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Study on Physiological Characters of Soybean Genotypes during *Kharif* Season

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A B S T R A C T

An experiment was conducted during *kharif* season of 2017 at Students' Farm, PJTSAU, Rajendranagar, Telangana with an aim to study the physiological characterization of soybean genotypes during *kharif* season. Observations were recorded at 15, 30, 45, 60, 75 DAS and at harvest. The growth parameters like Leaf area index (LAI), Crop growth rate (CGR), Relative growth rate (RGR), Leaf area ratio (LAR), Leaf area duration (LAD), total dry matter (TDM) production, SPAD chlorophyll meter reading (SCMR), yield and Harvest index (HI)were recorded to be maximum in the genotype MACS-1460. LAI, CGR, RGR, LAR, LAD, TDM, SCMR and HI were positively correlated with yield.

Introduction

Soybean (*Glycine max*) is a species of legume native of East Asia, widely grown for its edible bean which has numerous uses. India has occupied fifth place in world map of soybean. Soybean cultivation in India is rapidly increasing as an oilseed crop to overcome the shortage of edible vegetable-oil after oil extraction meal has equally important use for export and domestic food industry. Soybean contributes to 30-37 per cent of India's oilseed production with 120 lakh ha of area, 122 lakh mt production and 1017 kg ha-1 of average yield (Soybean Processors Association of India, 2013). In Telangana, it occupies about 2.42 lakh ha with 3.90 lakh tonnes of production and 1611 kg ha-1 of average productivity (Directorate of Economics and Statistics, 2015). Soybean cultivation is increasing in acreage over years with establishment of processing industries and market facilities. It is an alternate and remunerative crop to cotton, jowar and groundnut crops in major black cotton soils under rainfed situation in Telangana state. But, the occurrence of intermittent droughts during *kharif* in recent years necessitates the characterization of genotypes and their suitability for *kharif*. Different soybean genotypes may require different environment for their proper growth. Keeping this in view, a field experiment was conducted to study the physiological characters of soybean genotypes suitable for *kharif* in Telangana state.

Materials and Methods

The study was conducted with eight soybean genotypes *viz*., JS-335, Basara, JS-93-05, MACS-1460, NRC-37, ASB-13, ASB-15 and ASB-16 laid out in randomized block design with three replications. The soil of the experimental site was sandy loam with good drainage. Five plants per plot other than border ones were sampled at 15 days interval and was separated into different component parts. Then the component parts were dried in hot-air oven at 80^{o}C till constant weight was obtained. The dried samples were weighed to record data on dry matter partitioning. Data were collected on physiological parameters such as plant height, LAI, AGR, RGR, harvest index (HI), and chlorophyll content. All the growth parameters were calculated by applying the following formula as described by Watson (1952) and Radford (1967).After threshing, cleaning and drying, seed yield from one square meter area from each treatment was recorded and the data were used to express the seed yield on hectare basis.

Results and Discussion

Plant height (cm)

Plant height increased rapidly up to 75 DAS and sustained thereafter there was significant difference for the plant height among the soybean genotypes throughout the growth stages. Superiority in plant height was recorded in the genotypes Basara (55.59 cm) and NRC-37 (51.81 cm). The minimum plant height was recorded in ASB-16 (45.08 cm) which was statistically on par with the genotypes ASB-13 (46.85 cm), JS-335 (46.96 cm) and ASB-15 (47.89 cm). The variation in plant height among the soybean genotypes is influenced by the genetic makeup as well as the environmental factors.

Leaf area index

It was observed that LAI increased from 15 DAS to 60 DAS beyond which it declined (Table 1). The maximum LAI was recorded in genotype MACS-1460 (4.54) which was statistically on par with NRC-37 (4.16) and the minimum LAI was recorded in ASB-16 (3.13) followed by JS-335 (3.24).The leaf area index was found to be increasing in soybean 45 to 60 DAS and it was highest during reproductive stages. Higher values in LAI may be attributed to more plant height and more number of leaves. There was a positive correlation between LAI and seed yield (Table 4) (Tijani *et al.*, 2000). The decrease in the leaf area index towards maturity may be due to lesser number of leaves as a result of senescence of older leaves. At 75 DAS, JS-93-05 had minimum LAI as it reached senescence stage earlier.

