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RESPONSE OF SOYBEAN VARIETIES TO DIFFERENT SOWING WINDOWS UNDER CLIMATE CHANGE

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ABSTRACT

The present study was carried out to identify suitable variety and influence of sowing dates on yield of soybean during *kharif* (2018) in Agronomy farm, College of Agriculture, Nagpur. The experiment was laid out in Split Plot Design with eight treatment combinations with three replications consisting four levels of sowing date *i.e.*25th MW (D_2-18th June - 24thJune), 26th MW (D_2- 25th June - 01thJuly), 27th MW (D_3-02nd July - 08thJuly), 28th MW (D_4-09th July - 15thJuly) and three varieties i.e. V_1 (JS-335) , V_2 (JS-9560) and V_2 (AMS-1001) (Yellow Gold). Various sowing dates significantly influenced the growth and yield of soybean varieties. Salient conclusions arose from present investigation under growth contributing characters *viz*., plant height, number of branches plant^{-1}, total dry matter weight plant^{-1} were highest in variety JS-335 and found maximum during 2ndsowing date i.e. 26thMW during all growth stages. In relation to occurrence of a particular growth stages, there was variation of 2 to 7 days among various dates. It was notified that, growth stages appears highest in 26thMW and was lowest 28th MW among all three varieties. It was observed that the variety AMS-1001 availed the highest duration in the range of 114-127 days under different sowing dates, JS-335 was ranged 113-121 days and JS-9560 required lowest range of 102-107 days for maturity. Variety JS-335 were higher in yield contributing characters such as total number of pods plant^{-1}, average grain yield plant^{-1}, total grain yield, straw yield, biological yield and the observations were highest under 26thMW. In case of weather parameters, temperature requirement is highest when crop was sown on 25thMW than rest of the sowing dates.Temperature requirement was recorded highest in AMS-1001 variety when crop sown in 25thMW than rest of the sowing dates. Soybean varieties was not influenced due to relative humidity. It is inferred from this study as per Agro-meteorological analysis, sowing of soybean crop on 26thMW was found suitable, while variety JS-335 performed better than AMS-1001 and JS-9560.

(Key words :Soybean, dates of sowing,varieties, thermal requirement, relative humidity)

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a *kharif* oil seed crop in tropical and sub-tropical regions of India. Soybean belongs to family *Leguminoaceae*. India is ranking fifth on the basis of production (3.95%) of soybean crop in the world after USA (34%), Brazil (30%), Argentina (18%) and China (4%) (Anonymous, 2017b). The soybean production in the country during 2017-18 was 83.50 lakh metric tons from 101.56 lakh hectares area. The soybean production in Maharashtra during 2017-18 was 29.00 lakh m tones from 34.48 lakh hectares area. Whereas, Maharashtra and Madhya Pradesh are the two most important soybean growing states accounting for 89 per cent of total production of soybean in India. Other largest producers' states are Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat (Anonymous, 2017a). About 90 per cent of the oilseed cultivation in India is under rainfed, uncertain and abnormal weather condition. Irregular rains and inadequate irrigation of critical growth stages largely affect the final yield. Poor crop management under input starved condition and growing of crop in rainfed conditions are the main season for low yield of soybean.

Germination is most critical stage in soybean crop it requires 10-20^{0}C temperature for germination. Excessive cold temperature, more moisture or prolonged drought can cause injuries to plant. Therefore, the most optimum temperature range for *kharif* soybean crop growth is 18-30^{0}C. The minimum temperature for most of the growth and development stages is about 10^{0}C. Soybean can be adapted

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in winter. Secondly, soybean is sensitive to day length and flowering as well as maturity is controlled by day length. It is short day plant and requires at least 10 hrs or more of daily darkness for flowering. Photoperiod also affects the development stage.

Soybean crop can be grown in regions with seasonal rainfall of 550-750 mm. Its water requirement is 450-750 mm season^{-1}. 50 per cent moisture is required for germination. Its water use efficiency for harvested yield is 0.4 to 0.7 kg m^{-3}. Moisture stress during pod filling, pod development affects yield simultaneously, about 20 to 50 per cent. In general, the crop is sensitive to frost. Floral induction is greatly inhibited at 10^0C and moisture stress during pod filling reduces the yield and hot dry air also reduces yield. Sowing date is variable with the largest effect on crop yield. Planting date is an important factor affecting soybean growth, development, and yield. (Zhang *et al*., 2010).

