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Effect of Different Varieties and Plant Densities on Growth and Yield Contributing Character of Soybean [*Glycine max* (L.)]

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ABSTRACT: *The field experiment was conducted in factorial randomized block design with three replications during* kharif *2009 at the College of Agriculture, Latur (Maharashtra). The treatments were comprised of combinations of two varieties (JS 335 and MAUS-71) and four spacing (45 cm x 5 cm, 45 cm x 7.5 cm, 45 cm x 10 cm and 45 cm x 12.5 cm). The results revealed that higher seed yield of soybean can be obtained by sowing the soybean variety MAUS-71 with the spacing 45cm x 10 cm over all other treatments.*

Key words: *Growth, Plant densities, soybean, varieties*

In the past few years, the area under soybean crop is increasing consistently Marathwada and Vidharbha region of Maharashtra, particularly by replacing cotton crop (*http://articles.economictimes.indiatimes.com/2012-10-02/news, http://www.icar.org.in/files/state-specific/chapter/80*). Although, soybean performs very well in these regions, it got heavily infested in *kharif* 2008 by hairy caterpillar (*Amsacta moorei*) due to high plant population in addition to prevailing high humidity consequent upon higher rainfall. The recommended spacing of soybean crop is 45 cm x 5 cm. However, for small seeded popular varieties (NRC 37, MACS 57, MACS 58, vishwas, vijay and vishal) in the region and farmers invariably use high seed rate, the recommended spacing may result in higher planting density, which may provide salutary conditions for infestation with defoliators. Hence, to evaluate the optimum plant spacing for two popular varieties of soybean, the present investigation was undertaken.

A field experiment was conducted during *kharif* 2009 at the College of Agriculture, Latur. The soil of experimental plot was deep black (vertisol) with good drainage. The experiment was laid out in factorial randomized block design with three replications. There were eight treatment combinations with two varieties (JS 335 and MAUS 71) and four spacing (45 cm x 5 cm, 45 cm x 7.5 cm, 45 cm x 10 cm and 45 cm x 12.5 cm). The crop was sown on 01st July, 2009 by hand dibbling. Recommended dose of fertilizers (30:60:30: $N:P_2O_5:K_2O$ kg/ha) was applied as basal. The seeds were treated with Thirum 80 WP @ 3 g per kg seeds followed by inoculation with cultures of *Bradyrhizobium japonicum* and phosphorus solubilizing bacteria before sowing. The biometric observations for growth/yield attributing characters were taken at *30,45,60,75 and* at harvest stage of crop by randomly selecting five plants per plot. Data obtained on various variables were analyzed by analysis of variance method (Panse and Sukhatme, 1967)

The height of the plant increased continuously till maturity of the crop (Table 1). The varieties differed non significantly in respect of plant height. The rate of increase in height was maximum during 30-60 days in the varieties indicating grand growth period of crop. The plant spacing of 45 cm x 7.5 cm was at par with 45 cm x 5 cm spacing and these are significantly superior over spacing 45 cm x 12.5 cm spacing at 45 days. At 60 days the spacing 45 cm x 7.5 cm produced tallest plants over all other spacing; however, it was at par with 45 cm x 5 cm, 45 cm x 10 cm and 45 cm x 12.5 cm plant spacing. Similar trend of increase in plant height was observed at 75 DAS and harvest of crop. These findings are in confirmation with the findings reported by Gupta *et al*. (1973). Variety

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MAUS-71 recorded significantly more height than JS-335 at all the growth stages. This is because the varietal characters that MAUS-71 is taller in height as compared to JS-335 variety. Khelkar *et al*. (1991) also reported significant differences in plant height due to different plant population. The interaction effect in between varieties and plant spacings were non significant at all growth stages.

Mean number of functional leaves increased till 60 days of crop and declined thereafter (Table 2). The trend of increase in number of functional leaves in different treatments after 75 days was erratic hence not considered for interpretation. The significantly more number of leaves per plant was observed in spacing 45 cm x 10 cm than other plant spacing's. This might be because of optimum utilization of available resources like moisture and more space available for the plant growth. These results are in confirmation with the results reported by Arora (1981). Different plant spacing's influenced leaf number significantly. The plant spacing of 10 cm recorded significantly higher leaf number at all the growth stages except at 30 and 75 days from sowing, where it was at par with 7.5 cm of plant spacing. Similar result had been reported by Balyan and Mohta (1985). The variety MAUS-71 recorded significantly higher number of functional leaves than JS-335 variety due to more height and varietal adjustment with different plant population. The interaction effect in between varieties and plant spacings were found non significant at all growth stages of crop.

