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Analysis of Growth and Physiological Characteristics of Soybean Genotypes in Kharif Season of Telangana, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted at the Students' Farm, College of Agriculture, Rajendranagar, Hyderabad, during *kharif* 2017-2018. Results of analysis of growth and physiological characteristics of soybean genotypes showed that highest and lowest plant heights were recorded in Basara and ASB-16, respectively. More number of days to 50% flowering, was recorded for the genotype JS-335 and less in JS-93-05, MACS- 1460 and ASB-15 whereas days to reach maturity was highest in the genotypes JS-335, Basara, NRC-37, ASB-15 and lowest for the genotype JS-93-05. The maximum LAR was recorded for the genotype MACS-1460 while the maximum NAR was in the genotype ASB-15 and minimum was for MACS-1460 at 30- 45 DAS. The highest SLA was recorded in genotype JS-93-05 and the minimum was recorded in ASB-15, whereas the highest SLW was recorded in ASB-15 and the lowest was recorded in the genotype JS-93-05. Hence genotypes MACS-1460, NRC-37 and Basara were morphologically, physiologically more efficient among the soybean genotypes during *kharif* season.

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Keywords: Soybean; oil seed crop; physiological characteristics of soybean.

1. INTRODUCTION

Soybean is a significant oil seed crop that is produced all over the world for its high oil and protein content. Originally from East Asia, it is a well-adapted plant that grows well in both spring and summer in tropical, subtropical, and temperate climates across the globe. The world's leading producers of soybeans are the United States, Brazil, Argentina, China, India, Paraguay, and Canada. Because it is a significant source of protein, energy, fibre, vitamins, minerals, and polyunsaturated fat for both humans and livestock, it is currently regarded as a crucial crop in other nations. It has about 20% oil and 40–42% high-quality protein, compared to 20–25% in other legumes Agarwal et al., (2013). Globally, there are 121.53 million hectares of soybeans grown, with an average yield of 2.76 tonnes per hectare and 334.89 million tonnes produced year. In India, soybeans are primarily produced in the kharif season despite being a day-neutral plant. This season's unusual rainfall causes weeds to grow more quickly at first and to be more diverse, which depletes the soil of more nutrients and lowers seed output (Kumar et al., 2022). Tropical and subtropical climates are suitable for its growth, and it needs warm, humid seasons. The warm and moist climate with ideal temperature range seems to be between 25 and 30°C. Due to its greater market value and wide range of agroclimatic adaptation, soybeans are widely planted throughout India, but notably in Madhya Pradesh (Joshi et al., 2023). Madhya Pradesh is referred to as the "soybean belt" among Indian states because it alone accounts for 81% of the total area planted with soybeans. Rainfall is typically used to cultivate soybeans, and the start of the monsoon determines when to sow the crop. Because of this, the planting date for soybeans is crucial to consider (Neenu et al., 2017). The nation is currently experiencing an oilseed supply deficit, because of their low production, high demand-to-supply ratio, and imports, oilseeds are a pricey market commodity. The lack of suitable genotypes specific to the agroclimatic region that are resistant to both biotic and abiotic stress is one of the major constraints in soybean production. Therefore, one of the biggest challenges facing scientists and farmers is raising the productivity of oilseeds like soybeans. Previous research conducted globally has identified a number of plant characteristics that are crucial to take into account when choosing soybean genotypes for increased seed output. The newly recommended improved varieties of soybean have a wide range of maturity and variable form. Recognizing that different soybean genotypes may require distinct environmental conditions for optimal growth, the aim of study was to analyze the growth and physiological trait analysis of soybean genotypes in the kharif season in telangana state**.**

2. MATERIALS AND METHODS

2.1 Aim of the Study

To study the growth and physiological trait analysis of soybean genotypes during the Kharif season in Telangana state.

2.2 Site Details

The investigation was carried out at at Students farm, College of Agriculture, Rajendranagar, and Hyderabad. It is in the southern Telangana agro-climatic zone. According to troll's classification, it falls under semi arid tropics.

2.3 Soil Status

The soil of the experimental site was sandy loam with good drainage. The soil was slightly alkaline in reaction (pH 7.6) due to higher chloride and sulphate content of Ca and Mg with low organic carbon (0.48 %) and low available nitrogen (230 kg ha^{-1}), high in available phosphorus (P_2O_5) (23.48 kg ha^{-1}) and potassium (408.66 kg ha^{-1}).

