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Full Research Article

Influence of Sowing Seasons and Inter-plant Spacing on the Performance of Soybean [*Glycine max* (L) Merill]

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Abstract

Field experiments were conducted during *kharif* and *rabi* seasons of 2013 and 2013-14, respectively for two consecutive seasons at research farm of Regional Sugarcane and Rice Research Station, Rudrur to evaluate the effects of different cropping seasons and inter-plant spacing on performance of soybean genotypes. Higher seed yields were recorded during *kharif* season as compared to *rabi* season as lower thermal heat units were recorded during *rabi* season for both 50% flowering and maturity. Grain yield showed no significant difference under different inter-plant spacing. Branches plant^{-1} and clusters plant^{-1} showed significant variation under different inter-plant spacing and an inter-plant spacing of 10 cm recorded highest branches plant^{-1} and clusters plant^{-1}. The number of pods plant^{-1} which is a decisive character for seed yield showed significant variation among different inter-plant spacing in both *kharif* season and *rabi* season and an inter-plant spacing of 10 cm recorded highest number of pods plant^{-1}. Among genotypes Basar recorded highest grain yield during *kharif* season and JS-93-05 during *rabi* season. The *kharif* season crop recorded higher gross returns, net returns and B:C ratio when compared to *rabi* season crop. Among different spacings a spacing of 30×10 cm^2 was economically feasible as it recorded highest B:C ratio. Hence cultivation of soybean during *rabi* season in Northern Telangana Zone is not advisable as it is not economically feasible.

1. Introduction

Soybean is an important oilseed crop gaining importance in India and is considered as golden bean. Soybean occupied first rank among oilseeds in India since 2005. In India, Soybean is cultivated in an area of 120.327 mha with a production of 12.23 m t and productivity of 1017 kg ha^{-1} (SOPA, 2013). In North Telangana zone Soybean cultivation has increased to an area of 0.265 million ha i.e., 94.7% excess over the normal area (Anonymous, 2014). Soybeans are very rich in proteins (36.5%) besides containing a lot of fibre and are rich in calcium, magnessium. It is also rich in unsaturated fatty acids and low in saturated fatty acids. Soybean is generally used for oil extraction and in addition can also be used as dal after heat treatment, soya chunks, soyamilk etc. Soybean isoflavones have beneficial effects on human health due to these antiatheroselerotic, antioxidative, antitumoral and antiestrogenic activities (Davis et al., 1999).

Soybean is largely grown in temperate regions and it also has tremendous potential in tropics. However major problem encountered in Soybean production in the tropics and subtropics is rapid deterioration of seed in storage, leading to poor germination and suboptimal plant stand. Soybean crop is found to be more sensitive to higher cumulative heat units during cropping season and is vulnerable to increases in maximum temperature than in minimum temperature. Newly developed genotypes having good yield potential are suitable for varied climatic conditions. Optimum plant population is a prerequisite to obtain higher productivity of soybean (Singh, 2010). The effect of plant density on growth and yield varies due to varietal characters and growing season in the same geographical area. The relationship of yield and yield attributes under variable plant density is very important to optimize planting density for improving yield in soybean.

Soybean is commonly grown as *kharif* crop in Northern Telangana zone but availability of quality seed is a major problem because of poor storability and *kharif* season produced seed should be stored up to next *kharif* season. Soybean is highly sensitive to photoperiod and temperature and plant morphology changes with environment and genotype. Hence it is essential to identify suitable genotypes and production technology to attain sustained production under different environments. This study was taken up to identify suitable genotypes and spacings on seed yield of soybean genotypes and to study the feasibility of production of soybean during *rabi* season.

2. Materials and Methods

The experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur during *kharif* season, 2013 and *rabi* season, 2013-14. It comprised of 24 treatments with three inter-plant spacing (30×5, 30×7.5 and 30×10 cm^2) as main plots and varieties (AMS MB 5-18, AMS MB 5-19, Bheem, Basar, KS 103, KDS 344, JS 335 and JS 93-05) as sub plots replicated twice using net plot size of 6×6 m.

The sowings were carried out during second fortnight of June for *kharif* season, 2013 and second fortnight of November for *rabi* season, 2013-14 according to the treatments. Recommended doses of fertilizer were applied. All the agronomic practices were followed. The thermal heat units (THU) were calculated at 50% flowering and at maturity using following formula (Nuttonson, 1956).

$$THU=\sum_{i=1}^{n}\left\{\left[\frac{T\,max+T\,min}{2}\right]-Tb\right\}$$

Where n=number of days taken for completion of a particular growth phase.

T max and T min=The daily maximum and minimum are temperature respectively in °C

T_b=The minimum base temperature (threshold temperature) for a crop (°C) for soybean T_b10 °C

The data on plant height, branches plant^{-1} clusters plant^{-1}and pods plant^{-1} were collected from randomly selected ten plants plot^{-1} at the time of harvest. The crop was harvested when pods were matured. The harvested crop was sundried and threshed manually. The economics was calculated using prevailing prices of inputs and outputs. The data recorded were tabulated and analyzed statistically using Fischer's analysis of variance technique and least significant difference (LSD) test at 5% probability level was applied to compare differences among treatment mean (Steel et al., 1997).