During last few years, area under soybean in Vidarbha region is increasing due to reduction in area of cotton. Because cotton crop develops so many yield reducing factors under mono-cropping system and soybean is a best alternate *kharif* season crop to be chosen by farmers. Numbers of varieties of soybean are under cultivation. There is variation in crop duration as well as production. So, for suiting to the needof farmers under various crop sequences and cropping systems, the study is required to know the best sowing week of the particular variety and maturity duration with respect to growth and yield contribution. So, the research work is to be conducted, which can justify the performance of various soybean varieties under different agroclimatic conditions of Vidarbha region of Maharashtra state.

Generally, the time of sowing varies depending on the climatic condition of the region and the variety to be grown, Different varieties of soybean are sensitive to change in environmental conditions where the crop is being grown. Therefore, it is necessary to study the cultivar x environment interaction to identify the varieties which are stable in different environment. Sowing date is an important factor affecting soybean growth, development and yield. Delayed sowing generally shifts growth stages of plant into less favorable conditions like day length, radiation level and temperatures.

It is true that, weather parameters strongly influence the crop performance but, amongst them, the effects of only few parameters are significant so also, the contribution of different parameters vary to great deal. It becomes, therefore, necessary to identify such parameters and quantify their contribution besides developing the relations with growth and yield of the crop. (Sundari, 2003). It is observed that, there is no much attention focused in the country and the state on the aspect of knowledge of weather condition. Hence, keeping in view these facts the present research is formulated to explore "Response of soybean varieties to different sowing windows under climate change".

MATERIALS AND METHODS

The experimental field was fairly uniform and leveled. Soil of experimental plot was black. Soil samples were collected from randomly selected plots at a depth of 0-30 cm from the experimental area, mixed well and a composite sample of one kg was then prepared and analyzed for various physio-chemical properties of the soil. After studying the soil properties the experiment was laid out in split plot design with four treatments of dates of sowing 25th MW (D1-18th June - 24thJune), 26th MW (D2- 25th June - 01thJuly), 27th MW (D_3-02nd July - 08thJuly), 28thMW (D_4-09th July - 15thJuly) under main plot treatments and three varieties JS–335(V_1), JS-9560 (V_2) and AMS-1001 (Yellow Gold) (V_3) as sub plot treatment forming 12 treatment combinations and replicated three times in field of Agronomy section, College of Agriculture, Nagpur during *kharif* season of 2018. The distance between two replications was 1.35 m and 0.90 m between two plots. The gross and net plot size were 4.5 m × 4.0 m and 3.60 m × 3.60 m,respectively. The pre harvest biometric observations on plant height (cm), number of functional leaves plant^{-1}, number of branches plant^{-1}and dry matter accumulation plant^{-1}(g) were recorded periodically at 25, 50, 75 days after sowing and at harvest from five representative plants.The post harvest biometric observations were recorded on number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}(g), seed yield ha^{-1} (kg), straw yield plant^{-1}(kg), and harvest index (%) after harvest from five representative plants. The observations on plant stand plot^{-1}and test weight of seeds (g) were recorded on plot basis. Weather parameters like temperature requirement (Thermal) of each variety also referred as thermal unit, for each calendar day during crop period, for all the treatments daily weather data on maximum and minimum temperature were calculated as under

$$\text{Thermal requirement} = \frac{T_{Max} + T_{Min}}{2} - T_{Base}$$

Where,

T_{Max} – Maximum temperature

T_{Min} – Minimum temperature

T_{Base} – Base temperature (5 ^{0}C)

Base temperature is the temperature below which the physiological activities in plant practically cease and as a result plant does not show any growth. In present study base temperature for soybean crop was taken as 10^{0}C. Further total thermal unit requirement over crop period under each treatment was calculated by summation. Relative humidity for each crop growth period in respect of each treatment were added together so as to obtain relative humidity requirement in percentage during that crop period. Mean relative humidity over crop period under each treatment was calculated by summation.The total production of crop including both seed yield and straw yield in terms of rupees is known as gross monitory return and was estimated

on ha^{-1} basis. The net production of crop after reducing the total cost of cultivation from gross monetary return in terms of rupees is known as net monitory return and was estimated on ha^{-1}basis. The benefit : cost ratio was worked out by the dividing the gross monetary returns ($Rs.ha^{-1}$) with total cost of cultivation ($Rs.ha^{-1}$).

The data collected during the course of investigation was statistically analyzed by adopting standard method known as "Analysis of variance" for split plot design (Panse and Sukhatme, 1954). Wherever, the results were found significant, critical difference (C.D.) were worked out at 5 per cent level of probability for comparison of treatment means.

