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Influence of sowing dates and plant densities on yield attributes and yield of soybean (*Glycine max* (L.) Merrill)

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Abstract
A field experiment was conducted during *kharif* season, 2014 to study the influence of different sowing dates and plant densities on yield attributes and yield of soybean. It was comprised of nine treatments with three sowing dates (June 28, July 14 and July 29) as main plot treatments and three row spacings (30 cm x 10 cm, 45 cm x 10 cm and 60 cm x10 cm) as sub plot treatments and replicated thrice. Numbers of pods plant^{-1} (44.7), number of seeds per pod^{-1}(2.2), seed yield (1487 kg ha^{-1}), haulm yield (2496kg ha^{-1}), harvest index (39.1%) and test weight (9.9 g) increased with early sowing on June 28 than delayed sowing on July 14 and July 29. July 14 sown crop was on par to June 28 sown crop. Yield attributes and yield of soybean were inconsistent with different row spacings. The highest number of pods plant^{-1} (48.1), number of seeds per pod^{-1} (2.1) and test weight (9.9 g) were recorded at a spacing of 60 X 10 cm, highest seed yield (1396 kg ha^{-1}), haulm yield (2386kg ha^{-1}) and harvest index (39.2%), were recorded at spacing of 30 cm x 10 cm.

Keywords: Sowing dates, plant densities, soybean

Introduction
Soybean [*Glycine max* (L.) Merrill] is an important oilseed crop, which plays an important role in the economy of India. Soybean has now established as number one crop among oilseeds and contributes more than 50 per cent of oilseed production and 30 per cent of vegetable oil production. In India it is mainly grown in Madhya Pradesh, Maharashtra and Rajasthan (Anonymous, 2008) [3]. In 2013 in India it occupied an area of 12 mha with the production of 12 mt and grain yield of about 1079 kg/ha. It is a good source of protein (40%), oil (20%), unsaturated fatty acids and minerals like Ca and P including vitamin A, B, C, D which can meet different nutritional needs of human and animals (Mondal *et al*. 2012) [11]. Besides its main use for oil extraction, it can be used as dal, for soya milk, *tofu* etc. 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. In addition to sowing time planting density is one of the main factors that has an important role on the growth and yield of soybean. Optimum plant density ensures proper growth of the aerial and underground parts of the plant through efficient utilization of solar radiation, nutrients, land as well as air spaces and water (Malek *et al*. 2012) [11]. There are two general concepts to describe the relationship between plant density and seed yield. Firstly, irrespective of plant spacing within and among rows, plant density must be such that the crop develops a canopy able to intercept more than 95% of the incoming solar radiation during reproductive growth and secondly, a nearly equidistant plant arrangement minimizes interplant competition and produces maximum seed yield. Kang *et al.* (2001) [10] reported that appropriate plant density and cultivar is necessary for obtaining high yield and quality of soybean. The optimum plant density for higher yield may differ from cultivar to cultivar and location to location. There was a need to study the optimum sowing time and optimum plant density for producing higher yield. Therefore, an experiment was initiated in 2014 to study the optimum sowing time and optimum plant density.

Materials and Methods
A field experiment was conducted during *kharif*, 2014 at college farm, agricultural college, Mahanandi, ANGRAU. The soil of the experimental site was sandy loam and it was slightly alkaline in reaction with a pH of 7.98, EC of 0.06 dSm^{-1} and low in organic carbon (0.46%)

