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Growth and Yield of Soybean under Varied Environments and Plant Densities in South Telangana Agro Climatic Zone

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A B S T R A C T

Many factors limiting soybean production at farmer's field level. A field investigation was undertaken to optimize the sowing time and plant density during *kharif* 2015 and 2016 at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University Rajendranagar, at Hyderabad to realize higher productivity of soybean. The experiment was carried out with three dates of sowing (26 June, 6 July and 16 July) as first factor and three plant densities (3,33,333 plants ha^{-1}, 1,66,666 plants ha^{-1} and 1,11,111 plants ha^{-1}) as second factor. The study revealed that 26 June sown crop recorded significantly higher yield of 1535 and 2409 kg ha^{-1} during 2015 and 2016 respectively with superior growth and yield attributes over 6 July and 16 July sown crop. Plant density of 3,33,333 plants ha^{-1} (30 cm x 10 cm) recorded significantly higher seed yield of 1460 and 2310 kg ha^{-1} during 2015 and 2016 respectively with improved growth and yield attributes per unit area compared to other plant densities, even though plant density of 1,11,111 plants ha^{-1} recorded higher growth and yield attributes per plant.

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 has been considered as one of the potential rainy season crop in the rainfed regions of central and southern India and grown over an area of 10.9 million hectares with a production of 11.46 million tonnes and productivity of 951 kg ha^{-1}. The area under soybean in India has increased from 0.03 to 10.9 million ha during the period from 1970 to 2016 (SOPA, 2016). There are many factors limiting soybean production at farmer's farm.

Among these factors improper sowing time, climatic variability, low germination percentage, poor quality seed and moisture stress. Among these factors sowing time and plant densities are the important factors affecting soybean growth and development, grain yield (Zhang *et al.*, 2010) and seed quality (Rahman *et al.*, 2005).

Sowing dates influence soybean growth stages, due to variation in photoperiod (Han *et al.,* 2006; Kumudini *et al.,* 2007), air temperature (Chen & Wiatrak, 2010), and rainfall distribution and amount during the crop cycle (Hu & Wiatrak, 2012). The time of sowing has a considerable influence on growth and yield of soybean. Early sowing in the season may have poor emergence or limited growth. When the crop is exposed to hot temperatures, days shorter than critical length, they progress rapidly towards maturity. If this occurs before the plant reaches an adequate size, the soybean crop is stunted and gives low yield (Boquet and Clawson, 2007). However, delayed sowing may shrink the vegetative phase, which in turn reduces the dry matter accumulation leading to poor partitioning to reproductive parts and ultimately poor realization of the potential yield (Hari Ram *et al.,* 2011).

Planting density is an important determinant of seed yield and it plays a pivotal role in modulating the environmental factors related to growth and development of the crop. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. Plant density is considered to be one of the main factors of production which greatly influences light absorption into the plant cover (Board, 2002).

Keeping the above points in view the present study was conducted to evaluate the effect of sowing dates and plant densities on growth and yield of soybean.

Materials and Methods

The field experiment was conducted at Agricultural Research Institute, Rajendranagar, Hyderabad having $17^0$19' N Latitude, $78^0$23' E Longitude and 542.3 m above mean sea level. The experiment was laid out in randomized block design (factorial) with three sowing dates (26 June, 6 July and 16 July) as one factor and three plant densities (3,33,333 plants ha^{-1} (30 cm x 10 cm), 1,66,666 plants ha^{-1} (30 cm x 20 cm) and 1,11,111 plants ha^{-1} (30 cm x 10 cm) as another factor, replicated thrice. The soil of the experimental site was sandy loam in texture, neutral in reaction, low in available nitrogen, phosphorus and high in available potassium. The other package of practices used recommended for raising the crop. Data on different characters *viz.,* growth and yield components and yield, were subjected to analysis of variance procedures as outlined for randomized block design, factorial concept (Gomez and Gomez, 1984). Statistical significance was tested by F–value at 0.05 level of probability and critical difference was worked out where ever the effects were significant.

Results and Discussion

Plant height (cm)

Based on the analysis of variance (Table 1), sowing date and plant densities had a significant effect on all growth attributes. During both the years of study plant height increased as the age of crop advanced. Maximum plant height was recorded in 26 June sown crop and significantly superior to 6 July and 16 July sown crop, during 2015 and 2016 at all the growth stages except end of the juvenile phase where 6 July and 16 July were onpar with each other during 2015, 26 June and 6 July were on par each other during 2016. This decrease in the plant height under delayed sowing might be due to shorter vegetative period and low canopy competition among the plants. These results were in line with Wade and Johnston (1975) who stated that photoperiod sensitivity had marked reduction in growth period due to delayed sowing. It appears that early planting results

better use of water and nutrients and there by plant height could be more (Yari *et al.,* 2013). Plant density of 3,33,333 (30 cm x 10 cm) plants ha^{-1} showed more plant height and was on par with 1,66,666 plants ha^{-1} (30 cm x 20 cm). The lowest plant height was recorded in 1, 11,111 plants ha^{-1} inturn, 1, 66,666 plants ha^{-1} and 1,11,111 plants ha^{-1} were comparable with each other. The increased plant height might be due to morphological changes in plant due to increased density mainly because of competition for light when soil fertility and moisture are not limited. Increased plant density results in mutual shading of plants which usually results in stem elongation. However the number of nodes on the main stem decreased, suggesting internode elongation was responsible for the height increase (Rahman *et al.,* 2004).