RESULTS AND DISCUSSION

Soil, Season and Growth

The experimental site was fairly uniform and leveled. The soil analyzed on the experimental site have loamy clay in texture, slightly less in available nitrogen (231.04 kg ha^{-1}), medium in available phosphorus (14.65 kg ha^{-1}) and Sulphur (7.60 mg ha^{-1}) and rich in available potash (394.20 kg ha^{-1}). Organic carbon content was medium (0.41 g ha^{-1}) and soil reaction was slightly alkaline (7.6). The meteorological data are presented in Table 1 *i.e.* monthly Meteorological data for June 2018 to November 2018 in comparison with last ten-year average indicated that, there was slightly variation in meteorological observations during 2018-2019 as compared to their average. For June to November, the maximum temperature ranged from 30.2 to 37.3^0C, the minimum temperature ranged from 19.3 to 22.8^0C. The relative humidity ranged from 47.3 to 79.1 per cent, and total evaporation was 105.3 mm (Table 2). The total rainfall during crop growth period i.e. June 2018 to November 2018 was 953.6 mm received in 36 rainy days. Crop sown on 25^{th}MW affected due to less moisture and slight hot dry condition at the time of germination. Crop sown on 26^{th}MW and 27^{th}MW experienced favorable temperature and moisture condition showed better germination and crop growth. However, crop sown on 27^{th}MW slightly affected due to high rainfall and slight water logged condition during germination, shown proper germination but early wilting of some seedlings and stunted growth observed. As the temperatures lighthigh during germination and on seedling phase of the crop growth sown on 28^{th}MW as it affects vegetative growth, flowering, pod formation and seed filling resulting into low yields. The temperature and moisture condition for the crop sown in the 26^{th}MW and somewhat for 27^{th}MW were most favorable throughout the cropping period and thus shows better growth andyield.

Pre-harvest studies

The data regarding the pre harvest studies influenced by the different dates of sowing and varieties have been presented in Table 3.

The mean plant height increased with advancement in the age of the crop till harvest. The mean initial plant height was 19.02 cm at 25 days and increased up to 45.30 cm at harvest. The data (Table 9) revealed that, the plant height influenced by sowing dates recorded at 25 DAS was non-significant and at 50, 75 DAS and at harvest were found significant. The *kharif* soybean sown during 26^{th}MW has recorded maximum plant height at harvesting stage (47.16 cm). However, it was found at par with 27^{th} MW at 25, 50, 75 DAS and at harvest and significantly superior over 25^{th} MW and 28^{th} MW. This might be due to congenial climatic condition for better germination and further growth and development of *kharif* soybean crop. Similar to this result Singh *et al.* (1974) reported that delay in planting from 11^{th} June to 21^{st} July reduced plant height of soybean crop. Height of plant recorded at 25, 50, 75 DAS and at harvest was significantly influenced by different varieties. The variety JS-335 recorded significantly taller plant height *viz.,* 20.25 cm, 34.90 cm, 45.95 cm and 48.31 at 25, 50, 75 DAS and at harvest respectively. Whereas, it was found at par with variety AMS-1001 at 25 DAS. Lowest plant height was recorded by variety JS-9560.This might be due to genetic makeup of the variety JS-335. Similar to this result Karad *et al.* (1999)reported that plant height was highest in Pb-1 lowest in MAUS-55 in soybean. Interaction due to sowing dates with varieties was found to be non-significant at all the stage of crop growth.

Mean number of functional leaves $plant^{-1}$was increased continuously up to 75 DAS of crop growth and later on decreased due to shedding of leaves. Mean number of functional leaves was significantly influenced by different dates of sowing, at 50, 75 DAS and at harvest but was found non-significant at 25 DAS. The highest number of functional leaves was recorded in D_2 (MW 26) and was superior over D_4(28 thMW). Whereas, it was found at par with D_1 (25^{th}MW) at 25, 50 and 75 DAS and with D_4(27^{th}MW) at 25 and 50 DAS. Mean functional leaves were significantly influenced by different varieties at all stages of crop growth. The variety V_1 (JS-335) recorded significantly superior number of functional leaves over both V_2(JS-9560) and V_3 (AMS-1001). The interaction effect between date of sowing and cultivars was found to be non-significant at all stages.

Effect of sowing dates on number of branches $plant^{-1}$was significant at 50, 75 DAS and at harvest and non-significant at 25 DAS. Sowing of soybean at 26^{th}MW produced maximum number of branches (14.99) and revealed that, the number of branches was significantly affected due to different sowing dates. It was followed by 27^{th}MW and 25^{th}MW. Lowest numbers of branches were recorded by sowing dates under 28^{th}MW at all the growth stages of crop growth. Similarly Krishnamurthy *et al.*(2000) observed significant variation in number of branches $plant^{-1}$ with difference in the sowing dates in soybean. The highest number of branches $plant^{-1}$ was recorded in V_1 variety (JS-335) and was superior over V_2(JS-9560), whereas, it was found at par with V_3 (AMS-1001) at 75 DAS and at harvest. Interaction effect between sowing dates with varieties on number of branches $plant^{-1}$was found to be non-significant at all stages of crop growth.