And available nitrogen (266 kg ha^{-1}), medium in available phosphorous (145 kg P_2O_5 ha^{-1}) and high in available potassium (774.3 kg K_2O ha^{-1}). The experiment was laid out in factorial randomized block design and replicated thrice. The treatments consisted of three sowing dates *viz.*, D_1 (June 28), D_2 (July 14) and D_3 (July 29) and three plant densities, *viz.*, S_1: 30 X 10 cm (3.33 lakh plants ha^{-1}), S_2: 45 X 10 cm (2.22 lakh plants ha^{-1}) and S_3: 60 X 10 cm (1.66 lakh plants ha^{-1}). Variety JS335 which matures in 80-85 days was tested in this experiment. A uniform dose of nitrogen, phosphorous and potassium was applied as per the recommendation @30kg N, 60kg P_2O_5 and 40kg K_2O ha^{-1} through urea, single super phosphate (SSP) and muriate of potash (MOP) respectively to all the plots. Entire quantity of phosphorous and potassium was applied as basal where as nitrogen was applied in two equal splits, one at the time of sowing and another at 30 days after sowing (DAS). No serious attack of pests and diseases was observed. However, minor incidence of tobacco caterpillar (*Spodoptera litura* (Fab.) was observed at flowering. Monocrotophos @ 2 ml L^{-1} and Acephate (0.08%) @ 2ml L^{-1} were used for effective control of pest. Weeding was done at 15 and 30 DAS for each sowing date to keep the plots free from weeds. When crop was subjected to prolonged dry spell irrigation was given to protect the crop. The total rainfall received during crop growth was 515.2mm in 28 rainy days. Five plants were randomly selected in the net plot area and tagged. Plant height of these plants was recorded at 30, 60 DAS and at harvest from the base of the plant to the tip of the growing point. The mean value of five plants was computed and expressed as plant height in cm. Dry matter production was measured at 30, 60 DAS and at harvest. Five plants were randomly selected in the gross plot for destructive sampling. They were oven dried at 60 ^{0}C till a constant weight is obtained. The dry weight per m^2 was calculated and expressed as kg ha^{-1}. Leaf area index (LAI) was measured at 30, 60 DAS and at harvest. The leaf area was measured by electronic leaf area meter. LAI was calculated using the formula as Leaf area from the five plants divide by ground area allowed for five plants. The number of pods from tagged five plants were counted, averaged and expressed as number of pods $plant^{-1}$. The total number of seeds present in twenty pods, selected at random from the net plot area was counted and averaged as number of seeds per pod. After counting, these seeds were added to the net plot yields. One hundred seeds were counted from a sample drawn at random from the net plot seed yield and its weight was recorded in grams. At maturity, all the above ground soybean phytomass from each treatmental net area was harvested and transported to the threshing floor. After drying under sun for seven days, the phytomass from each plot was weighed before subjecting it for threshing. After threshing, weight of the grains was recorded plot-wise and expressed in kg ha^{-1}. The haulm yield from each plot was arrived by subtracting the grain weight and expressed in kg ha^{-1}. Harvest index was calculated by dividing of economic yield by biological yield and multiplied with hundred. Economics was calculated based on present market price of yield and inputs.

Results and Discussion
Effect of sowing dates
Growth parameters
The differences in plant height due to different sowing dates were significant from 30 days after sowing onwards to harvest. Sowing of soybean on June 28 increased the plant height (38.1 cm) significantly over rest of the sowing dates i.e. July 14 and July 29 at 30, 60 days after sowing and at harvest. Similarly next date of sowing July 14 sowing resulted in significantly taller plants than July 29 sowing at 30, 60 days after sowing and at harvest. Taller plants in early sowing date might be due to favorable environment enjoyed by early sown crop than that sown at later dates even after receiving similar inputs. The less number of nodes and reduced inter nodal distances caused by non-optimal sowing time could also be the reason for reduction in plant height under delayed sowing dates. Shuddhodhan and Jadhao (1986) [18] also reported the enhancement of growth characteristics with early sowings when compared to late sown conditions in soybean. The total drymatter production increased significantly from 30 days after sowing to harvest. A gradual increase in total dry matter production was noted from 60 days after sowing. The total dry matter production recorded at June 28 sowing was significantly higher (3762 kg ha^{-1}) over the rest of sowing dates i.e. July 14 and July 29 sowings. Maximum drymatter accumulation in the early sown crop was perhaps due to more plant height, higher leaf area index and vigorous vegetative growth. These are in conformity with the results reported by Hanumantharao *et al.* (1990) [9]. The maximum leaf area index (4.1) was registered with June 28 sowing over July 14 and July 29 sowings throughout the crop growth period.

