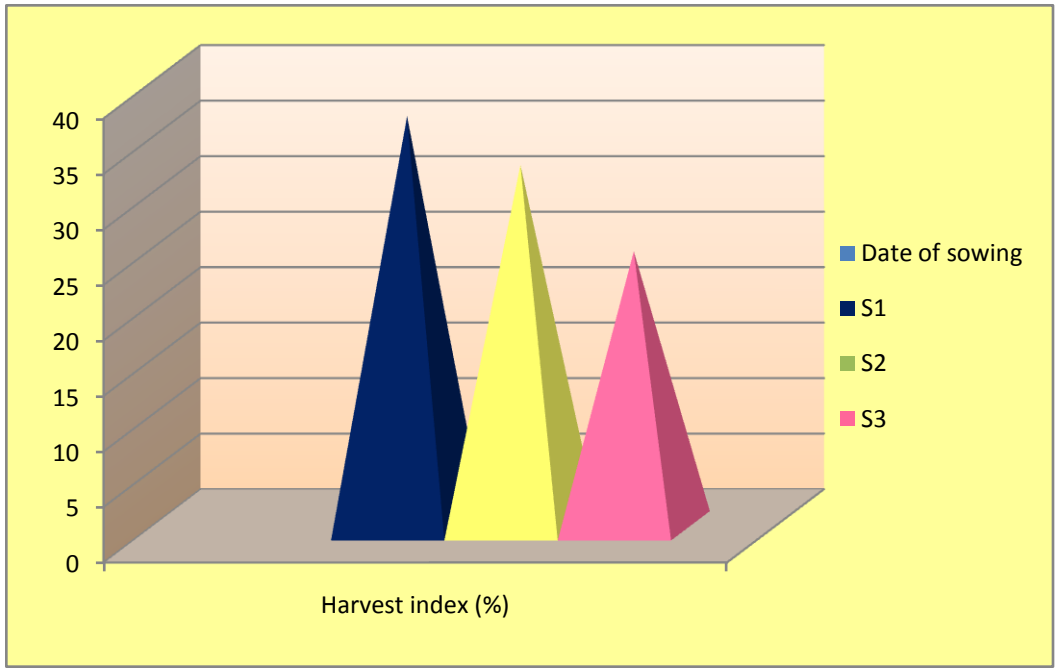
162) and V_4 (MAUS- 71) and remain at par with V_2 (MAUS 612) (i.e. 1204.26 kg ha^{-1}).

Table 23: Mean seed, straw and biological yields (kg ha^{-1}) and harvest index (%) of soybean as influenced by different treatments

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Date of sowing				
S_1 –MW 38	1465.79	2489.09	3964.88	36.96
S_2 –MW 39	1027.71	2071.11	3098.82	33.16
S_3 –MW 40	586.97	1771.13	2358.10	24.89
SE $\pm$	26.69	39.96	73.27	--
CD at 5 %	104.79	156.86	287.64	--
Varieties				
V_1 – JS-9560	1269.95	2109.06	3390.12	37.46
V_2 – MAUS-612	1204.26	2257.91	3464.39	34.76
V_3 – MAUS-162	844.60	2033.72	2878.32	29.34
V_4 – MAUS-71	788.49	2041.07	2829.56	27.86
SE $\pm$	27.72	20.65	35.00	--
C.D. at 5 %	82.35	61.34	103.99	--
Interaction (SxV)				
SE $\pm$	48.01	35.76	60.62	--
C.D. at 5 %	142.64	106.25	180.11	--
General mean	**1026.82**	**2110.44**	**3140.60**	**32.89**

4.5.1.3 Interaction effect

The interaction effect between dates of sowing and varieties was found to be significant in influencing seed yield (kg ha^{-1}) and is presented in Table 23 (a). The significantly higher seed yield (1671.11 kg ha^{-1}) was recorded with combination of S_1V_1 i.e. date of sowing 'MW 38' (S_1) and variety 'JS-9560' (V_1) over other treatment combinations and it was at par with S_1V_2 (i.e. MW 38 (S_1) and variety MAUS-612 (1618.05 kg ha^{-1}).



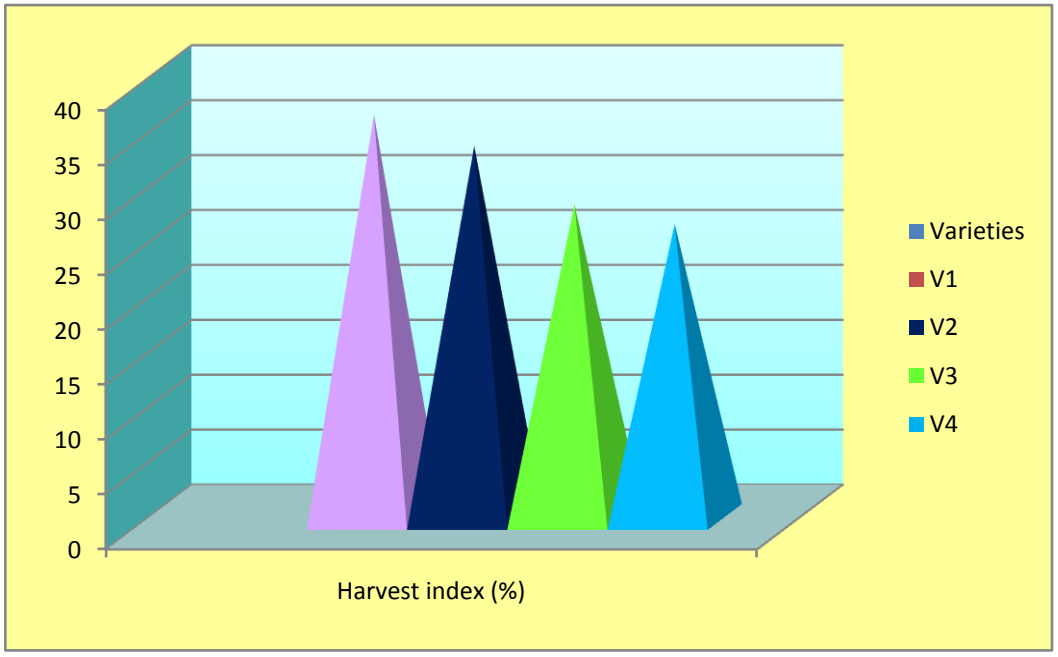


Fig. 21: Harvest index (%) of soybean as influenced by different dates of sowing and varieties

Table 23 (a) Interaction effects between dates of sowing and varieties on seed yield (kg ha^{-1}) of soybean

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	1671.11	1618.05	1312.13	1261.85
S_2 - MW 39	1384.39	1334.66	749.15	642.65
S_3 - MW 40	754.35	660.05	472.52	460.96
S.E. m ±	48.01			
C.D. at 5 %	142.64			

4.5.2 Straw yield

The data regarding straw yield was significantly influenced by different dates of sowing and varieties are presented in Table 23. The mean straw yield was (i.e. 2110.44 kg ha^{-1}).

4.5.2.1 Dates of sowing

The data presented in Table 23 indicated that crop sown in S_1 (MW 38) recorded higher straw yield (i.e. 2489.09 kg ha^{-1}) and found to be significantly superior over S_2 (MW 39) and S_3 (MW 40).

4.5.2.2 Varieties

Straw yield of soybean was influenced significantly by different varieties showed significant results and presented in Table 23. Data revealed that variety V_2 (MAUS 612) produced higher straw yield (i.e. 2257.91 kg ha^{-1}) and found significantly superior than the variety V_1 (JS- 9560), V_3 (MAUS- 162) and V_4 (MAUS- 71).

4.5.2.3 Interaction effect

The interaction effect of date of sowing and varieties in influencing straw yield (kg ha^{-1}) is presented in Table 23 (b).The interaction effect between

dates of sowing and varieties was found to be significant in influencing the straw yield of soybean. Interaction effects between date of sowing S_1 (MW 38) and V_2 (MAUS 612) recorded significantly the highest straw yield (2621.15 kg ha^{-1}) of soybean over rest of the treatment combinations.