Effect of sowing dates on dry matter accumulation plant^{-1}was significant at 50, 75 DAS and at harvest and non-significant at 25 DAS. Sowing taken on 26thMW recorded the significantly superior dry matter accumulation contents at all stages of growth over sowing carried out on 25thMW and 28thMW. However, it was at par with 27thMW at all stages of growth. Lowest dry matter accumulation was recorded i.e. sowing taken on 28thMW. Similarly Batwal *et al.* (2004) also reported reduced dry matter accumulation in 28th MW in soybean. During present investigation it was observed that, there was a progressive decrease in dry matter accumulation after 26thMW as sowing was late. Similar to this result Hundal *et al.*(2003) also reported decrease in dry matter accumulation after 26th MW of sowing in soybean.The effect of varieties on dry matter accumulation plant^{-1}was significant at 50, 75 DAS and at harvest and non-significant at 25 DAS. The highest dry matter accumulation plant^{-1} was recorded in variety V_1(JS-335) and was superior over V_2(JS-9560). Whereas, it was found at parwith V_3(AMS-1001) at all stages of growth. Interaction effect between sowing dates and varieties was found to be non-significant for dry matter accumulation plant^{-1}at harvest.

Post-harvest studies

The data regarding the post harvest studies influenced by the different dates of sowing and varieties have been presented in Table 4.

The days to maturity was significantly influenced due to varieties and sowing dates. The data presented in Table 4 revealed that, the mean days to maturity was 114 days. It was significantly influenced by different sowing dates. Sowing during 25thMW recorded maximum maturity duration (116 days) followed by 26thMW, 27thMW and 28thMW respectively. The different varieties were significantly influenced. Variety JS-9560 (V3) recorded minimum days of maturity (105 days), whereas maximum days to maturity recorded by variety AMS-1001 (Yellow Gold) is of 120 days. This was due to the meteorological condition at that time and genetic factor of those varieties. The interaction between sowing dates and varieties was non- significant in respect of days to maturity.

The number of pods plant^{-1}at harvest was significantly influenced due to varieties and sowing times. The data revealed that, the mean number of pods plant^{-1} at harvest was 31.50. Sowing taken on 26thMW had recorded significantly superior in number of pods (34.78 plant^{-1}) over sowing carried out on 25thMW and 28thMW and it was found at par with 27thMW. Delayed sowing recorded significantly lower number of pods. Subsequent delay in sowing resulted in significant reduction in total number of pods after 26thMW. In accordance to this result Deshmukh *et al.* (1977), Arora (1981) and Karad (1999) also reported significant reduction in total number of pods after 26th MW in soybean. The data pertaining to number of pods plant^{-1} at harvest was significantly influenced by different varieties. A variety JS-335 recorded maximum number of pods plant^{-1} (37.42) which was significantly superior over another two varieties. The lowest number of pods plant^{-1} was recorded by variety JS-9560 (24.83). This has indicated that, the significant difference in number of pods plant^{-1} due to different soybean varieties was more or less due to variety or might be due to lower number of branches plant^{-1}. Similar to this result Katti *etal.* (1970) also observed significant differences in number of pods plant^{-1} in different soybean varieties. The interaction between sowing times and varieties was found to be non-significant in respect of number of pods plant^{-1} at harvest.

The number of seeds pods^{-1}was significantly influenced due to sowing dates and varieties. The data presented that, the mean number of seeds pods^{-1}at harvest was 2.42. Number of seeds pods^{-1} was significantly influenced by different sowing dates. Sowing taken on 26thMW had recorded significantly superior in number of seeds pods^{-1} (2.77 seeds pods^{-1}) over sowing carried out on 25thMW and 28thMW. However, it was found at par with 27thMW. Lowest seeds pod^{-1}was recorded by 28thMW. A variety JS-335 recorded maximum number of seeds pods^{-1} (2.68 seeds pods^{-1}) which was significantly superior over JS-9560. Whereas, it was found at par with AMS-1001. This has indicated that, the significant difference in number of seeds pods^{-1} due to different soybean varieties was more or less due to variety or might be due to lower number of branches plant^{-1}.Similar to this result Katti *etal.* (1970) also reported significant difference in number of seeds pods^{-1} due to different soybean varieties. The interaction effect between sowing dates and varieties was found to be non-significant for number of seeds pods^{-1}at harvest.