2.4 Treatments Description

The experiment was laid out in randomized block design with eight soybean genotypes *viz*., JS-335, Basara, JS-93-05, MACS-1460, NRC-37, ASB-13, ASB-15 and ASB-16. The treatments were replicated thrice. The crop was sown at a spacing of 30 cm X 10 cm. Five tagged plants per plot, excluding those on the borders, were sampled every 15 days and separated into different component parts. These parts were then dried in a hot-air oven at 80°C until a constant weight was achieved. The dried samples were weighed to record data on dry matter partitioning. The data were analyzed statistically applying analysis of variance technique for randomized block design as suggested by Gomez & Gomez, (1984). The statistical significance was tested with ‘F’ test at 0.05 level of probability and where ever the ‘F’ value was found significant, critical difference (CD) was worked out to test the significance.

2.5 Net Assimilation Rate (g dm^{-2} day^{-1})

NAR = W_2-W_1 / t_2 -t_1 x Loge A_2-Loge A_1 / A_2-A_1

2.6 Specific Leaf Area (cm^2 g^{-1})

SLA = LA / LW

2.7 Specific Leaf Weight (mg cm^{-2})

SLW = LW / LA

2.8 Leaf Area Ratio (cm^2 g^{-1})

LAR = LA / W

2.9 Where the Symbols Represent:

A_1 : Total leaf area at initial
time A_2 : Total leaf area at final time
LA : Leaf area
LW : Leaf weight
t_1 : Initial time
t_2 : Final time
W : Dry weight of plant
W_1 : Initial dry weight
W_2 : Final dry weight
P : Land area

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

The data on plant height (Table 1) shows that there was significant difference for the plant height among the soybean genotypes throughout the growth stages. Plant height increased rapidly up to 75 days after sowing (DAS) and then remained steady. The tallest plants were observed in the Basara (55.59 cm) and NRC-37 (51.81 cm) genotypes. The shortest plant height was noted in the ASB-16 genotype (45.08 cm), which was statistically similar to ASB-13 (46.85 cm), JS-335 (46.96 cm), and ASB-15 (47.89 cm). The differences in plant height among the soybean genotypes are determined by both their genetic composition and environmental conditions. Similar results were found by Vahid et al., (2013) and Patil et al. (2014).

3.2 Days to 50% Flowering

There was significant difference for days to 50% flowering (Table 2). The genotype JS-335 took maximum days (44 days) to reach the stage of 50% flowering followed by Basara and NRC-37 (43 days) and minimum days to reach the 50% flowering were recorded in JS-93-05, MACS-1460 and ASB-15 (40 days). The days to 50% flowering had positive effect on soybean seed yield per plant. The significant variation in days to 50% flowering occurs due to difference in genetic constitution among the soybean genotypes and environmental interactions. Similar observation was recorded with Furuhata et al., [(2011) and Kuldeep et al., (2015).

3.3 Days to Maturity

The results (Table 2) revealed that, there was significant difference for days to maturity. The genotypes JS-335, Basara, NRC-37, ASB-15 and ASB-16 took maximum days (95 days) to reach the maturity and minimum days to maturity was observed in JS-93-05 (82 days) while MACS-1460 and ASB-13 have taken 92 and 93

Table 1. Plant height (cm) in soybean genotypes during *kharif* season

		Days after sowing					
S.No	Genotypes	15	30	45	60	75	At harvest
1	JS-335	9.92	15.56	30.35	40.13	46.96	46.96
2	BASARA	9.01	14.06	35.99	43.6	55.59	55.59
3	JS-93-05	9.95	16.96	36.95	42.61	49.71	49.71
4	MACS-1460	10.84	16.48	41.54	46.42	50.45	50.45
5	NRC-37	7.51	13.80	39.91	47.8	51.81	51.81
6	ASB-13	10.39	19.20	33.62	41.91	46.85	46.85
7	ASB-15	10.03	17.08	37.02	43.11	47.89	47.89
8	ASB-16	10.25	19.02	34.29	38.25	45.08	45.08
	Mean	9.74	16.52	36.21	42.98	49.29	49.29
	SEd	0.63	1.13	2.39	1.99	2.28	2.28
	CD(p=0.05)	1.35	2.43	5.13	4.27	4.89	4.89

Table 2. Phenological stages in soybean genotypes during *kharif* season

S.No	Genotypes	Days to 50% Flowering	Days to Maturity
1	JS-335	44	95
2	BASARA	43	95
3	JS-93-05	40	82
4	MACS-1460	40	92
5	NRC-37	43	95
6	ASB-13	41	93
7	ASB-15	40	95
8	ASB-16	41	95
	Mean	41.50	92.75
	SEd	1.36	1.57
	CD(p=0.05)	2.91	3.38

days respectively. The days to maturity in soybean genotypes varies according to its genetic makeup. Bange & Milroy, (2004) reported that the timing of crop maturity is largely determined by the capacity of the plant to continue the production of new fruiting sites (Shadakshari et al., 2014).