Table 23 (b) Interaction effects between dates of sowing and varieties straw yield (kg ha^{-1}) of soybean

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	2436.12	2621.15	2488.45	2410.67
S_2 - MW 39	2040.62	2201.67	1987.97	2054.15
S_3 - MW 40	1850.43	1950.92	1624.77	1658.40
S.E. m ±	35.76			
C.D. at 5 %	106.25			

4.5.3 Biological yield

The data regarding biological yield was significantly influenced by different dates of sowing and varieties are presented in Table 23. The mean biological yield was (i.e. 3140.60 kg ha^{-1}).

4.5.3.1 Dates of sowing

The data presented in Table 23 indicated crop sown in S_1 (MW 38) recorded higher biological yield (i.e. 3964.88 kg ha^{-1}) and found to be significantly superior over S_2 (MW 39) and S_3 (MW 40).

4.5.3.2 Varieties

Biological yield of soybean was influenced significantly by different varieties showed significant results and presented in Table 23. Data revealed that variety V_2 (MAUS 612) produced higher biological yield (i.e. 3464.39 kg ha^{-1}) and found significantly superior than the variety V_3 (MAUS- 162) and V_4 (MAUS- 71) but remained at par with V_1 (JS- 9560) (i.e. 3390.12 kg ha^{-1}).

4.5.3.3 Interaction effect

The interaction effect between dates of sowing and varieties were found to be significant in influencing the biological yield of soybean and is presented in Table 23 (c).

Table 23 (c) Interaction effects between dates of sowing and varieties on Biological yield (kg ha^{-1}) of soybean

Varieties / Date of sowing	V_1 JS – 9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	4140.56	4245.87	3800.57	3672.52
S_2 - MW 39	3425.01	3536.33	2737.12	2696.80
S_3 - MW 40	2604.78	2610.97	2097.28	2119.36
S.E. m ±	61.60			
C.D. at 5 %	183.04			

4.5.4 Harvest index

The data regarding harvest index was not statistically analyzed and inference were found on mean values and presented in Table 23 graphically represented in Fig. 21. The mean harvest index was 32.89 %.

4.5.4.1 Dates of sowing

The sowing dates S_1 (MW 38) recorded more harvest index i.e. 36.96 % than S_2 (MW 39) and S_3 (MW 40).

4.5.4.2 Varieties

The variety V_1 (JS- 9560) recorded more harvest index (i.e.37.46 %) followed by V_2 (MAUS 612) and V_3 (MAUS- 162) i.e. 34.76 % and 29.34 % respectively. Lowest index i.e. 27.86 % was recorded in V_4 (MAUS- 71).

4.6 Economics of soybean

The data on economics viz., gross monetary return, net monetary return and benefit cost ratio of soybean as influenced by different dates of sowing and varieties are showed in Table 24.

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

The data on gross monetary returns as influenced by different treatments were represented in above table. The mean gross monetary returns recorded were 31339 Rs.ha^{-1}.

Table 24: Gross and Net monetary returns (Rs ha^{-1}) and B: C ratio of soybean as influenced by treatments.

Treatment	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C ratio
Date of sowing			
S_1 –MW 38	44731	18151	1.69
S_2 –MW 39	31365	4786	1.19
S_3 –MW 40	17920	-8660	0.68
SE +	813	163	--
CD at 5 %	3194	640	--
Varieties			
V_1 – JS-9560	38754	11855	1.44
V_2 – MAUS-612	36752	10492	1.40
V_3 – MAUS-162	25780	-719	0.99
V_4 – MAUS-71	24069	-2591	0.91
SE +	845.	262	--
C.D. at 5 %	2511	779	--
Interaction (SxV)			
SE +	1463	454	--
C.D. at 5 %	4349	1349	--
General mean	**31339**	**4759**	**1.18**

4.6.1.1 Dates of sowing

The data from Table 24 revealed that dates of sowing differed significantly in respect of gross monetary returns. The sowing dates S_1 (MW 38) recorded significantly superior gross monetary returns (i.e. 44731 Rs. ha^{-1}) over S_2

(MW 39) and S_3 (MW 40). The date of sowing S_3 (MW 40) recorded significantly least gross monetary returns (17920 Rs. ha^{-1}).

4.6.1.2 Varieties

The effect of varieties on gross monetary returns was found to be significantly influenced by different varieties. The variety V_1 (JS- 9560) (i.e. 38754.62 $Rs.ha^{-1}$) recorded significantly superior gross monetary returns over the varieties V_3 (MAUS- 162) and V_4 (MAUS- 71) and was at par with V_2 (MAUS-612). The lowest gross monetary returns were recorded by V_4 (MAUS- 71) (i.e. 24069.25 $Rs.ha^{-1}$).

4.6.1.3 Interaction effect

The interaction effect between dates of sowing and varieties was found to be significant in influencing the gross monetary returns and presented in Table 24 (a).

Table 24 (a) Interaction effects between dates of sowing and varieties on Gross monetary returns (Rs. ha^{-1}) of soybean

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	50993	49376	40044	38510
S_2 - MW 39	42244	40729	22868	19621
S_3 - MW 40	23026	20151	14428	14075
S.E. m ±	1463			
C.D. at 5 %	4349			

Sowing in S_1 (MW 38) with variety JS-9560 (V_1) recorded significantly higher gross monetary returns (50993 Rs/ha) over other combinations and was at par with S_1V_2 (MW 38 and MAUS- 612) (i.e. 49376 (Rs. ha^{-1}).

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

The data on net monetary returns as influenced by different treatments is represented in Table 24. The mean net monetary returns recorded were 4759 Rs. ha^{-1}.

4.6.2.1 Dates of sowing

The data revealed that dates of sowing differed significantly in respect of net monetary returns. The sowing dates S_1 (MW 38) recorded significantly superior net monetary returns (i,e. 18151 Rs. ha^{-1}) over S_2 (MW 39) and S_3 (MW 40). The date of sowing S_3 (MW 40) recorded significant loss in net monetary returns (-8660 Rs. ha^{-1}).

4.6.1.2 Varieties

The effect of varieties on net monetary returns was found to be significant. A variety V_1 (JS- 9560) (i.e. 11855 Rs. ha^{-1}) recorded significantly superior net monetary returns over the varieties V_3 (MAUS- 162) and V_4 (MAUS-71) and was at par with V_2 (MAUS- 612). The loss in net monetary returns was recorded by V_4 (MAUS- 71) (i.e. -2591 Rs. ha^{-1}).

4.6.1.3 Interaction effect

The combined effect between varieties and dates of sowing was found to be significant in influencing the net monetary returns is presented in Table 24 (b).

Sowing in S_1 (MW 38) with variety V_1 (JS- 9560) found significantly superior net monetary returns (24094 Rs. ha^{-1}) over other combinations but it was at par with variety V_2 (MAUS-612) sown during same week.

Table 24 (b) Interaction effects between date of sowing and varieties on net monetary returns (Rs. ha^{-1}) of soybean

Varieties / Date of sowing	V_1 JS–9560	V_2 MAUS-612	V_3 MAUS-162	V_4 MAUS-71
S_1 - MW 38	24094	23117	13545	11851
S_2 - MW 39	15344	14469	-3631	-7039
S_3 - MW 40	-3874	-6109	-12072	-12584
S.E. m ±	454			
C.D. at 5 %	1349			

4.6.3 B : C Ratio

The data on mean harvest index (%) as influenced by different treatments were represented in Table 24. The data regarding B:C ratio was not statistically analyzed and inference were found on mean values The mean B:C ratio was 1.18.

4.6.3.1 Date of sowing

The data presented in Table 24 revealed that sowing with S_1 (MW 38) recorded the highest B:C ratio (1.69) followed by S_2 (MW 39) and S_3(MW 40). And the lowest B:C ratio was recorded with sowing date S_3 (MW 40) (i.e. 0.68).