The number of seeds plant^{-1} was significantly influenced due to sowing dates and varieties. Mean number of seeds plant^{-1}was 49.86. Sowing taken on 26thM Wrecorded significantly superior over sowing carried out on 25thMW and 28thMW in number of seeds plant^{-1} having 51.78 seeds plant^{-1}and it was at par with 27thMW. Lowest seeds plant^{-1} was recorded in sowing on 28thMW. This was due to low flower drop and more fruit setting during this season. Significantly higher number of seeds plant^{-1} were recorded by variety JS-335 (58.50 seeds plant^{-1}) than another two varieties and lowest seeds plant^{-1} were recorded in JS-9560 (37.92 seeds plant^{-1}). Higher number of seeds in JS-335 is attributed to higher number of pods plant^{-1} and higher number of seeds pod^{-1}.In accordance to this result Koti and Chetti (1999) also reported higher number of seeds in JS-335 of soybean. The interaction effect between sowing dates and varieties was found be non-significant for number of seeds plant^{-1} at harvest.

Weight of 100 seeds was influenced by sowing dates and varieties in soybean. Sowing of soybean during 26thMW significantly greater mean weight (11.88 g) of hundred seeds. Lowest test weight (11.14 g) was recorded under 28thMW, weight of hundred seeds was influenced significantly by different varieties of soybean. The highest mean hundred seed weight of variety JS-9560 was (13.11 g). Whereas, it was followed by variety AMS-1001 (10.86 g). Lowest test weight (10.61 g) was recorded under variety

JS-335. Equivalent to this Dhapke *et al.*(2017) also reported difference in test weight of soybean with difference in varieties. The interaction effect between sowing dates and varieties was found to be non-significant for test weight (g) at harvest.

The seed yield plant^{-1}was significantly influenced due to sowing dates and varieties. Seed yield plant^{-1} has significantly influenced by different sowing dates. Sowing taken on 26thMW has recorded significantly superior in seed yield plant^{-1}(6.05 g) over sowing carried out on 25thMW and 28thMW and it was found at par with 27thMW. Lowest seed yield plant^{-1}was recorded in sowing on 28thMW (5.24g). A variety JS-335 was observed significantly superior over JS-9560 and AMS-1001 having 6.21 g seed yield plant^{-1}. Lowest seed yield plant^{-1} was recorded in JS-9560 (4.98 g seeds yield plant^{-1}). The interaction effect between sowing dates and varieties was found to be non-significant for seed yield plant^{-1}(g) at harvest.

Mean straw yield of soybean was 3318 kg ha^{-1}. Sowing taken on 26thMW had recorded highest straw yield (3597 kg ha^{-1}) and found at par with 25thMW and 27thMW. Whereas, it was significantly superior over 28thMW and recorded lowest straw yield (2968 kg ha^{-1}). This was due to the production of a greater number of leaves, number of pods and branches plant^{-1}. Similar result was also observed by Anil Kumar *et al.* (2008). They recorded that variety AMS-1001 produced highest straw yield (3475 kg ha^{-1}) and was significantly superior over variety JS-9560 (3064 kg ha^{-1}). Whereas, it was at par with JS-335 (3383 kg ha^{-1}). The interaction effect between sowing dates and varieties was found to be non-significant for straw yield (kg ha^{-1}) at harvest.

Mean biological yield of soybean was 5559 kg ha^{-1}.Sowing taken on 26thMW had recorded highest biological yield (6097 kg ha^{-1}) and found at par with 25thMW and 27thMW.Whereas, it was significantly superior over 28thMW, recorded lowest biological yield (4977 kg ha^{-1}). Variety JS-335 recorded highest biological yield (5894 kg ha^{-1}) resulted significantly superior over variety JS-9560 (5009 kg ha^{-1}) and found at par with AMS-1001 (5775 kg ha^{-1}). The interaction effect between sowing dates and varieties found to be non-significant for biological yield (kg ha^{-1}) at harvest.The mean harvest index was 40.98 %. Harvest index ranged from 39.90% to 41.82% for different sowing dates. The observed data revealed that, sowing on 27thMW recorded higher harvest index (41.82%) as compared to other three sowing dates. The lowest harvest index observed under 28thMW(39.90%). Harvest index ranged from 39.90% to 42.78% for different varieties. Soybean variety JS-335 (42.78%) had recorded higher harvest index as compared to other two varieties. The lowest harvest index observed under variety JS-9560 (39.90%).