SCMR values

Significant difference was observed for SPAD values throughout the growth period among the soybean genotypes except at 45 DAS and 75 DAS. The SPAD values decreased from 30 DAS to maturity in all genotypes. The maximum value for SCMR was recorded in the genotype MACS-1460 (44.93) which was found to be statistically on par with NRC-37 (44.89), Basara (44.70), JS-93-05 (42.71) and ASB-15 (41.41) whereas the minimum was recorded in ASB-16 (37.33) followed by JS-335 (37.40). At 75 DAS, the variety JS-93-05 showed minimum SPAD value as it reached senescence stage earlier among the varieties. The chlorophyll content varies with the nitrogen content in the plant as nitrogen is an important element in the formation of chlorophyll pigment (Ghosh *et al.,* 2000).

Crop growth rate (gm^{-2} day^{-1})

The crop growth rate gradually increased with crop age and reached its peak during 70 to 90 days and thereafter declined (Table 1). The maximum crop growth rate (CGR) was observed at 60-75 DAS in all genotypes and at this stage highest CGR of 12.15 g m^{-2} day^{-1} was recorded by MACS-1460 which was on par with Basara (11.19 g m^{-2} day^{-1}) and NRC-37 (11.16 g m^{-2} day^{-1}). The minimum CGR was recorded in the genotype ASB-16 (8.90 g m^{-2} day^{-1}) followed by ASB-13 (9.21 g m^{-2} day^{-1}). There was a positive correlation between crop growth rate and grain yield per plant (Table 4). The increased leaf area index values and light interception increases the photosynthetic rate and dry matter production thereby increases the crop growth rate. After reaching the maximum CGR it decreases till maturity due to ageing of leaves and leaf abscission. A higher CGR was observed after the flowering stage in soybean genotypes (Pedersen and Lauer, 2004).

Relative growth rate (g g^{-1} day^{-1})

The maximum RGR was recorded in MACS-1460 (0.0147 g g^{-1} day^{-1}) followed by JS-93-05 (0.0146 g g^{-1} day^{-1}) and minimum RGR was recorded in genotype ASB-13 (0.0130 g g^{-1} day^{-1}) followed by ASB-16 (0.0133 gg^{-1} day^{-1}) (Table 2). The relative growth rate (RGR) was maximum in all genotypes at 15-30 DAS which decline from 30 DAS. Relative growth rate (RGR) decreased with the age of crop. The decrease in RGR values between 75 DAS to harvest may be attributed to senescence of leaves and reduction in SPAD values which might have resulted in reduction of photosynthetic rate thereby reduction in total dry matter. Salam *et al.,* (1987) concluded that the decrease in RGR value may be probably due to increased demand of assimilate and according to Hamid *et al.,* (1991) it was due to excessive mutual shading as the leaf area was maximum during this period and increased number of old leaves could have lowered the photosynthetic efficiency that resulted in RGR decline.

Leaf area ratio (cm^{2} g^{-1})

Leaf area ratio (LAR) revealed that there was significant difference among the genotypes at all growth stages except 60 DAS. The soybean genotypes *viz*., JS-335, Basara and JS-93-05 has shown a gradual decrease from 15 DAS upto 75 DAS whereas the genotypes *viz*., MACS-1460 and NRC-37 increased from 15 DAS to 30 DAS and gradually decreased upto 75 DAS. The genotypes *viz*., ASB-13, ASB-15 and ASB-16 decreased from 15 DAS upto 45 DAS, then showed a slight increase at 60 DAS and declined thereafter. The maximum LAR was recorded by the genotype MACS-1460 (49.12 cm^{2} g^{-1}) which was statistically on par with NRC-37 (48.63 cm^{2} g^{-1}) and the minimum was recorded by JS-93-05 (4.66 cm^{2} g^{-1}) followed by ASB-16 (7.18 cm^{2} g^{-1}). The decrease in LAR at maturity stage was due to decrease in leaf area because of senescence of older leaves and increase in dry weight.