Highest number of nodules per plant was observed in soybean variety MAUS-71 at all the growth stages (Table 3). The variety MAUS-71 was produced significantly higher number of nodule per plant over JS-335. Highest number of nodule was observed when plant was sown at 45 cm x 10 cm spacing. This might be due to availability of more space and other favorable condition for crop due to increasing plant spacing.

The mean number of branches increased from 45 days of crop age and it was maximum at 75 DAS and at harvest (Table 4). The spacing 45 cm x 10 cm recorded significantly higher number of branches over 45 cm x 7.5 cm and 45 cm x 5 cm spacing; however it was at par with 45 cm x 12.5 cm spacing at 45 days after sowing. At 60 DAS the spacing 45 cm x 10 cm recorded the maximum number of branches and it was found significantly superior over spacing 45 cm x 5 cm but at par with 45 cm x 7.5 cm and 45 cm x 12.5 cm spacing. The increase in branches might be due to more spacing available for development of crop and more moisture and nutrients taken by the plants from larger areas. The variety MAUS-71 recorded significantly higher number of branches than JS-335. It was reported by Khurana *et al*. (1984) and Patoliya (1988) that number of branches per plant varied from variety to variety and also due to different plant spacing.

The mean numbers of pods per plant were recorded 60 days onwards from sowing and same were increased gradually till harvest of the crop. The different plant spacing had significant effect on number of pods per plant (Table 5). The spacing 45 cm x 10 cm produced significantly more number of pods as compared to the spacing 45 cm x 5 cm and 45 cm x 12.5 cm spacing at 60 DAS, 75 DAS and at harvest stage. This might be because of increased growth characters and optimum utilization of different resources such as soil moisture, nutrient, solar radiation by the plant and optimum plant population in 45 cm x 10 cm as compared to other plant spacing's. The variety MAUS-71 recorded significantly higher number of pods than variety JS-335 at all the pod development stages. Interaction in different factors were non significant.

The dry matter was recorded from 30 DAS up to at harvest stage of crop (Table 6). The mean dry matter weight was suddenly increased at 60 -75 days of crop age. This was due to higher accumulation of dry matter in grand growth period. The plant spacing 45 cm x 10 cm produced the maximum total dry matter per plant which was significantly superior over spacing 45 cm x 5 cm but at par with spacing 45 cm x 7.5 cm and 45 cm x 12.5 cm. However, more or less similar trend was observed at 60, 75 DAS and at harvest stage of crop. This might be due to larger leaf area and more height which was resulted due to more photosynthetic activities and more accumulation of carbohydrate and thereby increased dry matter production. Variety MAUS-71 recorded significantly higher dry matter than variety JS-335 at the all growth stages. These results are in confirmation with the finding reported by Hudge *et al*. (1982) and Pople (1986). They also reported that different cultivars differed significantly in total dry matter production.

Leaf area index (LAI) slowly increased and it was maximum (1.80) at 75 days from sowing (Table 7). The spacing 45 cm x 5 cm was recorded highest LAI in all the growth stages as compared to other spacing's followed by 45 cm x 7.5 cm, 45 cm x 10 cm and 45 cm x 12.5 cm. There was consistent increase

in leaf area index as plant spacing was decreased. Variety MAUS-71 indicated higher leaf area index than variety JS-335. These findings are in confirmation with the findings reported by Deshmukh (1972).

The variety MAUS-71 produced the higher pod yield per plant as compared variety JS-335 all stages of crop growth (Table 8). The pod weight per plant was influenced significantly due to different treatments of spacing. The spacing 45 cm x 10 cm recorded significantly higher pod yield per plant (12.05 g) over spacing 45 cm x 5 cm; however, it was at par with 45 cm x 7.5 cm and 45 cm x 12.5 cm spacing. Rajput *et. al.,* (1985) found that increasing row or plant spacing increase the number of pod per plant.

The variety MAUS-71 produced the highest grain yield per plant but it was found at par with the variety JS-335 (Table 8). The spacing of 45 cm x 10 cm recorded significantly higher grain yield per plant (8.09 g) over spacing 45 cm x 5 cm; however, it was at par with 45 cm x 7.5 cm and 45 cm x 12.5 cm spacing. Abbas (1994b) observed that all yield-attributing characters decreased with increasing plant population from 400,000 to 800,000 plants ha^{-1}.

