The Pharma Innovation Journal 2023; 12(8): 1000-1003

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 1000-1003

www.thepharmajournal.com
Received: 02-06-2023
Accepted: 13-07-2023

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Evaluation of different sowing dates and spacing on soybean varieties for seed production during *rabi* season

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Abstract
The field experiment on soybean seed production during *rabi* season was conducted during 2021-22 at the Research Farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.
The research trial was laid out in split-split plot design with three replications. The experiment consisted of nine treatment combinations, comprising of three sowing dates *viz*., 16 December, 31 December and 15 January in main plot and three spacing like 30 x 10 cm, 45 x 10 cm and 60 x 10 cm in sub plot and three varieties are AMS 100-39, RSC 10-46 and KDS-753 in sub-sub plot.
The experimental results revealed that growth characters *viz*., plant height, number of branches plant^{-1}, leaf area plant^{-1}, dry matter accumulation plant^{-1} and number of root nodules plant^{-1} were extensively greater in early sown crop of 16 December and variety RSC 10-46. Plant height was higher with spacing 30 x 10 cm where as 60 x 10 cm was superior in, number of branches plant^{-1}, leaf area plant^{-1}, dry matter accumulation plant^{-1} and number of root nodules plant^{-1}.
Furthermore, the seed yield and stover yield were significantly maximum in 16 December sowing, 45 x 10 cm spacing and RSC 10-46 variety and significantly higher than other sowing dates, spacing and varieties. Delayed sowing in 31 December and 15 January showed radically inferior growth and yield attributes of soybean.

Keywords: Soybean varieties, sowing date, spacing, growth, seed yield

Introduction
Soybean (*Glycine max* L. Merrill) is widely grown due to high quality protein and edible oil. As it is a short duration, having drought resistance, with high yielding ability and reach in nutritive value, it is called as 'wonder crop'. Soybean contains 35-45 percent protein and 18-24 percent oil. It is a treasure of nutrients. Sowing of soybean should be done at recommended time to avoid the damages due to insects, weeds, freezing and diseases. Similarly, coinciding the flowering time with appropriate temperature and day length are the most important for producing good yield. Late sowing of soybean may reduce plant height, number of branches, harvest index and grain yield. (Khan *et al*., 2011) [6].
When a crop to be introduced in a new cropping system, identifying the suitable varieties compatible with the exposed agro-ecological conditions is extremely important. As different cultivars respond variably to environmental conditions.
The use of resources, especially light, nutrients and water, which enhances the rate of vegetative growth and plant development, especially the leaf area index (LAI) and plant height substantially determined by the planting density and row spacing. (Holshouser and Whittaker, 2002) [2].
Soybean as commercial crop is successful in *kharif* season as the agro-climatic conditions are found suitable. However, climatic conditions may cause the adverse effect on seed production of different soybean varieties in *kharif* season. However, obtaining quality soybean seed with high germination and vigour by sowing during November to December in *rabi* season. (Rehman and Hossain, 2013) [10].
The field weathering even before its harvest can adversely affect seed quality because of its high sensitivity. Even maintaining the minimum germination standard (70%) till next season becomes difficult as these factors affect seed germination and vigour severely. The seed requirement of soybean is high as compare to seed multiplication ratio in soybean, which forms the major bottleneck in augmenting the availability of quality seed.

Generally, the time of sowing varies depending on the climatic conditions of the region and the variety to be grown, different varieties of soybean are sensitive to changes in environmental conditions where the crop is being grown. Therefore, it is necessary to study the genotype and environment interaction to identify the varieties which are stable in different environments.

Materials and Methods

A field experiment was conducted to evaluate the performance of soybean varieties under different sowing dates and spacing for seed production during *rabi* season of 2021-22 at the Research Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

The soil of the experimental field was clayey in texture, low in organic carbon (0.57%) and available nitrogen (217.9 kg ha^{-1}), low in available phosphorus (15.89 kg ha^{-1}) and high in available potassium (364.23 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 8.6). Total rainfall received during the crop growth period was 42.6 mm over 1 rainy day during 52 MW. The average monthly maximum temperature of 42.4 ^{0}C was recorded in April and minimum of 11.3 ^{0}C was in the month of January.