4.6.3.2 Varieties

Amongst varieties, V_1 (JS-9560) recorded significantly higher B:C ratio (1.44) followed by V_2 (MAUS-612) and V_3 (MAUS-162). Variety V_4 (MAUS-71) recorded lowest B:C ratio (0.91).

4.7 Quality Studies

4.7.1 Test weight (g)

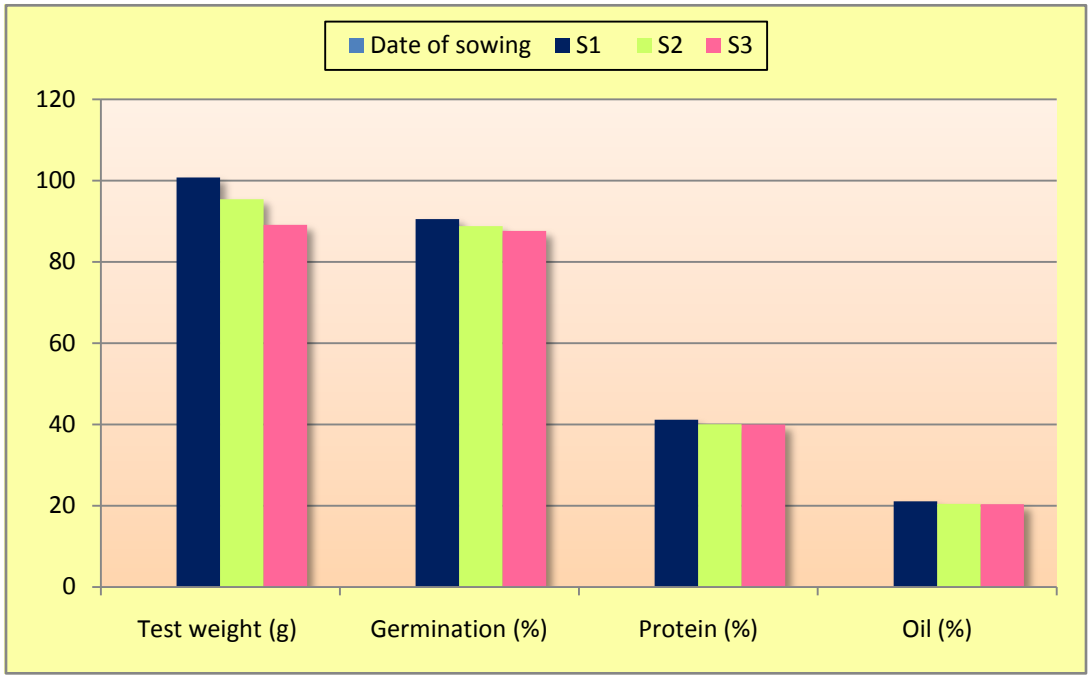
The data on mean test weight (1000 seeds weight) g as influenced by different treatments is presented in Table 25 graphically represented in Fig. 22. The mean test weight of seeds was 95.08 g.

Table 25: Test weight (g), seed germination (%), Oil content (%) and protein content (%) of soybean as influenced by different treatments.

Treatment	Test weight (g)	Seed germination (%)	Protein content (%)	Oil content (%)
Date of sowing				
S_1 –MW 38	100.75	90.47	41.08	21.03
S_2 –MW 39	95.40	88.71	40.02	20.42
S_3 –MW 40	89.08	87.60	39.94	20.34
SE $\pm$	1.31	0.89	0.37	0.18
CD at 5 %	5.13	NS	NS	NS
Varieties				
V_1 – JS-9560	110.56	90.18	40.32	21.01
V_2 – MAUS-612	97.22	88.31	40.51	20.62
V_3 – MAUS-162	84.42	88.20	39.93	19.97
V_4 – MAUS-71	88.10	89.01	40.61	20.78
SE $\pm$	2.14	1.00	0.21	0.25
C.D. at 5 %	6.35	NS	NS	NS
Interaction (SxV)				
SE $\pm$	3.70	1.73	0.36	0.44
C.D. at 5 %	NS	NS	NS	NS
General mean	**95.08**	**88.93**	**40.34**	**20.60**

4.7.1.1 Date of sowing

The mean test weight (1000 seeds weight) g was influenced significantly by sowing dates. Sowing on V_1 (MW 38) recorded significantly highest test weight (100.75 g) of seeds over rest of the sowing dates. Soybean crop



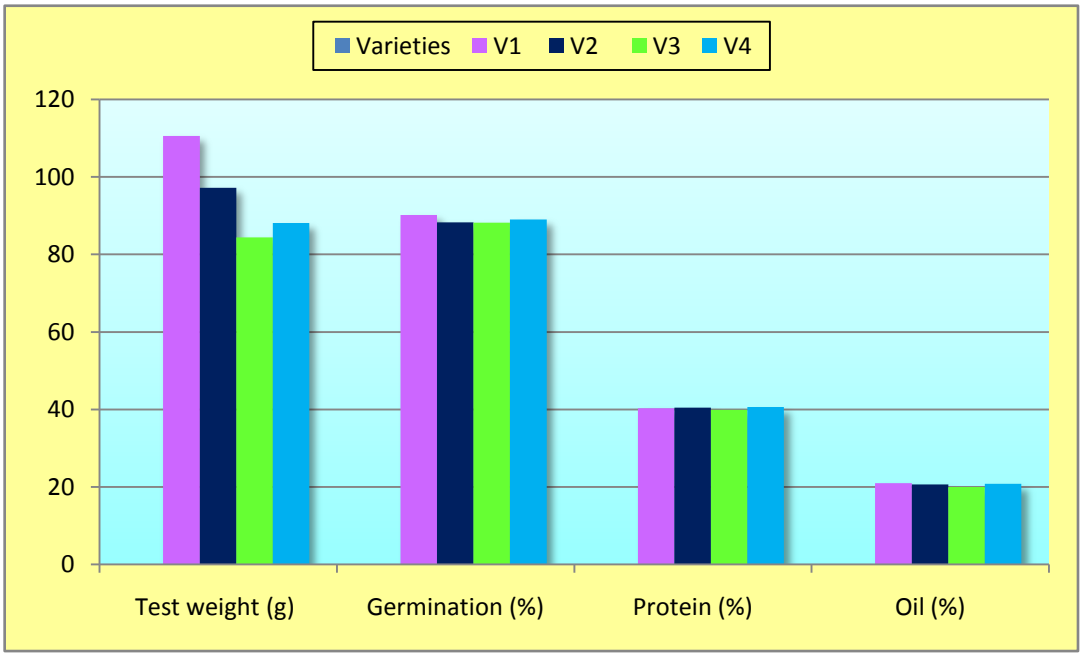


Fig. 22: Test weight, seed germination (%), Protein content (%) and Oil content of soybean as influenced by different dates of sowing and varieties

sown on MW 40 (V_3) recorded significantly the lowest test weight of seeds (89.08 g).

4.7.1.2 Varieties

V_1 (JS-9560) recorded the highest seed test weight (110.56 g) and found significantly superior over V_2 (MAUS-612) and V_3 (MAUS-162). However, variety MAUS-71 (V_4) gave the lowest seed test weight (88.10 g).

4.7.1.3 Interaction Effect

The interaction effect between dates of sowing and varieties was found to be non significant in influencing test weight (1000 seeds weight) g of soybean.

4.7.2 Seed germination (%)

The data on mean seeds germination (%) as influenced by different treatments is presented in Table 25 graphically represented in Fig. 22. The mean seeds germination % was 88.93%.

4.7.2.1 Date of sowing

The data on seed germination (%) was satisfactory but not significantly influenced by different dates of sowing**.**

4.7.2.2 Varieties

The data on seed germination (%) was satisfactory but not significantly influenced by different varieties**.**

4.7.3 Protein content (%)

The data on mean protein content (%) as influenced by different treatments is presented in Table 25 graphically represented in Fig. 22. The mean protein content (%) was 40.34 %.

4.7.3.1 Date of sowing

Data presented in Table 25 revealed that the protein content (%) of soybean was not significantly influenced due to different dates of sowing.