Weather parameter

The data on temperature requirement and relative humidity requirement are presented in Table 5. Mean temperature requirement of soybean during growth period is 424.97ºC days. The temperature requirement was reduced as the sowing is delayed. Sowing in 25thMW recorded highest (433.51ºC days) temperature requirement and sowing in 28thMW recorded lowest (416.86ºC days) temperature requirement. The different varieties recorded different temperature requirement. Variety AMS-1001 recorded highest (448.92ºC days) temperature requirement followed by variety JS-335 (433.95ºC days) and lowest in JS-9560 (392.80ºC days). The relative humidity requirement for *kharif* soybean was calculated by using average relative humidity during crop period. As regard effect of sowing dates on relative humidity requirement of crop, the average variation in maximum and minimum relative humidity during 28thMW was slightly greater than sowings carried out on 26thMW and 27thMW. However, sowing in 25thMW the variation in relative humidity was less as compared to other sowing dates. This indicates that, sowing of soybean variety was not influenced due to relative humidity. The different variety were not influenced due to relative humidity on the growth and development during crop period.

Economic study (Benefit : cost ratio)

It mainly consists of cost of production, gross monetary return and net monitory return in terms of Rs. ha^{-1}and benefit : cost ratio. The mean gross monetary return was Rs. 103158 ha^{-1}. Sowing taken on 26thMW had recorded significantly superior in GMR (Rs. 112969 ha^{-1}) over sowing carried out on 25thMW (Rs. 101738 ha^{-1}) and 28thMW (Rs. 92132 ha^{-1}). However, it was found at par with 27thMW (Rs. 105791 ha^{-1}). Data presented in Table 5 indicated that, variety JS-335 recorded highest GMR (Rs. 113178 ha^{-1}) resulted significantly superior over variety JS-9560 (Rs.90349 ha^{-1}) and AMS-1001 (Rs.105945 ha^{-1}). The interaction effect between sowing dates and varieties was found to be non-significant for GMR after harvest. The mean net monetary return was Rs. 66908 ha^{-1}. Sowing taken on 26thMW had recorded significantly superior in NMR (Rs.76719 ha^{-1}) over sowing carried out on 25th MW (Rs. 65488 ha^{-1}) and 28thMW (Rs. 55882 ha^{-1}). However, it was at par with 27thMW (Rs.69541ha^{-1}). Data indicated that, variety JS-335 had recorded highest NMR (Rs. 76928 ha^{-1}) resulted significantly superior over variety JS-9560(Rs. 54099 ha^{-1}) and AMS-1001 (Rs. 69695 ha^{-1}). Similar to this result Chaitanya *et al.* (2020) also observed that GMR and NMR varies with the varieties used in paddy. The interaction effect between sowing dates and varieties was found to be non-significant for NMR after harvest. Mean benefit :cost ratio of soybean crop obtained was 2.85. Highest B:C ratio for soybean was recorded with sowing on 26thMW (3.12) as compared to other three sowing dates. Increased in B:C ratio is due to significant increase in gross monetary return. Lowest B:C ratio was observed under 28th MW (2.54). The benefit : cost ratio was comparatively higher in soybean variety JS-335 (3.12) than varieties AMS-1001(2.92) and JS-9560 (2.49).

It is summarized from this that sowing of soybean during 25thMW significantly improved all the growth and

Table 1. Monthly meteorological data for June 2018 to November 2018 in comparison with last ten year average recorded at Agronomy Farm, College of Agriculture,Nagpur

Month	Temperature ^{0}C Maximum		Minimum		Total Rainfall(mm)		Rainy days		Relative Humidity(%)	
	N	A	N	A	N	A	N	A	N	A
June	37.6	37.3	26.8	20.3	151	180	9	6	50	47.3
July	32.0	30.2	24.8	20.2	361	550	16	20	80	79.1
August	30.4	30.6	24.3	22.2	275	132	13	5	61	71.9
September	32.0	31.6	23.8	22.8	197	91.6	9	5	62	72.1
October	32.9	34.3	20.3	22.7	42	0	2	0	58	58.4
November	30.1	32.4	19.1	19.3	16	0	1	0	57	56.1

Table 2. Weekly meteorological data from June 2018 to November 2018 recorded at Agronomy Farm, College of Agriculture, Nagpur

