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Response of soybean varieties to different sowing times

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Abstract
Field experiment was conducted during rabi season 2015-16 at S.V Agricultural College, Tirupati, Andhra Pradesh, India to study response of soybean varieties to different sowing times. It was comprised of 16 treatments with four sowing dates (16th September (D_1), 1st October (D_2), 16th October (D_3)) and 1st November (D_4) and four varieties (Basar, JS-93-05, Bheem and JS-335) replicated thrice. September 16th sowing with JS-335 (V_4) variety was promising in rabi while compared to other sowing times and varieties.

Keywords: Sowing time, Soybean, Varieties, yield

Introduction
Soybean (*Glycine max*. L. Merrill) has a prominent position among the legumes that supplement nearly one-third of the world population and popularly known as "Miracle Bean" because of its versatility. Soybean is a highly nutritive and energy rich monocarpic legume crop with proteins (40%) and edible oil (20%). Soybean now established as number one crop among oilseeds and contributes more than 50 per cent oilseed production and 30 per cent of vegetable oil production in India (Anonymous, 2008) [1]. Besides its main use for oil extraction, it can be used as dal after some heat treatment, soya milk, tofu etc. Soya flour is an important ingredient in the bakery products. Soybean isoflavones have beneficial effects on human health due to their antiatherosclerotic, antioxidative, antitumoral, and antiestrogenic activities (Davis *et al*. 1999) [4]. In 2015, it occupied an area of 11 m ha in India with an average seed yield of about 1000 kg ha^{-1}. It is mainly grown in Madhya Pradesh, Maharashtra and Rajasthan (Anonymous, 2008) [1]. The productivity of soybean is low due to various constraints. The time of sowing has a considerable influence on growth and yield of soybean. Early sowing in the season may encourage higher vegetative growth which may invite various diseases and insects pests. However, delayed sowing may shrink the vegetative phase, which in turn reduces dry matter accumulation leading to poor partitioning to reproductive parts and ultimately poor realization of the potential yield. The varieties are equally important for realization of the potential yield of this crop. The short duration genotypes may vacate the field in time for the sowing of the succeeding rabi season crop. There was a need to study the optimum sowing window of newly developed soybean varieties.

Materials and methods
The experiment was conducted at S.V Agricultural College, Tirupati (Andhra Pradesh) during rabi 2015-16. It was comprised of 16 treatments with four sowing dates (16th September (D_1), first October (D_2), 16th October (D_3) and 1st November (D_4) and four varieties (Basar, JS-93-05, Bheem and JS-335) replicated thrice. The soil of the experimental field was sand clay loam, low in nitrogen (213 kg ha^{-1}) and medium in available phosphorus (24.2 kg ha^{-1}) and potassium (254 kg ha^{-1}). The maximum temperature during September-January was 30.0°C and 31.5°C. Total rainfall recorded during crop season was 1147.1 mm. A pre-sowing irrigation was given one day prior to sowing of the seed to ensure good germination and establishment of the seedlings and subsequently need based irrigations were given to the crop. The crop was raised using seed rate of 75 kg ha^{-1} with line-to-line spacing of 30 cm. The seed was treated with Dithane M-45@ 3 g kg^{-1} seed to control seed rot and seedling blight. The nutrient dose @ 30 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare was applied at the time of sowing. Nitrogen was applied in two equal splits, one at the time of sowing and another at 30 days after sowing (DAS). Method of application adopted was basal placement of 5 cm below the soil and 5cm away from seed rows. Pendimethalin @ 1.0 kg a.i. ha^{-1} was sprayed as a pre-emergence application on the second day after sowing to control the weeds. Hand weeding was done twice at 15 and 30 DAS of each sowing date to keep the plots free from weeds.

Minor incidence of tobacco cutworm was observed at flowering. Monocrotophos @ 2 ml l^{-1} and Chlorpyriphos @ 2.5 ml l^{-1} was used for effective control of the tobacco cutworm with an interval of one week. The data on various phenological stages were collected from each plot. The data on plant height, leaf area index (LAI), drymatter production, number of effective root nodules $plant^{-1}$ and number of seeds pod^{-1} were collected from randomly selected five plants per plot at harvest. The plants in the net plot area after removal of the pods from haulms were sun dried thoroughly till constant weight was attained and haulm yield was recorded and expressed in kg ha^{-1}. From the total produce of each plot, 100 seeds were counted and weighed to express hundred seed weight. The crop was harvested when the pods were matured; the bundles were sun dried for few days and then threshed manually. The harvest index was calculated by dividing grain yield by biological yield.