4.7.3.2 Varieties

Data presented in Table 25 revealed that the protein content (%) of soybean was not significantly influenced due to different varieties.

4.7.4 Oil Content (%)

The data on mean oil content (%) as influenced by different treatments is presented in Table 25 graphically represented in Fig. 22. The mean oil content (%) was 20.60 %.

4.7.4.1 Date of sowing

Data presented in Table 25 revealed that the oil content (%) of soybean was not significantly influenced due to different dates of sowing.

4.7.4.2 Varieties

Data presented in Table 25 revealed that the oil content (%) of soybean was not significantly influenced due to different varieties.

Discussion

CHAPTER -V

DISCUSSION

The present investigation entitled "Performance of soybean (*Glycine max* L.) varieties in post monsoon under varied weather conditions." was carried out in *post monsoon* season 2017 at Department of Agronomy, College of Agriculture, VNMKV, Parbhani. The results of present investigation are discussed in brief under following sub-heads.

5.1 Weather

The meteorological data of experimental period indicated that the weather prevailed during the crop growth period was normal. The total rainfall received during crop growth period was 189.20 mm distributed over 10 rainy days. The sowing of soybean was successfully done on three dates of sowing according to meteorological weeks in post monsoon 2017.

The mean maximum and minimum temperature prevailed during crop growth period were 30.9C^0 and 14.9C^0, respectively. Morning and evening mean relative humidity was 78.2 per cent and 39.5 per cent, respectively.

The mean maximum BSS during crop growth period was 8.0 (Hrs.) and mean EVP during crop growth period was 4.4 (mm).

5.2 Soil

The mechanical and chemical analysis of experimental soil revealed that the soil of the experiment plot was clayey in texture (53.60 per cent clay), slightly alkaline in reaction (pH 7.8), low in available nitrogen (186.50 kg ha^{-1}), medium in available phosphorus (12.90 kg ha^{-1}) and rich in available potassium (518.70 ha^{-1}). (Table 2) Indicating that soil was good for growth of the crop.

5.3 Crop growth and development

Growth and development of soybean was studied periodically. The vegetative and reproductive development of the crop resulted into economic yield was the ultimate outcome of the growth, which was continuously influenced by interaction between environment and plant physiological process.

The critical scrutiny of data on different growth parameters and yield attributes recorded periodically showed that growth of soybean crop can be divided into three growth phases as below:

1. Emergence to early vegetative growth up to 30 days.
2. Grand growth phase from 31 to 60 days.
3. Reproductive phase from 61 days onward up to the harvest.

The growth and yield attributes recorded at different growth phases are discussed here at a glance.

The first growth phase started from sowing to 15 DAS in which the growth was slow in respect of plant height, number of leaves plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1}, total dry matter accumulation plant^{-1} and number of pods plant^{-1}.

Plant height increased continuously up to harvest. The rate of increase in plant height was fast up to 45 days after sowing and comparatively lower in later stage of crop growth. The mean plant height was 16.06 cm (60.30 % of maximum) at 30 DAS and increased to 25.06 cm (94.10 % of maximum) at 60 DAS and recorded highest at harvest i.e. 26.63 cm.

Number of leaves and leaf area plant^{-1} were maximum 10.65 and 5.43 dm^2 respectively at 60 DAS and reduced thereafter due to leaf senescence.

Number of branches plant^{-1} were recorded increased in between 30 to 75 DAS (0.77 to 1.92), and it was constant till harvest.

The rate of increase in number of pods plant^{-1} was progressive in between 60-75 days (10.74 to 14.90) and it was constant at harvest.

Dry matter accumulation of stem per plant was 0.65 g (19.63 %) at 30 days, which was increased to 3.31 g at harvest.

Dry matter accumulation of leaves per plant was 0.51 g (24.05 %) at 15 days, which was increased to 2.12 g at 60 DAS and reduced thereafter due to leaf senescence.

Dry matter accumulation of pods per plant was 0.77 g (14.47 %) at 45 days, which was increased to 5.32 g at harvest.

Total dry matter accumulation per plant was 1.15g (13.31 %) at 15 days, which was increased to 8.64 g at harvest.

5.4 Treatment effects

With a vision to get a broader outline about the growth pattern of the soybean crop, an extract of related information on growth and yield attributing characters as well as yield and quality of soybean as influenced by different date of sowing and soybean varieties are presented in Tables 26 and 27, respectively.

5.4.1 Dates of sowing

Mean emergence count and final plant stand were 81.69 % and 78.92 %, respectively. The differences were found to be non- significant.

The different dates of sowing showed substantial effect on various growth parameters of soybean crop *viz.*, plant height, number of functional leaves plant^{-1}, leaf area plant^{-1}, number of branches plant^{-1} and dry matter accumulation plant^{-1}.

The date of sowings differed significant regarding plant height except at 15 and 30 DAS, where it was found to be non- significant. This might be due to more competition to get sunlight. The rate of increase in plant height of the crop was maximum during 30-75 DAS in all the date of sowings indicating grand growth of the crop. The dates of sowing S_1 (MW 38) recorded comparatively tallest plants over the other dates of sowing at all stages growth of crop. The lowest plant height was recorded in S_3 (MW 40) at all growth stages of crop. This might be due to temperature variation when crop is sown late at S_3 (MW 40). The greater plant height recorded in

S_1 (MW 38) was probably due to comparatively longer growing period along with the optimum environmental conditions. These results are in conformity with Akter *et al.* (2016).

The difference in percentage of plant height plant^{-1} among the first dates of sowing to the last dates of sowing was calculated and it was 15.92 % at 45DAS, 15.87 % at 60 DAS, and 16.20 % at 75 DAS and at harvest. Hari Ram *et al.* (2010) also reported significant differences in plant height due to different dates of sowing.

The growth characters like number of functional leaves and leaf area (dm^2) plant^{-1} increased rapidly up to 60 DAS and suddenly decreased thereafter due to leaf senescence. The number of functional leaves and leaf area (dm^2) plant^{-1} was influenced by different dates of sowing and found significant superior over the rest of sowing dates under the S_1 (MW 38) at all the growth stages. The lowest number of functional leaves and leaf area (dm^2) plant^{-1} has recorded with the dates sowing S_3 (MW 40).

The difference in percentage of number of functional leaves plant^{-1} among from the first dates of sowing to the last dates of sowing was calculated and it was 3.12 % at 30 DAS, 9.09 % at 45 DAS, 27.68 % at 60 DAS, and 16.64 % at 75 DAS. Similar result was reported by Lodh (1994) and Sultana *et al.* (2017).

Dates of sowing also influenced by the number of branches plant^{-1}. Branching initiated after 15 DAS and increased progressively up to 75 DAS and remained constant thereafter up to harvest. Crop sown during S_1 (MW 38) recorded more number of branches plant^{-1} at all the growth stages and there was significantly less number of branches were produced by late sown soybean S_2 (MW 39) and S_3 (MW 40). Similar reduction in number of branches plant^{-1} under late sowing was observed by Ramani *et al.* (1996).

The difference in percentage of number of branches plant^{-1} from the first dates of sowing to the last dates of sowing was calculated and

it was 0.02 % at 30 DAS, 32.42 % at 45 DAS, 31.30 % at 60 DAS, and 30.73 % at 75 DAS. In earlier dates of sowing similar result was reported by Sultana *et al*. (2017).

The dates of sowing played a conspicuous role in total dry matter accumulation stem, leaf, pods and total dry matter plant^{-1}. Dry matter accumulation of stem plant^{-1} increased continuously up to harvest of the crop. Significantly highest dry matter of stem plant^{-1} was recorded by the dates of sowing S_1 (MW 38) than other late sowings at all growth stages of soybean crop.

Similarly, dry matter accumulation of leaves plant^{-1} increased rapidly up to 60 DAS and gradually decreased thereafter due to leaf senescence. The dates of sowing S_1 (MW 38) has recorded significantly highest dry matter of leaves plant^{-1} than other late sowings at all the growth stages of soybean crop. .