Leaf area duration (dm^{2} days)

Leaf area duration (LAD) increased gradually up to maturity in all genotypes (Table 2). There was a increase in LAD at reproductive stages (Xiaobing *et al.,* 2005). Among the genotypes maximum LAD was recorded in MACS-1460 (586.62 dm^{2} days) followed by NRC-37 (539.05 dm^{2} days) and minimum LAD was recorded by the genotype ASB-16 (405.27 dm^{2} days) followed by JS-335

(423.11 dm^2 days) at 60-75 DAS. Because of more LAD, the dry matter production is more in MACS-1460 and it may be attributed to more photosynthesis in the variety. The genotytpe NRC-37 (539.05 dm^2 days) was statistically on par with the genotype MACS-1460 (586.62 dm^2 days) at 60-75 DAS.

Total dry matter production (g m^{-2})

Total dry weight for soybean genotypes has shown significant difference among all the genotypes from 15 DAS to maturity. There was a steady increase in total dry weight in all the stages till maturity except the genotype JS-93-05 in which the dry matter showed slight decline. The highest dry matter production of 502.38 g m^{-2} was recorded in genotype MACS-1460 followed by NRC-37 (499.31 g m^{-2}) while minimum dry matter production of 401.73 g m^{-2} was recorded by the genotype ASB-16 followed by JS-335 (412.17 g m^{-2}). The genotypes NRC-37 (499.31 g m^{-2}) and Basara (488.61 g m^{-2}) were statistically on par with the genotype MACS-1460 (502.38 g m^{-2}) at harvest. The highest total dry matter production in the soybean genotype MACS-1460 may be attributed to more LAI, chlorophyll content, CGR, RGR, LAD recorded with the genotype. The highest dry matter production was at maturity (Sundari, 2003 and Xiaobing *et al.*, 2005). There was a positive correlation of total dry matter production with seed yield (Table 4) (Jain *et al.*, 2002).

Seed yield (kg ha^{-1})

Seed yield among the soybean genotypes varied significantly (Table 3). The highest seed yield was recorded in the genotype MACS-1460 (2014.81 kg ha^{-1}) followed by NRC-37 (1690.73 kg ha^{-1}) and Basara (1677.78 kg ha^{-1}) and the lowest seed yield was obtained from the genotype ASB-16 (1087.03 kg ha^{-1}) followed by JS-335 (1118.52 kg ha^{-1}) and ASB-13 (1160.37 kg ha^{-1}). The genotytpes NRC-37 (1690.73 kg ha^{-1}) and Basara (1677.78 kg ha^{-1}) were found to be statistically on par with the genotype MACS-1460. Similarly, the genotypes Basara, JS-93-05 and ASB-15 were statistically on par with the genotype NRC-37.

Table.1 LAI and CGR of soybean genotypes during *kharif* season

S.No	Genotypes	LAI					CGR				
		DAS					DAS				
		15	30	45	60	75	15-30	30-45	45-60	60-75	75-Harvest
1	JS-335	0.40	1.17	1.46	3.24	3.03	1.80	5.35	6.67	9.29	2.81
2	BASARA	0.44	1.38	1.88	3.99	3.65	1.87	5.21	10.10	11.19	2.76
3	JS-93-05	0.42	1.19	1.71	3.54	2.16	1.52	4.18	10.65	11.06	0.80
4	MACS-1460	0.51	2.05	2.55	4.54	4.14	1.75	5.56	10.39	12.15	2.54
5	NRC-37	0.51	1.98	2.36	4.16	3.82	1.71	5.26	10.98	11.16	2.57
6	ASB-13	0.29	1.17	1.46	3.51	3.05	1.63	5.20	8.89	9.21	2.23
7	ASB-15	0.36	1.19	1.74	3.56	3.25	1.67	6.70	7.22	10.25	1.73
8	ASB-16	0.33	1.17	1.57	3.13	2.87	1.60	5.99	7.19	8.90	1.97
	Mean	**0.41**	**1.41**	**1.84**	**3.71**	**3.24**	**1.69**	**5.43**	**9.01**	**10.40**	**2.18**
	SEd	**0.02**	**0.08**	**0.24**	**0.24**	**0.24**	**0.12**	**0.43**	**0.92**	**0.88**	**0.42**
	CD(p=0.05)	**0.05**	**0.18**	**0.51**	**0.51**	**0.51**	**NS**	**0.91**	**1.97**	**1.88**	**0.91**