Effect of sowing time

Plant height (Table 1) progressively increased with advancement in age of the crop up to harvest. Plant height significantly differed due to times of sowing from 16th September to 16th October (D_1, D_2 and D_3). Difference in plant height due to first and second times of sowing was not significant. However, the difference in plant height due to 16th October and 1st November (D_3 and D_4) sowings was not significant. Earliest sown crop (16th September) resulted in significantly taller plants. Plant height decreased with delay in sowings from D_1 to D_4. This can also be attributed to decrease in bright sunshine hours per day and more number of rainy days during the crop period. Leaf area index at harvest significantly varied due to each date of sowing from 16th September to 16th October (D_1, D_2 and D_3). However, the difference in leaf area index due to 16th October and 1st November (D_3 and D_4) was not significant. Earliest sown crop (16th September) resulted in significantly maximum leaf area index (LAI). Decrease in leaf area index with delayed sowing can be attributed due to progressive decrease in bright sunshine hours and leaf senescence. At harvest, the highest drymatter accumulation was with early date of sowing on 16th September (D_1) which was significantly superior to that due to 1st October (D_2), 16th October (D_3) and 1st November (D_4). Latest sown crop 1st November (D_4) produced least dry matter production. The increase in drymatter production can also be attributed to taller plants and higher LAI due to early sowings can be attributed to favourable weather for growth and development of soybean with early seeding. Higher number of nodules $plant^{-1}$ was with 1st October (D_2) with no significant disparity between first and third times of sowing i.e 16th September (D_1) and 16th October (D_3). Soybean sown during 1st November (D_4) recorded significantly lowest number of effective root nodules $plant^{-1}$. There was 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}.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. These are in conformity with the results reported by Wafaa *et al*. (2002) [11]. 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 leading to improvement in yield attributes such as number of pods $plant^{-1}$ and hundred seed weight. Earliest sown crop recorded significantly highest haulm yield. Haulm yield decrease significantly with delay in sowing from second fortnight of September (D_1) to 1st October (D_2). Taller plants, higher LAI and drymatter production with timely sowings resulted in highest haulm yield with early sowings (16th September and 1st October). These results are in conformity with those reported by Ram *et al*. (2010) [8]. Early sowings (16th September and 1st October), which were at par recorded significantly highest harvest index compared with the later sowings (16th October and 1stof November). Latest sown crop (1st November (D_4)) recorded lower harvest index compared to the crop sown on 16th October (D_3). Relatively higher harvest index with early sowings can be attributed to taller plants, higher LAI and higher drymatter production with early sown crop. Adequate soil moisture availability due to high rainfall and relatively longer sunshine hours might have contributed to improvement in growth parameters leading to higher harvest index with early sowings. Ram *et al*. (2010) [8] reported that timely planting of soybean recorded higher harvest index than the late sown crop.

Effect of varieties

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), which were at par, recorded the shortest plants (Table 1). Variety JS-335 (V_4) recorded significantly higher leaf area index compared with other varieties. Difference in LAI between Basar (V_1) and JS-93-05 (V_2) was not significant. Keeping the crop management practices constant, variation in LAI due to varieties can be ascribed to their morphological characteristics, higher plant height, varietal difference in leaf area and delayed senescence of leaves. JS- 335 (V_4) produced significantly higher drymatter production followed by Basar (V_1), Bheem (V_3) and JS-93-05 (V_2). Difference in drymatter production between any two varieties was significant. Variety JS-335 (V_4) recorded significantly highest number of effective root nodules $plant^{-1}$. Differences due to JS-335 (V_4) and Basar (V_1) were not significant. In general, JS-93-05 (V_2) and Bheem (V_3) had less number of effective root nodules $plant^{-1}$ compared to JS-335 (V_4) and Basar (V_1). Taller plants, higher LAI and higher drymatter production with JS-335 (V_4) at all the stages of crop growth might have contributed to more number of effective root nodules $plant^{-1}$. Kumar *et al.,* (2005) also reported genotypic differences with respect to number of pods $plant^{-1}$ plant. Among varieties tested, 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-93-05 (V_2) which were at par produced lowest number of seeds pod^{-1}. Highest hundred seed weight was recorded with the variety Bheem (V_3), which was statistically at par with JS-335 (V_4), but significantly higher than Basar (V_1) and JS-93-05 (V_2). Highest seed yield was recorded with the variety JS-335 (V_4), which was statistically at par with Basar (V_1), but significantly higher than Bheem (V_3) and JS-93-05 (V_2). High soybean yields of the varieties JS-335 (V_4) and Basar (V_1) might be due to better growth, higher tolerance to insect pests and diseases, adequate crop duration. Varieties of soybean do differ in seed yields (El Douby *et al.,* 2002 [4]; Veni *et al*, 2003 [10]; Billore *et al.*, 2009 [2]; De Bruin and Pedersen, 2009) [3]. Varieties having better leaf area, crop growth rate and net assimilation rate are expected to yield higher. Higher haulm yield with JS-335(V_4) and Basar (V_1)