Leaf Area Index (LAI)

The LAI decreased with delay in sowing from 26 June to 16 July during both the years. Maximum LAI was observed in 26 June sown crop and was significantly superior to 6 July and 16 July sown crop. Crop sown on 16 July showed the lowest LAI at all growth stages.

Among plant densities significantly higher LAI was noticed with 3,33,333 plants ha^{-1} and was significantly superior to 1,66,666 plants ha^{-1} and 1,11,111 plants ha^{-1} at the end of juvenile phase, flowering, pod development and physiological maturity stages during 2015 and 2016 (Table 2). Higher values of LAI with higher plant densities might be ascribed to the more plant stand coupled with taller plants having more leaves resulted in more LAI (Bilal *et al.,* 2009).

Yield attributes

Analysis of data revealed that all the yield and yield attributes were significantly ($p \leq 0.05$) affected due to variable weather conditions and plant densities (Table 3). Maximum number of pods $plant^{-1}$ and seeds pod^{-1}, seeds m^{-2} and 100 seed weight was noticed in crop which sown on 26 June and was significantly superior to 6 July and 16 July sown crop. Late planting reduces number of pod $plant^{-1}$ due to decreasing growing period due to decrease vegetative growth (Yari *et al.,* 2013). The decrease in number of seeds pod might be due to the less rate of translocation of assimilates to soybean pods during pod development phase because of prevailing lower range of maximum temperature under late sown crop (Kumar *et al.,* 2008).

Among plant densities more number of pods $plant^{-1}$, seeds pod^{-1} and 100 seed weight was obtained at reduced plant density of 1, 11,111 plants ha^{-1}. Whereas more number of seeds m^{-2} was observed in 3, 33,333 plants ha^{-1}. Though, lower plant density might result in higher mean number of branches, pods and seeds $plant^{-1}$ and 100-seed weight due to low inter plant competition, but the number of seeds m^{-2} was lower due to inadequate plant population per unit area (Hari Ram *et al.,* 2011).

Seed and haulm yield (kg ha^{-1})

The effect of sowing time and plant density on seed and haulm yield was significant (Table 4). The highest seed and haulm yield was obtained with 26 June sown crop and was significantly superior to 6 July and 16 July sown crop. Such increase in seed yield may be attributed in to the considerable increase in number of pods per plant and 1000-seed weight. The variation in the total amount of rainfall received during the crop period might be the reason for yield variation in 2015 and 2016. Early sowing provides long vegetative and reproductive growth periods there by, facilitating the crop to produce more biomass, which enhanced the number of pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight (Kumar *et al.,* 2005).

Table.1 Plant height (cm) of soybean at different growth stages under different dates of sowing and plant densities

Treatments	Crop Growth Stages							
	End of juvenile stage		Flowering stage		Pod development stage		Physiological maturity stage	
Date of sowing (D)	2015	2016	2015	2016	2015	2016	2015	2016
26 June	10.6	12.5	35.5	39.0	42.1	59.3	46.2	62.8
06 July	9.8	12.4	27.2	28.1	34.4	47.5	37.0	54.5
16 July	9.8	11.7	22.8	23.0	30.7	40.6	31.9	45.5
S.Em±	0.2	0.2	0.9	1.0	0.9	1.1	1.3	0.8
CD (P=0.05)	0.6	0.6	2.8	3.0	2.7	3.3	3.8	2.3
Plant densities (S)								
30x10 cm (3,33,333 plants ha^{-1})	10.2	12.7	30.6	32.2	37.9	51.9	42.4	56.4
30x20 cm (1,66,666 plants ha^{-1})	10.1	12.0	27.9	30.0	35.5	49.2	38.6	54.1
30x30 cm (1,11,111 plants ha^{-1})	10.0	11.9	25.9	27.9	33.8	46.2	34.9	52.2
S.Em±	0.2	0.2	0.9	1.0	0.9	1.1	1.3	0.8
CD (P=0.05)	NS	0.6	2.8	3.0	2.7	3.3	3.8	2.3
Interaction (D X S)								
S. Em±	0.3	0.33	1.6	1.7	1.6	1.9	2.2	1.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table.2 Leaf area index (LAI) of soybean at different growth stages under different dates of sowing and plant densities