Mean dry matter production of pods plant^{-1} was increased progressively up to harvest of the crop. The rate of dry matter accumulation of the pods plant^{-1} was faster during 60 to 75 DAS. The dates of sowing S_1 (MW 38) recorded significantly the highest dry matter of leaves plant^{-1} than other late sowings at all the growth stages of soybean crop.

The rate of increase in total dry matter accumulation plant^{-1} was comparatively slow during early period of 30 to 45DAS and become faster during 45to 75 DAS due to grand growth of crop with maximum number of leaves, branches and pods during this period.

The difference in percentage of total dry matter accumulation plant^{-1} from the first dates of sowing to the last dates of sowing was calculated and it was 21.69 % at 30 DAS, 33.63 % at 45 DAS, 33.18 % at 60 Das, 34.34 % at 75 DAS and 34.00 % at harvest. The dates of sowing S_1 (MW 38) has recorded significantly highest total dry matter plant^{-1} and there was significant reduction in total dry matter accumulation plant^{-1} at every late sowing date at all the growth stages of soybean crop. The lowest dry matter plant^{-1} was recorded in dates of sowing S_3 (MW 40). These

results are in the confirmation with the findings of Kausale (2000) and Asewar *et al*. (2015).

The different dates of sowing exerted significant effect and mean number of pods plant^{-1}. The dates of sowing S_1 (MW 38) recorded maximum number of pods plant^{-1} as compared to S_2 (MW 38) and S_3 (MW 40) at all the growth stages of soybean crop. The dates of sowing S_3 (MW 40) recorded the lowest number of pods plant^{-1} at all the growth stages of crop. The lowest number of pods plant^{-1} recorded under the dates of sowing S_3 (MW 40) due to less branching and delayed dates of sowing and light for comfortable crop growth. Similar results were reported by Raj Singh *et al.* (2010), Jaybhay *et al.* (2015) and Sultana *et al*. (2017).

The difference in percentage of number of pods plant^{-1} among from the first dates of sowing to the last dates of sowing was calculated and it was 25.38 % at 45 DAS, 52.79 % at 60 DAS, 52.20 % 75 DAS and at harvest. Similar reduction in number of pods plant^{-1} due to unfavourable climate with delayed sowings were onserved by Barik and Sahoo (1989), Pramila Rani (1999) and Shaikh *et al*. (2011).

The data on growth indices like AGR (plant height and dry matter) and RGR were highest during 31 to 45 DAS and declined later on. This indicates that's the grand growth period of crop was between 31-45 DAS. AGR (plant height and dry matter) and RGR were higher with date of sowing S_1 (MW 38) at all the stages growth and last sowing date S_3 (MW 40) recorded lowest values AGR and RGR. Similar reduction in AGR and RGR with delayed sowing of soybean was found by Kausale (2000) and Astha and Singh (2016)

The mean leaf area index (LAI) was recorded highest under the dates of sowing S_1 (MW 38) than the rest of sowing dates at all the growth stages of soybean crop but the lowest LAI recorded under the dates of sowing of S_3 (MW 40) at all the growth stages of crop.

The magnitude of the expression of yield attributes like number of developed plant^{-1}, weight of pod plant^{-1}, weight of seed plant^{-1},

test weight and number of seeds pod^{-1} were recorded maximum with sowing dates S_1 (MW 38) and was significantly superior over other dates of sowing. These yield attributes found to be decreased with further delay in sowing after S_1. The least values of yield attributes like weight of pod plant^{-1}, weight of seed plant^{-1}, test weight and number of seeds pod^{-1} were observed with last sowing date S_3 (MW 40). Higher yield attributes with early sowing date might be due to congenial weather parameters particularly favourable temperature. Later sowing dates received low temperature. Raj Singh *et al* (2010) found similar results in yield attributes like pods plant^{-1} and 1000- seed weight. Decrease in pod number plant^{-1} with late sowing was reported by Jasani *et al*. (1994), Pramila Rani (1999) and Raj Singh *et al.* (2010).

Effect of different dates of sowing evident on pod weight plant^{-1} (g). The dates of sowing S_1 (MW 38) recorded significantly highest on pod weight plant^{-1} (g) over the rest dates of sowing, but the lowest pod weight plant^{-1} (g) was recorded under the dates of sowing S_3 (MW 40).

Effect of different dates of sowing was evidenced on test weight (g). The dates of sowing S_1 (MW 38) recorded significantly the highest test weight (g) than other dates of sowing and the lowest test weight (g) recorded in S_3 (MW 40). This result is conformity by Naidu *et al*. (2017) and Shaikh *et al*. (2011).

Seed yield was a function of various yield attributes. Similarly, biological yield of crop plant has close relationship with its economical yield. The dates of sowing S_1 (MW 38) recorded the highest seed yield ha^{-1} and was significantly superior to rest of the sowing dates. This might be due to longer duration of vegetative and reproductive stages from earlier sown soybean. This result is conformity by Chain and Wiatrak, (2010).

The difference in the seed yield was 59.95 % among the dates of sowing. This might be due to higher seed yield plant^{-1} which occurred from increase pod number and pod weight plant^{-1} and number of seeds plant^{-1}. The lowest seed and biological yields ha^{-1} has recorded by S_3 (MW 40).

This might be due to delayed sowing generally shifted reproductive growth into less favorable conditions with shorter days, lower radiation and temperature. Similar reduction in yield due to late sowing of soybean was reported by Egli and Bruening, (2002), Shaikh *et al*. (2005), Jaybhaye *et al.* (2016), Akter *et al.* (2016) and Nath *et al*. (2017).

Straw yield was an augmenting effect of increased vegetative growth through plant height, number of branches and number of leaves plant^{-1}. Profound effect on straw yield ha^{-1} was noted due to different dates of sowing. Sowing during (MW 38) produced the highest straw yield which was significantly superior over rest of the sowing dates. The difference in the straw yield was 11.47 % in among the first and last dates of sowing. This might be due to more number of leaves, highest plant height and maximum dry matter accumulation as a result of this highest straw yield. Similarly result was reported by Singh and Arya (1994).

Early sowing dates favoured seed, pod and biological yields due to congenial weather parameters for better and balanced vegetative growth and proper portioning of dry matter in reproductive parts which was reflected through higher values of harvest index at S_1 (MW 38) sowing date. Billore *et al*. (2000), Anil kumar *et al.* (2008) and Hari Ram *et al.* (2010)

Table 26: An extract of maximum values on growth, yield and quality contributing characters, yield and economic studies of soybean as influenced by different date of sowing.

Sr. No	Particulars	Dates of sowing		
		MW 38	MW 39	MW 40
1.	Mean plant height (cm) at harvest	28.81	26.94	24.14
2.	Maximum number of functional leaves plant^{-1} (at 60 DAS)	11.90	10.75	9.32
3.	Maximum n leaf area plant^{-1} (dm^2) (at 60 DAS)	6.58	5.57	4.13
4.	Number of branches plant^{-1} at harvest	2.31	1.92	1.60
5.	Total dry matter plant^{-1} at harvest (g)	10.41	8.63	6.87
6.	Number of pods plant^{-1} at harvest	20.19	14.86	9.65
7.	Weight of pods plant^{-1} (g)	6.60	5.42	3.94
8.	Weight of seeds plant^{-1} (g)	4.09	2.93	1.70
9.	Number of seeds pod^{-1}	2.08	2.07	2.03
10.	Number of seeds plant^{-1}	40.56	30.13	19.02
11.	1000 seed weight (g)	100.75	95.40	89.08
12.	Seed yield kg ha^{-1}	1465.79	1027.71	586.97
13.	Straw yield kg ha^{-1}	2489.09	2071.11	1771.13
14.	Biological yield kg ha^{-1}	3964.88	3098.82	2358.10
15.	Harvest index (%)	36.96	33.16	24.89
16.	Seed germination (%)	90.47	88.71	87.60
17.	Oil content (%)	21.03	20.42	20.34
18.	Protein content (%)	41.08	40.02	39.94
19.	Gross monetary returns (Rs ha^{-1})	44731	31365	17920
20.	Net monetary returns (Rs ha^{-1})	18151	4786	-8660

The different dates of sowing also affect the Gross monetary returns (GMR) and net monetary returns (NMR). The dates of sowing S_1 (MW 38) recorded significantly the highest GMR and NMR over other dates of sowing. This might be due to highest seed and straw yields (Kg ha^{-1}).