3. Results and Discussion

3.1. Yield and yield attributes

It was observed that in general the yield was higher during *kharif* season as compared to *rabi* season. Koti and Chetti (1999) reported that temperature has a decisive role in determining the morphological characters which in turn influence the seed yields.

Days to 50% flowering was found to be non significant among different inter-plant spacing both during *kharif* season and *rabi* season Table:1 and significant among genotypes in both the seasons. According to Ahmed et al. (2010) days to 50%

Table 1: Effect of inter-plant spacing and genotypes on plant characters and yield attributes during rainy season and winter season

Spacing (cm^2)	Days to 50% flowering		Branches plant^{-1}		Clusters plant^{-1}		Pods plant^{-1}		100 seed wt		Seed yield ha^{-1}	
	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter
30×5	46	53	4.08	4.35	17.20	9.21	55.54	27.69	13.50	11.22	21.93	12.29
30×7.5	46	53	4.96	4.84	21.45	10.00	60.90	29.44	13.20	11.08	23.79	12.58
30×10	46	53	5.74	5.65	23.35	11.27	74.16	35.89	13.44	10.82	27.30	12.56
CD (*p*=0.05)	NS	NS	1.231	0.810	3.055	NS	6.877	4.895	NS	NS	NS	NS
Genotypes												
AMSMB 5-18	46	55	3.67	5.48	23.73	9.33	78.87	24.32	13.12	13.63	23.39	7.89
AMSMB 5-19	46	56	4.63	3.77	21.37	8.35	73.27	26.12	12.99	13.48	29.13	8.80
Bheem	46	55	5.30	4.32	14.60	10.05	41.90	26.52	13.21	9.48	19.69	9.30
Basar	46	51	5.03	5.57	25.53	8.20	81.13	26.32	13.08	13.40	33.67	9.02
KS-103	47	54	5.43	5.02	22.03	12.78	70.77	35.83	12.95	9.38	25.65	15.82
KDS-344	50	51	5.51	4.75	25.00	10.63	76.13	38.02	13.04	8.39	21.88	8.48
JS-335	44	50	5.00	5.65	16.30	11.55	44.33	37.10	14.25	8.55	22.65	19.09
JS-93-05	42	51	4.77	5.03	16.77	10.38	41.87	33.83	14.38	12.00	18.67	21.41
CD (*p*=0.05)	0.417	0.357	NS	NS	0.013	NS	17.66	NS	0.599	NS	5.983	6.65

flowering is a varietal character and is controlled genetically and spacing cannot influence this character. Days taken to 50% flowering were more in *rabi* season as compared to *kharif* season. According to Chapman (1986) high temperature promoted and low temperature delayed the initiation of flowering in early, medium and late cultivars of soybean.

The number of branches plant^{-1} behaved similarly in both the seasons. A significant variation inter-plant spacing of 10 cm recorded highest number of branches plant^{-1} over 7.5 and 5 cm. Similar increase in number of branches plant^{-1} with decreased plant density was observed by Rahman and Hussain (2011); Reddy et al. (1999) which is attributed to less carbon accumulation which is not sufficient to support more branching. However, there was no significant variation in number of branches plant^{-1} among genotypes in both the seasons.

The *kharif* season recorded significant variations in number of clusters plant^{-1} among different inter-plant spacing and genotypes. An inter-plant spacing of 10 cm (23.35) and among genotypes, Basar (25.53) recorded highest number of clusters plant^{-1} during *kharif* season. In *rabi* season no significant variation was observed either among genotypes or different inter-plant spacing for number of clusters plant^{-1}.

The number of pods plant^{-1} showed significant variation among different inter-plant spacing in both *kharif* season and *rabi* season and an inter-plant spacing of 10 cm recorded highest number of pods plant^{-1}. Singh (2010) and El Douby etal (2002) reported similar increase in number of pods plant^{-1}with decreased plant density which was attributed to reduced competition among plants for resources like nutrients, moisture, light and space. Among the genotypes significant variation was observed in number of pods plant^{-1} during *kharif* season only. The numbers of pods plant^{-1} were higher during *kharif* season as compared to *rabi* season. Board et al. (1995) indicated that source strength during R1–R7 (reproductive stages) influences soybean yield primarily by affecting pod numbers. The number of pods is an important yield determinant and has positive association with seed yield in soybean during *kharif* season (Singh et al., 1994). According to Koti and Chetti (1999) lower pod number during *rabi* season could be due to reduction in plant height and number of branches plant^{-1}.

The *kharif* season recorded higher 100 seed weight over *rabi* season. 100 seed weight was found to be non significant among different inter-plant spacing and significant among genotypes. Genotype JS 93-05 recorded highest 100 seed weight during *kharif* season. In *rabi* season 100 seed weight was found to be non significant among genotypes. 100 grain weight in soybean has been reported to differ in different sowing dates (Wafaa et al., 2002).