An experiment was laid out in split-split plot design with three replications. The experiment consists of twenty seven treatment combinations, comprising of three sowing dates *viz*., 16 December, 31 December and 15 January in main plot, three spacing like 30 x 10 cm, 45 x 10 cm and 60 x 10 cm in sub plot and three varieties which are AMS 100-39, RSC 10-46 and KDS-753 in sub-sub plot in the experiment. The recommended dose of fertilizers 30:60:30 kg N: P2O5: K2O ha^{-1} was applied through vermicompost and phosphorus rich organic manure.

The sowing of soybean was carried out as per the treatment. Seeds were drilled as per the spacing in treatments and at the time of thinning expected plant stand was achieved maintaining plant to plant distance of 10 cm. As required gap filling was done on 6th and thinning on 10th day after each sowing so as to maintain intra plant spacing of 10 cm. The hand weeding and hoeing were given to keep the experimental plots weed free and aerated. In order to record the various biometric observations, five plants were selected randomly to present the population in each plot, labeled it and observations were recorded on them at periodic intervals. The data was analyzed statistically as per Panse and Sukhatme (1967) [7].

Results and Discussion

Effect of sowing dates

Plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$, number of root nodules $plant^{-1}$ was significantly influenced throughout the crop growth period by different growing environment created through different sowing dates. The crop sown on 16 December recorded significantly higher plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$, number of root nodules $plant^{-1}$ than the crop sown on 31 December and 15 January. It can be attributed to the availability of sufficient time and favorable environment for the vegetative growth and development in case of the early sown crop. Karad (1999) [4], Kausale (2000) [5] and Rajendra Prasad (2002) [9] also reported similar results.

There was progressive increase in dry matter accumulation $plant^{-1}$ and reached to its maximum 17.67 g and 18.98 g at harvest. Accumulation of maximum dry matter was observed with 16 December sown crop and it was closely followed by 31 December sowing. Later sown crop that decreased the dry matter accumulation might be due to decreased growth period of the crop which decreased with each successive delay in sowing and resulted in reduced dry matter accumulation in late sowings. Number of root nodule approximates the extent of nitrogen fixation with soybean plant. Any deflection in the number is suggestive of the treatment differences, as other factors were held constant. Sowing at 16 December recorded significantly more number of root nodules. The number of root nodules $plant^{-1}$ were reduced with delay in sowing. The results are in conformity with the results recorded by Singh *et al*. (2011) [11].

16 December sown crop recorded significantly maximum seed and stover yield over 31 December and 15 January with delay in sowing, plant height, number of pods $plant^{-1}$, seed yield $plant^{-1}$ and seed index decrease (Jasani *et al*., 1994) [3], ultimately resulting in lower yields. It was also due to favorable weather encountered across different phenophases by this early sowing dates as compared to late sown crop. Partha *et al.* (2016) [8] reported maximum seed yield with sowing of soybean on 2 December than the sowing in November month.

Effect of spacing

The maximum plant height was observed in 30 x 10 cm. However, the number of branches $plant^{-1}$, leaf area $plant^{-1}$ and dry matter accumulation $plant^{-1}$ was recorded in spacing of 60 x 10 cm. It might be due to proper aeration and plant gets enough space for growth of plant as compare to other spacing. Aastha and Singh (2016) [1] observed same results. Grain and stover yield of soybean was significantly higher with the spacing of 45 x 10 cm. This might be due to the ideal plant density which was adequate to compensate the plant population and thus resulted in significantly higher seed and stover yield.

Effect of varieties

Differences due to varieties on the plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$ and dry matter accumulation $plant^{-1}$ were significant at all stages of crop growth. It was observed that RSC 10-46 recorded significantly higher plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$ and dry matter accumulation $plant^{-1}$ as compared to AMS 100-39 and KDS-753. The superior performance of RSC 10-46 compared to other two varieties in terms of plant height could be mainly due to inherent genetic characteristic. Superior yield level with RSC 10-46 was due to better expression of reproductive components as compared to AMS 100-39 and KDS-753. These favorable phenomena resulted in highest yield. Similarly, it might be due to potential yield of the variety as a varietal inheritance.

The interaction effect was found not significant at all the stages of plant growth.