While in case of B: C ratio, sowing during S_1 (MW 38) recorded numerically maximum B: C ratio than rest of the sowing dates and the lowest B: C ratio has recorded under S_3 (MW 40).

There was no significant effect of dates of sowing on seed germination (%), protein and oil contain (%).

5.4.2 Varieties

The varieties under study differed significant regarding plant height except at 15 and 30 DAS, where it was found to be non- significant. This might be due to more competition to get sunlight. The rate of increase in plant height of the crop was maximum during 30-75 DAS in all the varieties indicating grand growth of the crop. Variety V_3 (MAUS-162) recorded the maximum plant height. The other varieties remained approximately equal in respect of the height characteristic. This could be attributed to genetic makeup of variety. In general, the plant height of individual variety was directly proportional to the duration of that variety. Ruhul Amin *et al.* (2009) also reported significant differences in plant height due to different varieties. Similar result of varied plant height among different varieties was also observed by Singh (2003), Kumar *et.al*. (2008) and Bhangre (2010).

The maximum number of functional leaves was produced by variety V_2 (MAUS-612) at all the stages of crop growth. The tendency of leaf in varieties under study was just the same as that of number of functional leaves. This might be due to genetic composition of varieties, nutrient, moisture and light. Patoliya (1998) also stated significant differences in number of functional leaves due to different varieties.

The varieties varied in bearing the number of branches $plant^{-1}$ significantly. The highest mean number of branches $plant^{-1}$ was recorded by

variety V_2 (MAUS-612) over rest of the varieties at all the stages of crop growth. This might be due to the growing habit of soybean crop. Varietal differences in branching as genotypic character was also observed by Kurmvanshi *et al*. (1996) and Bhangre (2010).

Flowers commencement was started from 32th day onwards in variety V_1 (JS- 9560), from 37th day in V_2 (MAUS-612) and V_3 (MAUS-162) and from 34th day in V_4 (MAUS-71). The number of pods plant^{-1} increased continuously till maturity. The performance of variety V_1 (JS- 9560) and V_2 (MAUS-612) as regard to number of pods plant^{-1} was superior as compared to other varieties V_3 (MAUS-162) and V_4 (MAUS-71). Varietal differences in number of pods plant^{-1} as genotypic character was also observed Sarawgi and Rajput (2005) and Tabbasum *et al*. (2015).

Dry matter accumulation of stem plant^{-1} increased continuously up to harvest of the crop. The mean dry matter accumulation plant^{-1} was influenced due to different varieties. Significantly the highest dry matter of stem plant^{-1} recorded by variety V_2 (MAUS-612). This might be due to more branching of the soybean crop.

Similarly, dry matter accumulation of leaves plant^{-1} increased rapidly up to 60 DAS and gradually decreased thereafter due to leaf senescence. Variety V_2 (MAUS-612) produced maximum dry matter of leaves at all the stages of crop growth.

Mean dry matter production of pods plant^{-1} was increased progressively up to harvest of the crop. The rate of dry matter accumulation of the pods plant^{-1} was faster during 60 to 75 DAS. Variety V_1 (JS- 9560) produced maximum dry matter of pods plant^{-1} followed by variety V_2 (MAUS-612).

Increase in total dry matter accumulation plant^{-1} was the cumulative effect of increase in various growth characters like number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}. The mean total dry matter accumulation plant^{-1} was influenced due to different varieties. Significantly highest dry matter plant^{-1} recorded by variety V_2 (MAUS-612)

followed by variety V_1 (JS- 9560) than V_3 (MAUS-162) and V_4 (MAUS-71). This might be due to more photosynthetic activities and more accumulation of carbohydrates and by this means increased dry matter accumulation and its continuous translocation to reproductive storage organs. Significant varietal differences in dry matter accumulation plant^{-1} were observed by Ramana *et al,* (2012) and Naidu *et al*. (2017).

The yield contributing characters *viz.*, pod weight plant^{-1}, seed weight plant^{-1} (g), number of pods plant^{-1} and 1000 seed weight (g) were maximum in variety V_1 (JS- 9560) which was significantly superior over variety V_3 (MAUS-162) and V_4 (MAUS-71) but at par with V_2 (MAUS-612). However, number of seeds pod^{-1} was maximum in variety V_3 (MAUS-162). The lowest yield contributing characters were recorded in the variety V_4 (MAUS-71). The varietal differences might be due to genotypic characters and different durations of varieties such as variety V_1 (JS- 9560) was short durational while V_2 (MAUS-612), V_4 (MAUS-71) were medium durational and V_3 (MAUS-162) was long durational. Significant varietal differences in number of pods plant^{-1} were observed by Koti and Chetti (1999), Bhangre (2010), Meena and Meena (2013) and Tabbasum *et al*. (2015). While Khurana *et al.* (1984), Anil Kumar (2008) and Hari Ram *et al*. (2010) observed varietal differences in soybean in respect of seeds per pod.

Effect of different varieties was evidenced on number of seeds plant^{-1}. A variety V_2 (MAUS-612) recorded maximum number of seeds plant^{-1} followed by variety V_1 (JS- 9560) which was significantly superior over V_3 (MAUS-162)and V_4 (MAUS-71). This result is conformity by Khurana *et al*. (1984) and Ngalamu *et al*. (2012).

Variety V_1 (JS- 9560) has significant effect on test weight (1000 seeds weight) and it is recorded higher than the rest of the varieties contributing to higher seed yield in this variety. These results are in close collaborate to those reported with Pramila Rani (1997), Bhangre (2010) and Niaz *et al*. (2018).

Seed yield is a function of yield attributes. Similarly, biological yield of crop plant has a close relationship with its economical yield. The variety V_1 (JS- 9560) recorded highest seed yield which was superior over the variety V_3 (MAUS-162) and V_4 (MAUS-71) but at par with V_2 (MAUS-612). This may be due to of higher seed yield plant^{-1} which occurred from increased pod number, pod weight plant^{-1} and seed weight plant^{-1}. These results collaborate to those reported by Rajput and Shrivastava (1999), Singh *et al*. (2013) and Meena and Meena (2013)

Straw yield (kg ha^{-1}) an augmenting effect of increased vegetative growth through plant height, number of branches and number of leaves plant^{-1} of the variety. Profound effect on straw yield (kg ha^{-1}) was noted due to different varieties. Variety V_2 (MAUS-612) produced higher straw yield than V_3 (MAUS-162) and V_4 (MAUS-71) variety. This might be due to profused branching, more number of leaves, plant height and maximum dry matter as result of this higher straw yield. Singh *et al*. (1993) reported the same result.

All the varieties have non-significant effect on seed germination (%), protein and oil content (%).