relative to Bheem (V_3) and JS-93-05(V_2) can be attributed to improvement in growth parameters like plant height, LAI and drymatter production with the two varieties (JS-335 and Basar). Ram *et al*. (2010) [8] recorded better haulm yield in SL 790 than in SL 744 and SL525 soybean varieties. Higher harvest index with JS-335 (V_4) and Basar (V_1) can be attributed to improvement in growth parameters like taller plants, higher LAI and higher drymatter production with these two varieties compared with Bheem (V_3) and JS-93-05 (V_2). Favourable weather in terms of rainfall, bright sunshine hours might have contributed to improvement in growth and development leading to higher harvest index with JS-335 (V_4) and Basar (V_1). Ram *et al*. (2010) [8] and (Sharma and Sharma.1993) [9] also reported similar varietal variations with regard to harvest index in soybean.

Conclusion

Based on study, it is concluded that soybean should be sown on 16th September (D_1) gives plants using varieties JS-335 (V_4) for getting higher grain yields and net returns.

Table 1: Effect of sowing times and varieties on growth characters of soybean

Treatments	Plant height(cm)	Leaf Area Index (LAI)	Drymatter Production (DMP) (kg ha^{-1})	Number of effective root nodules plant^{-1}
Sowing time				
D1: 16th September	38.2	3.50	4798.3	26.2
D2: 1st October	36.1	3.30	4316.0	26.9
D3: 16th October	33.1	3.10	3360.8	25.5
D4: 1st November	32.4	3.00	3003.8	23.2
SEm±	0.3	0.06	85.0	0.8
CD (P=0.05)	1.0	0.18	246.6	2.2
Varieties				
V_1: Basar	34.9	3.30	4155.3	27.1
V_2: JS-93-05	35.1	3.10	3264.8	25.3
V_3: Bheem	34.1	3.20	3643.6	22.8
V_4: JS-335	36.2	3.50	4415.2	26.6
SEm±	0.3	0.06	85.0	0.8
CD (P=0.05)	1.0	0.18	246.6	2.2

Table 2: Effect of sowing times and varieties on yield of soybean

Treatments	Number of seeds pod^{-1}	Hundred seed weight (g)	Haulm yield (kg ha^{-1})	Harvest index (%)	Seed yield (kg ha^{-1})
Sowing time					
D1: 16th September	3.0	11.2	2399.1	30.8	1417.3
D2: 1st October	2.4	11.3	2158.0	29.9	1319.4
D3: 16th October	2.1	9.8	1680.4	26.5	840.6
D4: 1st November	1.6	9.5	1501.9	23.3	787.5
SEm±	0.1	0.3	38.2	0.9	44.2
CD (P=0.05)	0.2	0.9	110.7	0.7	128.3
Varieties					
V_1: Basar	2.5	10.3	2077.7	28.2	1158.9
V_2: JS-93-05	2.0	9.8	1632.4	25.8	942.2
V_3: Bheem	2.1	11.2	1821.8	26.8	1058.7
V_4: JS-335	2.7	10.5	2207.6	29.7	1204.9
SEm±	0.1	0.3	38.2	0.9	44.2
CD (P=0.05)	0.2	0.9	110.7	2.7	128.3

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