Treatments	Crop Growth Stages							
	End of juvenile stage		Flowering stage		Pod development stage		Physiological maturity stage	
Date of sowing (D)	2015	2016	2015	2016	2015	2016	2015	2016
26 June	0.31	0.34	3.68	3.74	5.10	5.13	1.55	1.87
06 July	0.22	0.24	2.56	3.12	4.19	4.48	1.09	1.57
16 July	0.17	0.17	2.01	2.01	2.55	3.09	0.51	1.22
S.Em±	0.01	0.01	0.09	0.1	0.28	0.13	0.14	0.10
CD (P=0.05)	0.04	0.03	0.26	0.3	0.82	0.4	0.41	0.30
Plant densities (S)								
30x10 cm (3,33,333 plants ha^{-1})	0.29	0.34	3.60	3.84	5.23	5.68	1.52	2.06
30x20 cm (1,66,666 plants ha^{-1})	0.24	0.24	2.69	2.93	3.90	3.91	1.05	1.64
30x30 cm (1,11,111 plants ha^{-1})	0.17	0.17	1.96	2.10	2.70	3.11	0.58	0.96
S.Em±	0.01	0.01	0.09	0.1	0.28	0.13	0.14	0.10
CD (P=0.05)	0.04	0.03	0.26	0.3	0.82	0.4	0.41	0.30
Interaction (D X S)								
S. Em±	0.02	0.02	0.15	0.18	0.48	0.23	0.24	0.18
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table.3 Yield attributes of soybean as influenced by dates of sowing and plant densities

Treatments	Yield attributes							
	Number of pods plant^{-1}		Number seeds pod^{-1}		Number of seeds m^{-2}		Seed index (g)	
Date of sowing (D)	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
26 June	79	101	2.8	2.8	3805	5026	11.2	14.2
06 July	68	90	2.7	2.7	3151	4353	9.7	13.6
16 July	56	79	2.6	2.6	2475	3687	8.6	13.0
S.Em±	3	3	0.04	0.03	161	147	0.10	0.10
CD (P=0.05)	7	8	0.12	0.08	474	436	0.29	0.28
Plant densities (S)								
30x10 cm (3,33,333 plants ha^{-1})	45	64	2.6	2.6	3847	5530	9.6	13.3
30x20 cm (1,66,666 plants ha^{-1})	70	91	2.7	2.7	3119	4049	9.9	13.6
30x30 cm (1,11,111 plants ha^{-1})	88	116	2.8	2.8	2464	3487	10.1	14.0
S.Em±	3	3	0.04	0.03	161	147	0.10	0.10
CD (P=0.05)	7	8	0.12	0.08	474	436	0.29	0.28
Interaction (D X S)								
S. Em±	4	5	0.07	0.05	279	257	0.17	0.17
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table.4 Seed yield and haulm yield (kg ha^{-1}) of soybean under different dates of sowing and plant densities

Treatments	Seed yield (kg ha^{-1})		Haulm yield (kg ha^{-1})	
Date of sowing (D)	**2015**	**2016**	**2015**	**2016**
26 June	1523	2409	1939	3182
06 July	1277	2002	1650	2290
16 July	1027	1704	1338	1747
S.Em±	34	41	49	55
CD (P=0.05)	100	121	144	161
Plant densities (S)				
30x10 cm (3,33,333 plants ha^{-1})	1460	2310	1924	2818
30x20 cm (1,66,666 plants ha^{-1})	1277	2031	1631	2453
30x30 cm (1,11,111 plants ha^{-1})	1089	1774	1372	1948
S.Em±	34	41	49	55
CD (P=0.05)	100	121	144	161
Interaction (D X S)				
S. Em±	59	71	84	95
CD (P=0.05)	NS	NS	NS	NS

The decline in seed yield of soybean with delayed sowing could be attributed to a shorter length of growing season leading to overall reduction in growth; short days associated with low radiation and low temperature contributing to slower growth rates and lower pod set, and a dramatic reduction in the relative duration of key phenophases which mostly resulted from reduced photoperiod (Zhang *et al.*, 2010). The shorting of duration at various growth phases in the late sown crop might be the probable reason of the reduction in haulm yield (Kumar *et al.*, 2008).

Among plant densities crop sown at 3,33,333 plants ha^{-1} with closer spacing of 30 cm x 10

cm was proved significantly superior to get higher seed and haulm yield over 1, 66,666 plants ha^{-1} and 1,11,111 plants ha^{-1}. The highest seed yield at higher plant density might be due to early canopy closure in the narrow rows that facilitate high TDM production. The increased leaf area development with higher plant density contributed to increased TDM production due to more solar radiation interception that contributed to higher yield production (Ball *et al.*, 2000).

In concluding remarks, based on two years experimental results optimum sowing time and plant density for soybean would be 26 June with plant density of 3,33,333 plants ha^{-1} at a spacing of 30x10 cm is proved to be best to obtain higher seed yield in South Telangana Agro climatic zone of Telangana State.

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