Date		Met Week	Temp ^{0}c Max	Min	R.H. % Morn	Eve	Total Rainfall (mm)	No. of Rainy days	BSH	Wind Speed Km/hr	Evaporation (mm)
28 – 03	Jun 18	22	42.5	21.9	40	23	00.0	0	-	5.4	8.2
04 – 10		23	38.1	18.3	64	45	76.8	2	-	6.8	8.7
11 – 17		24	36.6	20.3	55	39	73.8	2	-	7.1	7.7
18 – 24		25	36.0	20.6	65	47	29.0	2	-	5.1	6.2
25 – 01	Jul 18	26	31.5	19.6	79	66	107.6	3	-	4.7	5.1
02 – 08		27	31.1	19.9	86	67	308.2	7	-	4.8	7.4
09 – 15		28	29.6	19.7	83	76	31.8	4	-	5.6	2.8
16 – 22		29	29.7	20.2	81	75	57.0	4	-	5.7	3.1
23 – 29		30	29.0	21.9	82	96	45.4	2	-	5.1	2.3
30 – 05	Aug18	31	32.9	22.5	69	51	00.0	0	-	6.6	3.9
06 – 12		32	30.4	22.4	79	68	07.8	1	-	9.7	2.7
13 – 19		33	30.3	21.7	85	67	35.0	2	-	5.6	2.6
20 – 26		34	28.9	22.2	85	71	89.2	2	-	5.7	1.0
27 – 02	Sep18	35	27.8	21.7	86	77	21.4	2	-	4.4	2.0
03 – 09		36	29.6	21.1	81	69	25.6	2	-	5.3	2.2
10 – 16		37	33.5	23.4	71	52	00.0	0	-	3.1	3.9
17 – 23		38	33.5	23.6	77	67	44.6	1	-	5.3	4.5
24 – 30		39	33.7	24.1	76	65	00.0	0	-	2.2	3.9
01 – 07	Oct 18	40	34.7	23.8	72	49	00.0	0	-	1.6	3.7
08 – 14		41	33.7	22.6	68	44	00.0	0	-	3.0	3.7
15 – 21		42	34.6	23.2	69	40	00.0	0	-	1.4	3.0
22 – 28		43	34.3	21.3	68	41	00.0	0	-	1.6	2.4
29 – 04	Nov18	44	31.4	20.8	67	43	00.0	0	-	3.0	2.8
05 – 11		45	32.8	20.1	68	39	00.0	0	8.5	1.9	2.5
12 – 18		46	33.0	18.9	67	46	00.0	0	8.4	1.3	3.2
19 – 25		47	32.4	17.3	74	45	00.0	0	8.1	1.5	2.8
26 – 02	Dec18	48	30.0	16.2	70	32	00.0	0	7.3	1.5	3.0

Table 3. Influence of various treatments on different pre-harvest traits of soybean at different growth stages

Treatments	Mean plant height (cm)				No. of functional leaves plant^{-1}				Mean number of branches plant^{-1}				Dry matter accumulation plant^{-1}(g)			
Sowing Dates	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
D1: 25th MW	18.81	31.44	43.04	45.03	11.78	22.22	24.00	4.22	5.44	11.59	13.78	13.81	2.99	11.98	29.47	35.59
D2: 26th MW	20.17	33.61	45.20	47.16	12.56	23.00	25.89	5.67	5.78	12.63	14.78	14.99	3.29	12.82	31.33	36.69
D3: 27th MW	19.66	33.16	43.54	46.09	11.44	22.00	23.78	4.00	5.33	11.78	13.89	14.04	3.17	12.27	29.92	35.99
D4: 28th MW	17.43	31.31	41.20	42.91	10.39	20.33	22.67	3.33	4.11	10.78	12.56	12.79	2.82	11.29	28.11	34.09
SE(m) ±	0.62	0.51	0.52	0.60	0.61	0.47	0.56	0.35	0.39	0.29	0.41	0.37	0.12	0.24	0.44	0.28
CD at 5%	-	1.76	1.79	2.09	-	1.62	1.94	1.20	-	1.01	1.42	1.28	-	0.83	1.54	0.95
Varieties																
V1: JS-335	20.25	34.90	45.95	48.31	12.92	24.50	26.67	6.33	6.08	12.50	14.50	14.54	3.29	12.92	31.33	38.00
V2: JS-9560	17.46	28.74	40.13	41.28	10.42	20.08	22.33	2.83	4.50	11.18	13.17	13.38	2.84	10.88	27.41	32.34
V3: AMS-1001	19.34	33.50	43.66	46.30	11.29	21.08	23.25	3.75	4.92	11.40	13.58	13.80	3.07	12.47	30.39	36.43
SE(m) ±	0.31	0.41	0.40	0.38	0.44	0.61	0.57	0.45	0.29	0.32	0.32	0.27	0.12	0.16	0.54	0.83
CD at 5%	0.93	1.23	1.19	1.15	1.32	1.84	1.72	1.34	0.87	0.97	0.95	0.82	-	0.47	1.63	2.48
Interaction																
SE(m) ±	0.62	0.82	0.79	0.76	0.88	1.23	1.14	0.89	0.58	0.65	0.63	0.55	0.24	0.31	1.09	1.65
CD at 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G.M.	19.02	32.38	43.25	45.30	11.54	21.89	24.08	4.31	5.17	11.69	13.75	13.91	3.07	12.09	29.71	35.59