Table 27: An extract of maximum values on growth, yield and quality contributing characters and economic studies of soybean as influenced by different varieties

Sr. No.	Particulars	Soybean Varieties			
		JS – 9560	**MAUS – 612**	**MAUS – 162**	**MAUS – 71**
1	Mean plant height (cm) at harvest	23.12	29.40	31.52	22.49
2	Number of functional leaves plant^{-1} (at 60 DAS)	10.20	12.29	9.84	10.29
3	Maximum leaf area plant^{-1} (dm^2) (at 60 DAS)	5.55	6.40	4.51	5.25
4	Number of branches plant^{-1} at harvest	1.15	3.11	0.91	2.66
5	Total dry matter plant^{-1} at harvest (g)	9.48	9.65	7.86	7.78
6	Number of pods plant^{-1} at harvest	18.14	17.04	12.84	11.57
7	Weight of pods plant^{-1} (g)	6.09	5.91	4.76	4.53
8	Weight of seeds plant^{-1} (g)	3.61	3.43	2.38	2.20
9	Number of seeds pod^{-1}	1.85	2.03	2.21	2.15
10	Number of seeds plant^{-1}	32.95	33.89	28.08	24.70
11	Test weight (g)	110.56	97.22	84.42	88.10
12	Seed yield kg ha^{-1}	1269	1204	844	788
13	Straw yield kg ha^{-1}	2109	2257	2033	2041
14	Biological yield kg ha^{-1}	3390	3464	2878	2829
15	Harvest index (%)	37.46	34.76	29.34	27.86
16	Seed germination (%)	90.18	88.31	88.20	89.01
17	Oil content (%)	21.01	20.62	19.97	20.78
18	Protein content (%)	40.32	40.51	39.93	40.61
19	Gross monetary returns (Rs ha^{-1})	38754	36752	25780	24069
20	Net monetary returns (Rs ha^{-1})	11855	10492	-719	-2591

Summary and Conclusion

CHAPTER -VI

SUMMARY AND CONCLUSIONS

The investigation entitled "Performance of soybean (*Glycine max* L.) varieties in post monsoon under varied weather conditions." was carried out on experimental farm at Department of Agronomy, V.N.M.K.V. Parbhani during *post monsoon* season 2017. The field experiment was laid out in split plot design (SPD). The aim of present study was to study the performance of varieties and dates of sowing on growth and yield of soybean. Twelve treatment combinations with three dates of sowing and four different varieties replicated in thrice. Three dates of sowing *i.e.* S_1 (MW 38), S_2 (MW 39), S_1 (MW 40) as main plot treatments and four varieties JS-9560 (V_1), MAUS-612 (V_2), MAUS-162 (V_3) and MAUS-71 (V_4) as sub plot treatments. The gross plot size was 5.4 x 4.5 m^2 and net plot size was 4.5 x 4.2 m^2. The crop was sown by dibbling method at spacing of 45 x 5 cm^2. Periodical observations were recorded on growth and yield contributing characters, yield and quality parameters.

The basal dose of 30 kg N ha^{-1}, 60 kg P ha^{-1} and 30 kg K ha^{-1} was applied at the time of sowing. The recommended cultural practices and plant protection measures were undertaken.

The various ancillary observations on growth and yield contributing characters were recorded at interval of 15 days and post harvest studies were carried out to evaluate the treatment effects on soybean crop.

Some of the important findings emerged out from this investigation are summarized below.

6.1 Dates of sowing

The different dates of sowing showed substantial effect on various growth parameters of soybean *viz.*, plant height, number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$.

The dates of sowing S_1 (MW 38) recorded significantly maximum plant height over rest of the sowing dates.

The growth attributes like number of functional leaves and leaf area (cm^2) $plant^{-1}$ were significantly higher under the date of sowing S_1 (MW 38) over rest of the sowing dates.

The number of branches and dry matter accumulation of stem $plant^{-1}$ (g), dry matter accumulation of leaves $plant^{-1}$(g), dry matter accumulation of pods $plant^{-1}$ (g) and total dry matter accumulation of $plant^{-1}$ (g)were highest under the dates of sowing S_1 (MW 38) and it was significantly superior over rest of sowing dates.

The different dates of sowing exerted significant effect and mean number of pod $plant^{-1}$. The dates of sowing S_1 (MW 38) recorded significantly maximum number of pod $plant^{-1}$ as compared to rest dates of sowing dates.

The data on growth indices like AGR for height indicates that the dates of sowing S_1 (MW 38) recorded numerically maximum AGR values at all the stages of crop growth.

The dates of sowing S_1 (MW 38) noted numerically the highest values of AGR for dry matter RGR and LAI than other dates of sowing.

The magnitude of the expression of yield attributes like number of developed pods $plant^{-1}$, weight of pods $plant^{-1}$, weight of seed $plant^{-1}$, test weight (g) and number of seed $plant^{-1}$ were recorded maximum with dates of sowing S_1 (MW 38) and was significantly superior over rest of the sowing dates. However, the number of seeds pod^{-1} was not influenced significantly by different dates of sowing.

Increase values of yield contributing characters with dates of sowing S_1 (MW 38) reflected in production of seed, straw and biological yields ha^{-1}. The dates of sowing S_1 (MW 38) produced significantly the highest seed, straw and biological yields than the rest of the sowing dates.

Numerically maximum harvest index was found under dates of sowing S_1 (MW 38).

The gross and net monetary returns were significantly the highest in dates of sowing S_1 (MW 38) than the rest of sowing dates. While in

case of B: C ratio, the dates of sowing S_1 (MW 38) recorded numerically maximum over other dates of sowing.

The seed germination (%), protein content an oil content (%)of soybean was satisfactory but it was not influenced significantly by different dates of sowing.

6.1 Varieties

The plant height increased continuously up to harvest. Variety V_3 (MAUS-162) was produced much taller height, whereas, rest of the varieties found to be shorter in plant height.

The variety V_2 (MAUS-612) found significantly superior for producing maximum number of functional leaves and leaf area (cm^2) over rest of the soybean varieties under study.

The maximum number of branches $plant^{-1}$ was noticed in variety V_2 (MAUS-612) than rest of the soybean varieties under study.

The maximum numbers of pods $plant^{-1}$ were noticed in variety V_1 (JS- 9560) over the variety V_3 (MAUS-162) and V_4 (MAUS-71) but it was at par with V_2 (MAUS-612).

Dry matter accumulation $plant^{-1}$ was increased up to harvest. The maximum dry matter accumulation was recorded in V_2 (MAUS-612) over the variety V_3 (MAUS-162) and V_4 (MAUS-71) but it was at par with V_1 (JS- 9560).

The magnitude of yield attributes like number of developed pods $plant^{-1}$, weight of pods $plant^{-1}$, weight of seed $plant^{-1}$ and test weight (g), were recorded maximum with variety V_1 (JS- 9560) than the variety V_3 (MAUS-162) and V_4 (MAUS-71) but it was at par with V_2 (MAUS-612). However, number of seed $plant^{-1}$ were recorded maximum with variety V_2 (MAUS-612) and it ws at par with V_1. The number of seed pod^{-1} was found to be maximum with variety V_3 (MAUS-162).

The data on growth indices *viz*. AGR due to plant height was more with variety V_3 (MAUS-162). Whereas, variety V_2 (MAUS-612) recorded maximum AGR due to dry matter, RGR and LAI.

The highest seed yield (kg ha^{-1}) was obtained with variety V_1 (JS- 9560) and it was at par with V_2 (MAUS-612). The highest straw yield (kg ha^{-1}) was obtained in variety V_2 (MAUS-612) followed by the variety V_1 (JS-9560).

Maximum harvest index was found in variety V_1 (JS- 9560) and minimum was found in variety V_4 (MAUS-71).

Among the varieties under study, variety V_1 (JS- 9560) recorded the highest gross monetary returns and net monetary returns and B: C ratio followed by variety V_2 (MAUS-612).

Numerically maximum seed germination (%) was found in the variety V_1 (JS- 9560).

The variety MAUS-71 (V_1) recorded numerically maximum oil and protein content and minimum was found in the variety V_3 (MAUS-162).

6.3 Interaction effect

The interaction effect between dates of sowing and varieties was found to be significant in influencing the various growth characters, yield attributing characters, seed yield, straw yield, biological yield, harvest index, GMR and NMR.

The sowing of soybean with date of sowing in S_1 (MW 38) with Variety JS- 9560 i.e. (S_1V_1) recorded significantly higher number of pods, soybean seed yield, harvest index GMR, NMR which was followed by (S_1V_2) than rest of the treatment combinations, this might be due to favourable weather conditions and superior varietal characters.

CONCLUSIONS

After considering the results of experiment, the following conclusions can be drawn from the present investigation:

- In post monsoon season, early sowing of soybean during 38th MW (S_1) resulted in higher growth yield and economic returns as compared to late sowing during MW 39th and 40th MW.
- Under varied weather conditions in post monsoon, variety JS-9560 and variety MAUS-612 performed better growth, yield and monetary returns than varieties MAUS-162 and MAUS-71.
- From the study, In post monsoon, it may be concluded that early sowing of soybean during 38th MW with varieties JS-9560 and MAUS-612 is better to obtain higher seed yield.