Table.2 LAD and RGR of soybean genotypes during *kharif* season

S.No	Genotypes	LAD				RGR				
		DAS				DAS				
		15	30	45	75	15-30	30-45	45-60	60-75	75-Harvest
1	JS-335	106.12	177.56	317.04	423.11	0.0398	0.0339	0.0179	0.0144	0.0031
2	BASARA	123.46	220.54	397.28	516.49	0.0445	0.0336	0.0245	0.0142	0.0026
3	JS-93-05	108.93	195.99	354.28	384.79	0.0413	0.0326	0.0289	0.0146	0.0008
4	MACS-1460	173.47	311.33	479.65	586.62	0.0347	0.0338	0.0239	0.0147	0.0023
5	NRC-37	168.31	293.24	440.09	539.05	0.0346	0.0329	0.0258	0.0135	0.0024
6	ASB-13	98.70	178.12	335.69	442.70	0.0419	0.0358	0.0230	0.0130	0.0024
7	ASB-15	104.97	198.25	357.82	459.93	0.0414	0.0407	0.0171	0.0143	0.0018
8	ASB-16	101.19	184.49	317.03	405.27	0.0431	0.0394	0.0184	0.0133	0.0023
	Mean	**123.14**	**219.94**	**374.86**	**469.75**	**0.0402**	**0.0354**	**0.0225**	**0.0140**	**0.0022**
	SEd	**5.08**	**15.83**	**31.91**	**31.91**	**0.0020**	**0.0001**	**0.0001**	**0.0002**	**0.0002**
	CD(p=0.05)	**10.90**	**33.95**	**68.44**	**68.44**	**0.0040**	**0.0002**	**0.0003**	**NS**	**0.0004**

Table.3 Yield and Harvest index in soybean genotypes during *kharif* season

S.No	Genotypes	Seed Yield (kg/ha)	Harvest Index (%)
1	JS-335	1118.52	43.16
2	BASARA	1677.78	43.24
3	JS-93-05	1533.33	44.04
4	MACS-1460	2014.81	45.92
5	NRC-37	1690.73	41.98
6	ASB-13	1160.37	32.68
7	ASB-15	1262.97	38.68
8	ASB-16	1087.03	33.55
Mean		**1443.19**	**40.41**
SEd		**221.03**	**3.45**
CD(p=0.05)		**474.06**	**7.40**

Table.4 Correlation of growth parameters with yield in soybean genotypes

Growth parameters	Yield
Yield	**1.0000**
CCI	0.7207*
SCMR	0.5954
LAI	0.6201
HI	0.8256*
TDM	0.9108 **
LAD	0.8073 *
LAR	0.1376
RGR	-0.1493
CGR	0.1581

*significant at 5 % level ** significant at 1 % level

The highest seed yield in MACS-1460 can be attributed to highest dry matter production, more number of pods per plant, and number of seeds per pod. The high chlorophyll content might have increased the photosynthate production and their translocation to developing seeds, thereby increasing the seed yield. The seed yield has shown positive correlation with dry matter production (Bange and Milroy, 2004).

Harvest index (%)

The maximum harvest index of 45.92% was recorded in genotype MACS-1460 followed by JS-93-05 (44.04 %), Basara (43.24 %) and the lowest harvest index of 32.68 % was recorded in ASB-13 followed by ASB-13 (32.68 %) followed by ASB-16 (33.55 %)and it is represented in Table 3.The genotytpes Basara and JS-93-05 were statistically on par with the genotype MACS-1460.The harvest index reflects the physiological ability of the crop genotype to mobilize photosynthates to the economic portion of the plant (Snyder and Carlson, 1984). It was positively correlated withseed yield (Chandra and Yadav, 1997 and Kuldeep *et al.*, 2015).

In conclusion based on the results of the present investigation, it is concluded that the genotypes MACS-1460, NRC-37 and Basara had physiologically and yield wise more efficient performance among the soybean genotypes during *kharif* season. Hence they can be recommended for cultivation in the region of Telangana state.

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