Table 1: Plant height (cm), number of branches plant^{-1}, leaf area (cm^{2}plant^{-1}), dry matter accumulation plant^{-1}, number of root nodules plant^{-1} of soybean as influenced by sowing dates, spacing and varieties

Treatments	Plant height (cm)		No. of Branches plant^{-1}		Leaf area (cm^{2}plant^{-1})		Dry matter accumulation (g plant^{-1})			Number of root nodules plant^{-1}	
	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS
I) Main plot treatments (Sowing Dates)											
D_1- 16 December	34.87	36.90	9.11	11.67	612.07	710.45	12.35	15.65	17.67	10.50	16.85
D_2- 31 December	30.39	34.31	7.77	10.53	589.26	621.18	10.47	14.30	16.58	8.05	14.69
D_3- 15 January	27.28	30.97	6.49	9.11	346.30	490.81	9.20	11.00	13.70	7.29	14.52
S. E. (m) ±	0.82	0.64	0.11	0.19	6.49	5.15	0.20	0.25	0.13	0.34	0.33
C. D. at 5%	2.36	1.84	0.32	0.56	18.62	14.79	0.57	0.72	0.37	0.98	0.93
II) Sub plot treatments (Spacing)											
S_1- 30 X 10 cm	35.14	38.02	6.92	8.43	532.53	592.85	10.23	11.84	15.00	8.02	13.60
S_2- 45 X 10 cm	32.26	34.02	8.24	9.96	556.53	619.00	10.95	13.96	16.21	8.21	15.39
S_3- 60 X 10 cm	27.14	30.15	8.80	11.29	567.12	673.74	11.25	15.17	16.95	9.61	17.06
S. E. (m) ±	1.28	1.06	0.19	0.43	3.52	6.41	0.21	0.40	0.38	0.47	0.20
C. D. at 5%	3.95	3.26	0.57	1.34	10.84	19.75	0.66	1.23	1.17	NS	NS
III) Sub-sub plot treatments(Varieties)											
V_1- AMS 100-39	31.01	34.81	8.12	10.73	586.35	621.26	10.91	14.23	16.03	8.76	15.76
V_2- RSC 10-46	33.80	37.41	8.74	11.44	610.24	673.23	12.35	16.03	17.63	9.51	15.85
V_3- KDS-753	27.73	29.96	6.52	9.14	474.05	574.16	8.76	10.69	14.29	8.31	15.65
S. E. (m) ±	1.08	1.67	0.30	0.39	6.34	6.96	0.27	0.43	0.34	0.31	0.05
C. D. at 5%	4.25	6.56	1.18	1.53	24.90	27.34	1.07	1.70	1.34	NS	NS

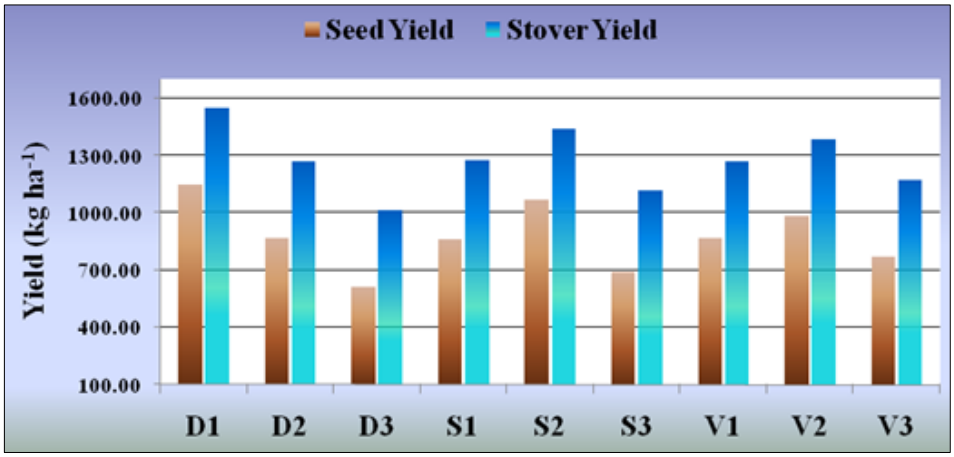

Fig 1: Seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of soybean as influenced by sowing dates, spacing and varieties

Conclusion

From the overall point of view of the result and discussion, it can be concluded that the 16 December sowing, 45 x 10 cm spacing and RSC 10-46 variety displayed superior performance compared to the others sowing dates, spacing and varieties for enhancing growth, seed yield and stover yield of soybean during *rabi* season.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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