The above conclusions are based on a single season research findings and it needs further confirmation by repeating the trial for at least one more season.

Literature Cited

CHAPTER VII

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Thesis Abstract

THESIS ABSTRACT

a) Title of the Thesis	:	**PERFORMANCE OF SOYBEAN (*Glycine max* L.) VARIETIES IN POST MONSOON UNDER VARIED WEATHER CONDITIONS.**
b) Name of student	:	**SANGEKAR YOGESHWARI DILIP.**
c) Degree to be awarded	:	M.Sc. (Agriculture)
d) Year of award of degree	:	2018
e) Major subject	:	Agronomy
f) Total No. of pages in the thesis	:	
g) Number of words in thesis abstract	:	305
h) Signature of the student	:	**(SANGEKAR Y. D.)**
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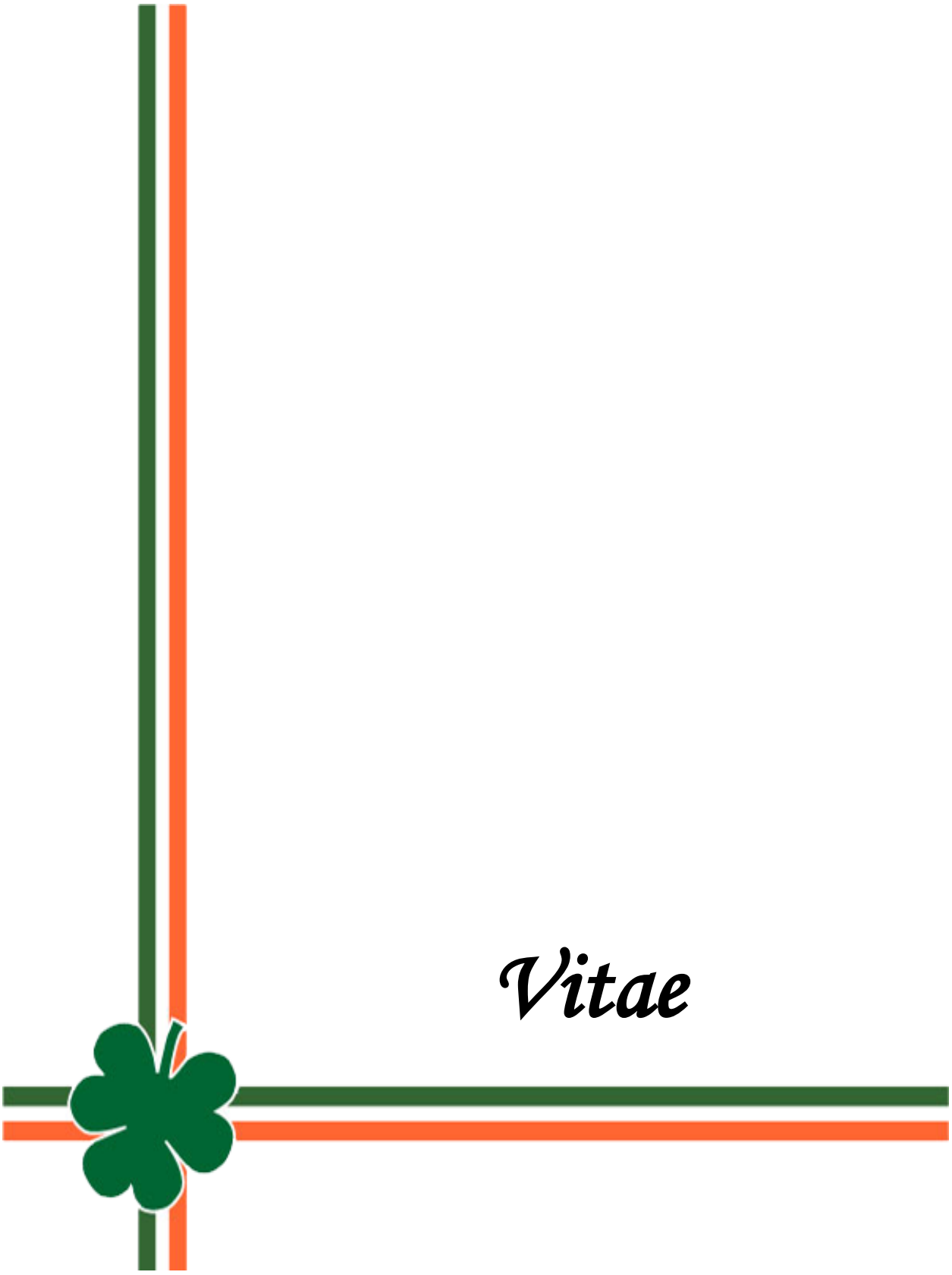
ABSTRACT

The field investigation entitled “Performance of soybean (*Glycine max* L.) varieties in post monsoon under varied weather conditions.” was conducted at P.G. Research Farm, Department of Agronomy, College of Agriculture, V.N.M.K.V., Parbhani (M.S.) India. The experimental field was leveled and well drained. The soil was clayey in texture, low in available nitrogen, medium in phosphorus, high in potassium and slightly alkaline in reaction. The environmental conditions prevailed during research period was favorable for normal growth and maturity of soybean crop. The experiment was laid down in split-plot design with 12 treatment combinations comprising of three dates of sowing i.e. S_1 (MW 38), S_2 (MW 39), S_3 (MW 40) as main plot treatments and four varieties i.e. JS-9560 (V_1), MAUS–612 (V_2), MAUS–162 (V_3) and MAUS–71 (V_4) as subplot treatments. Each treatment was replicated three times. The gross and net plot size of each experimental unit was 5.4 x 4.5 m^2 and 4.5 x 4.2 m, ^{2} respectively. Sowing was done according to MW as per the treatments. Periodical observations were recorded on growth and yield contributing characters, yield and quality parameters. Both dates of sowing and varieties shown the significant effect on different growth parameters, yield attributing characters and yield. Among the dates of sowing S_1 (MW 38) and Variety MAUS-612 (V_2) and recorded significant higher growth attributing characters *viz.,* number of functional leaves, number of branches, leaf area, total dry matter plant^{-1} while yield contributing characters *viz.* pod weight plant^{-1}, seed weight plant^{-1}, number of pods plant^{-1}, 1000 seeds weight, seed yield, HI and economic studies *viz.,* gross and net monetary returns and B:C ratio were significantly higher in dates of sowing S_1 (MW 38) with variety JS-9560 (V_1) over the rest of the varieties and it was at par with MAUS - 612 (V_2), indicating the suitable date of sowing is S_1 (MW 38) and varieties are JS-9560 (V_1) and MAUS-612 (V_2) for post monsoon soybean.

APPENDIX

Cost of cultivation of soybean depend upon following prices.

Sr. No.	Particulars		Total cost (`Rs ha^{-1})
I	**Common cost**		
A.	**Land Preparation**		
1.	Ploughing		2700
2.	Harrowing and planking (2 Pairs bullock)		1550
3.	Preparation of beds, bunds and irrigation channels		900
B.	**Input charges**		
1.	Sowing and fertilizer application		2000
2.	Fertilizer		3027
4.	Seed treatment		120
C.	**After care**		
1.	Gap filing		360
2.	Plant protection measures		1250
3.	Irrigation		1100
4.	Weeding		3600
5.	Hoeing		990
D.	**Harvesting**		3000
E.	**Threshing and winnowing**		1800
F.	**Land revenue**		100
	A to F cost		22500
II	**Variable cost**		
	Cost of seeds		
1.	JS-9560	(80 kg)	4400
2.	MAUS-612	(80 kg)	3760
3.	MAUS-162	(80 kg)	3600
4.	MAUS-71	(80 kg)	4000
D.	**Sales Price output**		
1.	Soybean seed	(`Rs qt^{-1})	3050
2.	Soybean straw	(`Rs qt^{-1})	50



Vitae

Vitae

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