Table 4. Influence of various treatments on different post-harvest traits of soybean

Treatments	Yield contributing characters observed at harvest						Yield observations in kg ha^{-1}			Economic studies of soybean(Rs.ha^{-1})				
	Average days of maturity	No. of pods plant^{-1}	No. of seeds pod^{-1}	No. of seeds plant^{-1}	Seed yield plant^{-1}(g)	Test weight (g)	Seed yield	Straw yield	Biological yield	Harvest index (%)	Cost of production	GMR	NMR	B:C Ration
D1: 25th MW	116	30.56	2.31	48.67	5.50	11.52	2199	3398	5597	39.90	36250	101738	65488	2.81
D2: 26th MW	115	34.78	2.77	51.78	6.05	11.88	2470	3597	6067	41.24	36250	112969	76719	3.12
D3: 27th MW	112	32.33	2.53	51.33	5.81	11.56	2330	3266	5596	41.82	36250	105791	69541	2.92
D4: 28th MW	111	28.33	2.06	47.67	5.24	11.14	2009	2968	4977	40.96	36250	92132	55882	2.54
SE(m) ±	0.58	1.12	0.13	0.79	0.11	0.10	51.99	121.03	140.52	-	-	2181.64	2181.64	-
CD at 5%	2.01	3.89	0.44	2.72	0.38	0.34	179.91	418.81	486.26	-	-	7549.49	7549.49	-
Varieties														
V1: JS-335	116	37.42	2.68	58.50	6.21	10.61	2510	3383	5894	42.78	36250	113178	76928	3.12
V2: JS-9560	105	24.83	2.09	37.92	4.98	13.11	1945	3064	5009	39.90	36250	90349	54099	2.49
V3: AMS-1001	120	32.25	2.48	53.17	5.77	10.86	2300	3475	5775	40.26	36250	105945	69695	2.92
SE(m) ±	0.50	1.28	0.09	0.66	0.14	0.27	56.93	103.70	98.13	-	-	1963.40	1963.40	-
CD at 5%	1.51	3.85	0.27	1.99	0.43	0.82	170.68	310.91	294.20	-	-	5886.27	5886.27	-
Interaction														
SE(m) ±	1.00	2.57	0.18	1.33	0.29	0.54	113.86	207.41	196.26	-	-	3927	3927	-
CD at 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G.M.	114	31.50	2.42	49.86	5.65	11.53	2252	3308	5559	40.98	36250	103158	66908	2.85

Table 5. Temperature (^{0}C) and relative humidity (%)requirement for linseed as influenced by various treatments

Treatments	Temperature requirement (^{0}C)	Meteorological Weeks		Relative Humidity (%)		
				Maximum	Minimum	Variation
Sowing dates						
D1: 25th MW	433.51	**25thMW**	(1stSowing)	65	47	18
D2: 26th MW	427.47	**26thMW**	(2ndSowing)	79	66	13
D3: 27th MW	421.30	**27thMW**	(3rdSowing)	86	67	19
D4: 28th MW	416.86	**28thMW**	(4thSowing)	83	76	7
Varieties		**29thMW**	-	81	75	6
V1: JS-335	433.95	**30thMW**	-	96	82	14
V3: JS-9560	392.80	**31stMW**	-	69	51	18
V2: AMS-1001	448.92	**32ndMW**	-	79	68	11
GM	424.97	**33rdMW**	-	85	67	18
		34thMW	-	85	71	14
		35thMW	-	86	77	9
		36thMW	-	81	69	12
		37thMW	-	71	52	19
		38thMW	-	77	67	10
		39thMW	-	76	65	11
		40thMW	-	72	49	23
		41stMW	(1stHarvesting)	68	44	24
		42ndMW	(2ndHarvesting)	69	40	29
		43rdMW	(3rdHarvesting)	68	41	27
		44thMW	(4thHarvesting)	67	43	24

yield components as compared to sowing of soybean during 26th, 27thand 28thMW resulting in significant increase in seed yield of linseed and yield components. Among the three different cultivars of soybean JS 335 recorded significantly higher growth and yield components resulting in increased seed yield as compared to JS-9560 and AMS-1001. The temperature requirement of soybean is more in crop sown on 25th MW. Finally it is inferred from this study that sowing of soybean crop on D_2 (26thMW) would be suitable and variety V_1 (JS 335) which also is likely to give maximum benefit : cost ratio.

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