The mean number of grains per plant was significantly influenced due to varieties and plant spacing's of crop (Table 8). The spacing of 45 cm x 10 cm recorded significantly higher number of grains per plant (79.23) over 45 cm x 5 cm spacing but it was at par with 45 cm x 7.5 cm and 45 cm x 12.5 cm spacing. This might be because of improvement in yield contributing character (number of pods per plant) and optimum utilization of available resources viz. moisture and nutrients from the soil and also due to the optimum plant population in 45 cm x 10 cm spacing as compared to the other plat population. The variety MAUS-71 produced the more number of grains per plant than JS-335 variety.

The mean test weight was significantly higher (96.33 g) in MAUS-71 as compared to JS-335 (Table 8). The spacing 45 cm x 10 cm produced highest test weight (95.83 g) as compared to all other spacing's. The increased test weight may be attributed to improvement in different growth and yield contributing characters of soybean. The effect of interaction due to variety and different plant spacings was found non significant. However Krishnaswami (1971) and Singh (1978) reported significant influence of varieties on test weight.

Table 1
Mean plant height (cm) as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*				
	30	*45*	*60*	*75*	*At harvest*
Varieties					
V_1- JS -335	21.11	28.56	29.21	28.95	28.05
V_2- MAUS -71	21.46	28.89	29.40	29.23	28.26
SE ±	0.31	0.43	0.58	0.61	0.69
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Spacing's (cm^2)					
S_1- 45 x 5.0	21.46	28.96	29.43	29.36	28.46
S_2- 45 x 7.5	22.70	29.60	30.53	30.00	28.50
S_3- 45 x 10	22.16	28.66	28.90	28.80	28.13
S_4- 45 x 12.5	19.13	27.73	28.36	28.20	27.53
SE ±	0.44	0.61	0.82	0.86	0.96
CD at 5%	1.34	1.86	2.48	2.61	2.96
Interactions(VxS)					
SE ±	0.62	0.86	1.16	1.22	1.38
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	21.29	28.74	29.30	29.09	28.15

Table 2
Mean number of functional leaves $plant^{-1}$ as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*			
	30	*45*	*60*	*75*
Varieties				
V_1- JS -335	6.58	11.28	15.90	12.05
V_2- MAUS -71	6.80	12.20	16.93	12.23
SE ±	0.24	0.88	0.86	0.68
CD at 5%	N.S.	N.S.	N.S.	N.S.
Spacings (cm^2)				
S_1- 45 x 5.0	6.23	9.36	14.70	12.03
S_2- 45 x 7.5	6.70	11.36	15.96	11.20
S_3- 45 x 10	6.96	13.53	17.60	12.76
S_4- 45 x 12.5	6.86	12.70	17.40	12.56
SE ±	0.34	1.25	1.22	0.96
CD at 5%	1.03	3.81	3.70	2.93
Interactions (VxS)				
SE ±	0.48	1.77	1.73	1.37
CD at 5%	N.S.	N.S.	N.S.	N.S.
General mean	**6.69**	**11.74**	**16.41**	**12.14**

Table 3
Mean number nodules plant^{-1} as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*				
	30	*45*	*60*	*75*	*At harvest*
Varieties					
V_1- JS -335	3.83	8.33	11.58	13.58	11.08
V_2- MAUS -71	3.91	8.58	13.58	18.16	14.08
SE ±	0.77	0.90	1.54	2.48	1.85
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Spacings (cm²)					
S_1- 45 x 5.0	2.83	7.00	9.10	10.66	10.33
S_2- 45 x 7.5	3.33	7.00	11.50	14.83	11.16
S_3- 45 x 10	5.50	11.80	16.00	20.83	16.33
S_4- 45 x 12.5	3.83	8.03	13.66	17.16	12.50
SE ±	1.09	1.27	1.89	2.38	1.88
CD at 5%	N.S.	3.85	5.67	7.15	5.65
Interactions (VxS)					
SE ±	1.54	1.80	2.49	3.06	2.49
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	3.87	8.45	12.58	15.87	12.58