Yield attributes and yield
The number of pods $plant^{-1}$, number of seeds pod^{-1} increased significantly with early sowing. Higher number of pods $plant^{-1}$ (44.7) and number of seeds pod^{-1} (2.2) were recorded with June 28 sowing over other two sowings of July 14 and July 29. Higher number of pods $plant^{-1}$ and number of seeds pod^{-1} in early sowings might be due to adequate and increased availability of nutrients for development of more number of pods $plant^{-1}$ and better seed filling with maintenance of better source-sink relationship. Highest seed yield kg ha^{-1} (1487 kg ha^{-1}) was recorded at early sowing of June 28 over other sowing dates i.e. July 14 and July 29 sowing. The significant increase in yield of early sowing over delayed sowing dates might be due to partition of higher proportions of its total drymatter into component parts of the plant. Added to the above, better growth and development of crop at this date when compared to other dates of sowing in all aspects might have reflected in better yield expression. Ramani *et al.* (1996) [15] also expressed similar views that higher seed yield with the early sown crop than late sown crop. The haulm yield decreased from June 28 to July 29 sowing. Delayed sowings on July 29 produced the lowest haulm yield (1911 kg ha^{-1}) compared to other sowings i.e. June 28 and July 14. This might be due to best performance of early sown crop due to prevailing high temperature and moisture during crop growth period that resulted in increased drymatter and which in turn reflected in higher seed yield. Variation in haulm yield due to dates of sowing was also reported by Amarajyothi and Pullarao (2002) [2]. The harvest index of soybean was highest (39.1 %) with June 28 sowing date. The lowest harvest index was recorded with July 29 sowing date compared to other sowings. Higher yield attributes at early sowing date might have contributed to higher harvest index, as it produced more grain yield due to efficient partitioning of drymatter produced. Billore *et al.* (2000) [5] also reported higher yield in early sowing which was ascribed to higher values of harvest index. Test weight of soybean was significantly highest (9.9g) with June 28 sowing date, which was on par with that of July 14 sowing date. Whereas, the July 29 sowing date recorded the lowest test weight. Reduction in test weight in delayed

sowings was due to lower drymatter accumulation. Increases in test weight with early sowing were reported by Halvankar *et al.* (2001) [7]. Gross returns, net returns and B: C ratios were more with early sowing compared to delay sowing. The gross returns, net returns and B: C ratio recorded were higher with June 28 sowing compared to other two sowings i.e. July 14 and July 29.

Effect of plant densities

Growth parameters

With regard to spacings narrow row spacing 30 cm x 10 cm recorded more plant height (40.7 cm) than 45 cm x 10 cm and 60 cm x 10 cm spacings at 30, 60 days after sowing and at harvest. Similarly medium row spacing 45 cm x 10 cm resulted in significantly taller plants than wider row spacing 60 cm x 10 cm at 30, 60 days after sowing and at harvest. The positive relationship of closer spacing on plant height might be attributed to high inter-plant competition, which caused internodal elongation as reported by Ravichandran and Ramaswami (1992) [16] and Halvankar *et al.* (1993) [8]. Among row spacings 30 cm x 10 cm spacing recorded highest total dry matter production (3532 kg ha^{-1}) and it was significantly superior over rest of row spacings i.e. 45 cm x 10 cm and 60 cm x 10 cm. Higher drymatter production in closer spacing may have been due to the cumulative effect of more number of plants per unit area, higher leaf area index and more light interception. Arnon (1971) [4] indicated that dry matter yield tend to increase linearly with increase in plant density of different crops. The present findings are in accordance with the findings reported by Duraisingh and Gopalaswamy (1991) [6]. Narrow row spacing of 30 cm x 10 cm recorded maximum leaf area index (4.7) over the 45 cm x 10 cm and 60cm x 10 cm spacings at all the stages of crop growth. Similarly 45cm x 10 cm spacing recorded a higher leaf area index values over 60 cm x 10 cm spacing throughout the crop growth period. Increase in leaf area index with early sowing was due to favorable environment for the crop during vegetative phase. The decrease in leaf index particularly at later stages of crop growth was mainly due to leaf senescence. Similar results were reported by Sahoo *et al.* (1991) [17].