The seed yield ha^{-1} has fallen down drastically during *rabi* season as compared to *kharif* season. Among different inter-plant spacing there is no significant variation in seed yield ha^{-1} both during *kharif* season and *rabi* season. These results of seed yields are in accordance with Rani and Kodandaramaiah (1997) who reported that grain yield of soybean were similar with 0.4 and 0.6 million plants ha^{-1} and higher than those with 0.2 million plants ha^{-1}. Genotypes showed significant variation in seed yield ha^{-1} in both the seasons. Basar recorded highest yield of 2.565 t ha^{-1} during *kharif* season and genotype JS 93-05 recorded highest yield of 2.441 t ha^{-1} during *rabi* season. According to Koti and Chetti (1999) this variation in yield over season may be attributed to variation in temperature and relative humidity.

3.2. *Thermal heat Units*

The thermal heat units were reduced for both 50% flowering and maturity during *rabi* season Table 2. The genotype KDS 344 recorded highest thermal units for both 50% flowering and maturity during *kharif* season and AMS MB 5-18 and Basar recorded highest thermal units during *rabi* season.

Table 2: Effect of season on thermal heat units required for 50% flowering and maturity for soybean genotypes

Variety	Flowering			Maturity		
	Rainy season	Winter	Mean	Rainy season	Winter	Mean
AMSMB 5-18	906.5	732.0	819.3	1248.5	1049.5	1149.0
AMSMB 5-19	906.5	748.0	827.3	1248.5	1033.5	1141.0
Bheem	884.5	695.0	789.7	1213.0	788.5	1000.7
Basara	906.5	732.0	819.3	1248.5	1049.5	1149.0
KS-103	924.5	712.5	818.5	1268.0	887.5	1077.7
KDS-344	962.5	695.0	828.7	1286.5	824.0	1055.3
JS-335	864.0	687.5	775.7	1138.5	701.5	920.0
JS-93-05	827.0	695.0	761.0	1079.5	796.0	937.7

Lower yields in *rabi* season may be attributed to decreased accumulation of thermal heat units both for flowering and maturity. Similarly Agarwal et al. (2014) reported that crop which accumulated highest GDD recorded highest biological and grain yield. Vanschaik and Probist (1958) and Sato (1976) observed that the difference between the maximum and minimum temperature should be the least for getting higher yields in soybean.

3.3. Economics

The economics of soybean production during *kharif* season crop recorded higher gross returns, net returns and B:C ratio as compared to *rabi* season. In *rabi* season a few varieties reported negative net returns and less than one B:C ratio indicating that there in less feasibility for cultivation of soybean during *rabi* season Table 3.

The different inter-plant spacing showed significant variation during *kharif* season with 10 cm spacing recording highest gross returns, net returns and B:C ratio. This may be attributed to reduction in seed cost. Genotypes showed significant variation for gross returns, net returns and B:C ratio. Gross returns, Net returns and B:C ratio was found highest for genotype Basar during *kharif* season which is attributed to higher yields in the variety.

4. Conclusion

Crop sown during *kharif* season accumulated higher thermal heat units which resulted in greater yields as compared to *rabi* season. Hence cultivation of soybean during *rabi* season in Northern Telangana Zone is not advisable as it is not economically feasible. Among the different inter-plant spacing studied a spacing of 30×10 cm^2 is ideal though there is no significant variation in yield as it recorded lower cost of cultivation and higher B:C ratio. Among the genotypes Basar is highly suitable for cultivation during *kharif* season in this location.

Table 3: Economics of soybean as affected by season, inter-plant spacing and genotypes

Spacing (cm^2)	Gross returns (₹)		Net returns (₹)		B:C ratio	
	Kharif season	*Rabi*	*Kharif* season	*Rabi*	*Kharif* season	*Rabi*
30×5	56142.22	31466.72	25058.22	382.72	1.806	1.013
30×7.5	60906.67	32195.81	31850.67	3139.88	2.097	1.109
30×10	69946.67	32142.098	41878.67	4074.10	2.493	1.440
CD (p=0.05)	10624.50	NS	10624.50	NS	0.360	NS
Genotypes						
AMSMB 5-18	59875.56	201958.87	30472.89	-9206.78	2.057	0.692
AMSMB 5-19	74571.85	22518.71	45169.18	-6883.96	2.548	0.768
Bheem	50394.07	23798.52	20991.41	-5604.15	1.730	0.813
Basar	86186.67	23087.41	56784.00	-6315.26	2.937	0.783
KS-103	65659.26	40485.88	36256.59	11083.21	2.242	1.400
KDS-344	56011.85	21713.07	26609.18	-7689.60	1.913	0.730
JS-335	57979.26	48876.99	28576.59	19474.32	1.993	1.665
JS-93-05	47976.30	54802.73	18573.63	25400.06	1.637	1.858
CD (p=0.05)	17349.73	15671.17	17349.73	15671.17	0.587	0.538

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