Table 4
Mean number of branches plant^{-1} as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*				
	30	*45*	*60*	*75*	*At harvest*
Varieties					
V_1- JS -335	1.78	2.76	4.36	4.45	4.45
V_2- MAUS -71	1.83	2.83	4.43	4.45	4.45
SE ±	0.11	0.18	0.21	0.22	0.22
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Spacing's (cm²)					
S_1- 45 x 5.0	1.56	2.20	3.80	3.83	3.83
S_2- 45 x 7.5	1.83	2.50	4.23	4.26	4.26
S_3- 45 x 10	1.93	3.03	5.03	5.06	5.06
S_4- 45 x 12.5	1.90	3.00	4.53	4.66	4.66
SE ±	0.16	0.25	0.30	0.96	0.96
CD at 5%	N.S.	0.78	0.91	0.96	0.96
Interactions (VxS)					
SE ±	0.23	0.36	0.42	0.45	0.45
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	1.80	2.80	4.40	4.45	4.45

Table 5
Mean number of pods plant^{-1} as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*		
	60	*75*	*At harvest*
Varieties			
V_1- JS -335	21.53	35.35	36.21
V_2- MAUS -71	22.25	36.53	37.73
SE ±	1.09	0.76	1.49
CD at 5%	N.S.	N.S.	N.S.
Spacings (cm²)			
S_1- 45 x 5.0	17.36	29.43	30.16
S_2- 45 x 7.5	22.23	36.13	36.50
S_3- 45 x 10	24.20	39.76	40.76
S_4- 45 x 12.5	23.76	38.43	40.53
SE ±	1.55	1.07	2.10
CD at 5%	4.71	3.25	6.38
Interactions (VxS)			
SE ±	2.19	1.52	2.98
CD at 5%	N.S.	N.S.	N.S.
General mean	21.89	35.94	36.99

Table 6
Mean total dry matter plant^{-1} (g) as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*				
	30	*45*	*60*	*75*	*At harvest*
Varieties					
V_1- JS -335	1.26	5.24	09.66	18.67	17.44
V_2- MAUS -71	1.36	5.30	10.89	18.85	17.69
SE ±	0.15	0.30	1.03	1.52	1.00
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Spacings (cm²)					
S_1- 45 x 5.0	1.01	4.36	07.93	15.00	14.21
S_2- 45 x 7.5	1.20	5.28	10.36	18.31	17.43
S_3- 45 x 10	1.55	6.01	12.05	21.88	19.93
S_4- 45 x 12.5	1.50	5.41	10.76	19.86	18.31
SE ±	0.21	0.43	1.46	2.15	1.41
CD at 5%	N.S.	1.31	4.44	6.53	4.29
Interactions (VxS)					
SE ±	0.30	0.61	2.07	3.05	2.00
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	1.31	5.27	10.27	18.76	17.57

Table 7
Mean leaf area index (LAI) as influenced by different treatments at various growth stages of crop

Treatments	*Days after sowing*			
	30	*45*	*60*	*75*
Varieties				
V_1- JS -335	0.86	1.19	1.69	1.81
V_2- MAUS -71	0.88	1.32	1.73	1.84
Spacing (cm²)				
S_1- 45 x 5.0	1.17	1.74	2.40	2.54
S_2- 45 x 7.5	0.91	1.32	1.79	1.86
S_3- 45 x 10	0.73	1.05	1.41	1.55
S_4- 45 x 12.5	0.56	0.80	1.10	1.17
General mean	0.85	1.24	1.69	1.80

Table 8
Pod yield plant^{-1} (g), Grain yield plant^{-1}(g), No. of grains plant^{-1} and Test weight (g) as influenced by different treatments at harvest stage of crop

Treatments	*Pod yield plant^{-1} (g)*	*Grain yield plant^{-1} (g)*	*No. of grains plant^{-1}*	*Test weight (g)*
Varieties				
V_1- JS -335	9.48	6.08	63.63	91.70
V_2- MAUS -71	10.43	6.65	69.12	96.33
SE ±	0.70	0.54	5.63	0.98
CD at 5%	N.S.	N.S.	N.S.	N.S.
Spacings (cm²)				
S_1- 45 x 5.0	7.26	4.70	50.03	90.83
S_2- 45 x 7.5	9.39	5.79	62.70	94.06
S_3- 45 x 10	12.05	8.09	79.23	95.83
S_4- 45 x 12.5	11.14	6.87	73.55	95.33
SE ±	0.99	0.76	7.96	1.39
CD at 5%	2.99	2.31	24.12	N.S.
Interactions (VxS)				
SE ±	1.40	1.08	11.26	1.97
CD at 5%	N.S.	N.S.	N.S.	N.S.
General mean	9.96	6.36	66.37	94.01

CONCLUSION

From the investigation, it could be concluded that, farmer can obtained higher soybean yield by sowing the variety MAUS 71 with the spacing of 45 cm × 10 cm.

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