Yield and yield attributes

With regard to row spacings the number of pods plant^{-1} and number of seeds pod^{-1} increased significantly with increasing row spacing from 30 cm x 10 cm, 45 cm x 10 cm to 60 cm x 10 cm spacings. The highest number of pods plant^{-1} (48.1) and seeds pod^{-1}(2.1) was recorded with the spacing of 60 cm x 10 cm than other row spacings i.e. 45 cm x 10 cm and 30 cm x 10 cm. Less competition in wider spacing and ample availability of light, moisture, better source sink relationship and nutrients might had resulted in more number of branches plant^{-1} which in turn might have increased more number of pods plant^{-1} and also more number of seeds pod^{-1}. Higher number of seed pod^{-1} at lower plant densities were also reported by Rajput and Kaushik (1992) [14]. Among different row spacings significantly highest seed yield (1396 kg ha^{-1}) and haulm yield (2386) were recorded with narrow row spacing of 30 cm x 10 cm over other two spacings i.e. 45 cm x 10 cm and 60 cm x 10 cm. Though all the yield attributing characters were higher at wider spacings, these improvements were not sufficient to compensate the yields that were obtained due to higher plant population per unit area from closer spacing. Similar increase in seed yield at closer spacings was also reported by Manjappa *et al* (2002) [12] and Sundari (2003) [19]. Row Spacings also produced significant difference in harvest index of soybean. Harvest index was significantly higher (39.2 %) with 30 cm x 10 cm spacing and superior over other two spacings i.e. 45 cmx 10 cm and 60 cm x 10 cm spacings. This was due to more grain yield produced by 30 cm x 10 cm spacing which in turn resulted in higher harvest index. Abbas *et al.* (1994) [1] also noticed similar increase in harvest index with decrease in plant density. Test weight of soybean was also influenced by row spacings significantly. A significant increase in test weight (9.9g) was resulted due to 60 cm x 10 cm spacing over other two spacings i.e. 30 cm x 10 cm and 45 cm x 10 cm. Increases in test weight with wider row spacing was also reported by Masum Akond *et al.* (2012) [13]. The gross returns, net returns and B: C ratio varied due to row spacings. The highest gross returns, net returns and B: C ratio were recorded with 30 cm x 10 cm spacing compared to other two spacings i.e. 60 cm x 10 cm and 45 cm x 10 cm. Seed yield obtained was maximum at June 28 sowing with 30 cm x 10 cm spacings that lead to highest gross returns, net returns and B: C in early sowings and narrow spacings.

From above investigation it can be concluded that sowing of soybean June 28 with the spacing of 30 X 10 cm row spacing was more beneficial for getting higher grain yield.

Table 1: Growth parameters as influenced by sowing dates and plant densities

Treatment	Plant height (cm)			Dry matter production (kg ha^{-1})			Leaf area index		
	30 DAS	60DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Sowing dates									
June 28	23.6	36.7	38.1	486	2228	3762	1.5	4.1	3.7
July 14	22.4	36.3	37.8	467	2126	3389	1.4	3.6	3.32
July 29	21.7	35.8	37.1	441	2005	3051	1.3	3.1	2.6
SEm±	0.2	0.2	0.01	1.5	0.01	17	0.009	0.006	0.05
C.D.(P=0.05)	0.66	0.05	0.01	4.43	2.03	51.57	0.02	0.01	0.16
Plant densities									
30 X 10 cm	25.0	39.1	40.7	594	2423	3532	1.8	4.7	4.2
45 X 10 cm	22.2	36.7	37.8	460	2049	3379	1.6	3.9	3.4
60 X 10 cm	20.6	33.7	34.4	341	1887	3292	0.9	2.1	1.8
SEm±	0.2	0.2	0.01	1.5	0.01	17	0.009	0.006	0.05
C.D. (P=0.05)	0.66	0.05	0.01	4.43	2.03	51.57	0.02	0.01	0.16
D X S									
SEm±	0.3	0.3	0.01	2.6	0.01	30	0.01	0.01	0.09
C.D.(P=0.05)	NS	0.12	0.03	10	4.61	116.9	NS	0.04	0.37

NS- Non significant

Table 2: Yields attributes and yield as influenced by sowing dates and plant densities

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Test weight (g)
Sowing dates						
June 28	44.7	2.2	1487	2496	39.1	9.9
July 14	42.6	2.1	1289	2177	37.9	9.6
July 29	40.6	1.8	1036	1911	33.8	9.3
SEm±	0.01	0.04	02	10	0.6	0.06
C.D.(P=0.05)	0.02	0.12	6.12	31.02	1.99	0.17
Row spacings						
30 X 10 cm	36.7	1.9	1396	2386	39.2	9.3
45 X 10 cm	43.2	2.0	1274	2170	37.3	9.5
60 X 10 cm	48.1	2.1	1143	2027	34.4	9.9
SEm±	0.01	0.04	02	10	0.6	0.06
C.D. (P=0.05)	0.02	0.12	6.12	31.02	1.99	0.17
D X S						
SEm±	0.01	0.07	04	18	1.1	0.1
C.D. (P=0.05)	0.05	NS	13.90	70.37	4.51	NS

NS- Non significant

Table 3: Economics as influenced by sowing dates and plant densities.

Treatment	Gross returns (` ha^{-1})	Net returns (` ha^{-1})	B: C ratio (` ha^{-1})
Sowing dates			
June 28	47537	34928	2.6
July 14	41267	28653	2.2
July 29	33152	20523	1.4
SEm±	41	07	0.09
C.D.(P=0.05)	122	19.95	0.28
Row spacings			
30 X 10 cm	44670	31443	2.3
45 X 10 cm	40712	28129	2.2
60 X 10 cm	36574	24532	1.8
SEm±	41	07	0.09
C.D. (P=0.05)	122	19.95	0.28
D X S			
SEm±	71	12	0.1
C.D. (P=0.05)	277	45.25	NS

NS- Non significant

References

1. Abbas M, Singh MP, Nigam KB, Kandalkar VS. Effect of phosphorus, plant density and plant type on yield and yield attributing characters of soybean *(Glycine max* (L.) Merrill). Indian Journal of Agronomy. 1994; 39(2):249-251.
2. Amarajyothi P, Pullarao CH. Nutrient uptake and quality aspect of soybean as influenced by sowing dates and N-P fertilizer levels. Andhra Agricultural Journal. 2002; 49(3, 4):389-391.
3. Anonymous. Annual report, All India coordinated research project on soybean. Directorate of Soybean Research, Indore, 2008.
4. Arnon. Crop production in dry regions. Background and principles Volume I. Leonard Hill books. London, 1971, 442-457.
5. Billore SD, Joshi OP, Ramesh A. Performance of soybean *(Glycine max* (L.) Merrill) genotypes on different sowing dates and row spacings in vertisols. Indian Journal of Agricultural Sciences. 2000; 70(9):577-580.
6. Duraisingh R, Gopalaswamy N. Effect of plant geometry and levels of nitrogen and phosphorus on the productivity of soybean (*Glycine max* (L.) Merrill). Indian Journal of Agronomy. 1991; 36(4):545-548.
7. Halvankar GB, Taware SP, Raut VM. Response of soybean varieties to sowing dates during summer season. Journal of Maharashtra Agricultural Universities. 2001; 26(2):223-224.
8. Halvankar GB, Raut VM, Taware SP, Patil VP. Effect of genotype and plant stand on yield of soybean. Indian Journal of Agricultural Sciences. 1993; 63(11):712-715.
9. Hanumantharao Y, Sudhakar K, Ramakrishnareddy T, Venkateswarlu B. Studies on growth and yield of soybean varieties at different dates of sowing. Andhra Agricultural Journal. 1990; 37(4):401-403.
10. Kang YK, Kim HT, Cho NK, Kim YC. Effect of planting date and plant density on yield and quality of soybean in Jeju. Korean Journal of Crop Science. 2001; 46(1):95-99.
11. Malek MA, Shafiquzzaman M, Rahman MS, Ismail MR, Mondal MMA. Standardization of soybean row spacing based on morphophysiological characters. Legume Research. 2012; 35:138-143.
12. Manjappa K, Mutnal SM, Joshi VR. Influence of spacing and fertilizer levels on seed yield of soybean grown on residual moisture in paddy fallows. Karnataka Journal of Agricultural Sciences. 2002; 15(1):139-141.
13. Masum Akond G, Ragin Bobby, Richard Bazzelle, Wilsheana Clark. Effect of two row spaces on several agronomic traits in soybean (*Glycine max* (L.) Merr.) Atlas Journal of Plant Biology. 2012; 1(2):18-23.
14. Rajput RL, Kaushik JP. Effect of irrigation, phosphorus and row spacing on yield and economic return of soybean. GAU Research Journal. 1992; 17(2):137-139.
15. Ramani B, Modhwadia M. Response of soybean to dates of sowing and row spacings under varying plant densities. GAU Research Journal. 1996; 21(2):93-95.
16. Ravichandran VK, Ramaswami C. Response of soybean to different plant densities. Madras Agricultural Journal. 1992; 79(3):181-182.
17. Sahoo NC, Mahapatra PK, Dixit RC, Uttaray SK. Effect of sowing date on growth, yield and quality of soybean (*Glycine max* (L). Merrill). Indian Journal of Agricultural Sciences. 1991; 61(9):665-668.
18. Shuddhodhan R, Jadhao SL. Effect of different dates of sowing on yield of various *rabi* crops. Thesis Abstract. 1986; 12(1-4):31.
19. Sundari A. Response of soybean to sowing dates, plant density and phosphorus levels. Advances in Plant Sciences. 2003; 16(1):243-246.