3.4 Net Assimilation Rate (mg cm^{-2} day^{-1})

Net assimilation rate (NAR) for all soybean genotypes are presented in Table 3. The NAR measures the amount of photosynthetic product that is converted into plant material. It estimates the net carbon assimilated through photosynthesis after accounting for the carbon lost due to respiration. It showed significant differences for net assimilation rate (NAR) among the soybean genotypes throughout the growth. Maximum net assimilation rate (NAR) was recorded during 45-60 DAS in genotypes which gave higher yield *viz*., JS-93-05 (2.05 mg cm^{-2} day^{-1}), Basara (1.73 mg cm^{-2} day^{-1}), NRC-37 (1.67 mg cm^{-2} day^{-1}) and MACS-1460 (1.47 mg cm^{-2} day^{-1}). In other varieties *viz*., ASB-15 (2.29 mg cm^{-2} day^{-1}), ASB-16 (2.15 mg cm^{-2} day^{-1}), JS-335 (1.98 mg cm^{-2} day^{-1}) and ASB-13 (1.91 mg cm^{-2} day^{-1}), maximum NAR was during 30-45 DAS. The minimum NAR at 30-45 DAS was recorded in MACS-1460 (1.17 mg cm^{-2} day^{-1}) and at 45-60 DAS, the minimum NAR was for ASB-15 (1.41 mg cm^{-2} day^{-1}). The genotytpes ASB-16 and JS-335 was found to be statistically at par with the genotype ASB-15 at 30-45 DAS. The maximum net assimilation rate during late flowering stage and seed formation stage was for high yielding soybean cultivars. The increase in NAR at different growth stages may be attributed to the variation in SPAD and CCI values. The increase in leaf area may also attribute to the increase in NAR by more light interception and thereby increasing assimilate production. There was a negative correlation between NAR and seed yield which was in accordance with the study of Tandale & Ubale (2007).

3.5 Specific Leaf Area (cm^2 g^{-1})

Data on specific leaf area (SLA) presented in Table 4 has shown significant differences among the soybean genotypes. Specific leaf area (SLA) is a functional trait of plants that quantifies the ratio of a leaf's surface area to its dry weight. SLA in the soybean genotypes did not follow a

Table 3. Net assimilation rate (mg cm^{-2} day^{-1}) in soybean genotypes during *kharif* season

		NAR Days after sowing			
S.No	Genotypes	15-30	30-45	45-60	60-75
1	JS-335	1.21	1.98	1.44	1.43
2	BASARA	1.09	1.56	1.73	1.41
3	JS-93-05	0.99	1.41	2.05	1.91
4	MACS-1460	0.76	1.17	1.47	1.36
5	NRC-37	0.76	1.18	1.67	1.36
6	ASB-13	1.25	1.91	1.83	1.36
7	ASB-15	1.16	2.29	1.41	1.48
8	ASB-16	1.17	2.15	1.54	1.45

		NAR Days after sowing			
S.No	**Genotypes**	**15-30**	**30-45**	**45-60**	**60-75**
	Mean	1.05	1.71	1.64	1.47
	SEd	0.07	0.16	0.19	0.16
	CD(p=0.05)	0.14	0.34	0.40	0.33

particular trend in the study. The genotype SLA in the soybean genotypes did not follow a particular trend in the study. The genotype JS-93-05 showed highest SLA (85.14 cm^2 g^{-1}) followed by Basara (80.38 cm^2 g^{-1}) at 15 DAS. At 30 DAS, the highest SLA was for the genotype MACS-1460 (82.55 cm^2 g^{-1}) followed by NRC-37 (80.63 cm^2 g^{-1}). While minimum SLA was recorded in ASB-15 (19.21 cm^2 g^{-1}) followed by ASB-13 (21.24 cm^2 g^{-1}) at 45 DAS. The SLA in soybean genotypes showed a positive correlation with yield. Specific leaf area (SLA) as an indirect measure of several basic leaf processes, such as photosynthetic capacity.

3.6 Specific Leaf Weight (mg cm^{-2})

Specific leaf weight (SLW) for all soybean genotypes are presented in Table 5. Specific leaf weight (SLW) is a morphological characteristic of plants that is determined by dividing the dry weight of the leaves by their surface area. The SLW significantly differed among all genotypes and like SLA, specific leaf weight (SLW) also did not show a particular trend in the genotypes. The highest SLW was recorded at 45 DAS in ASB-15 (55.94 mg cm^{-2}) followed by ASB-13 (47.47 mg cm^{-2}). The lowest was recorded at 15 DAS in the genotype JS-93-05 (11.76 mg cm^{-1}) and at 30 DAS by genotype MACS-1460 (12.12 mg cm^{-2}). SLW represents the leaf thickness and gives an estimative of the proportion between the assimilatory surface and the veins that sustain those leaf tissues (Cruz et al., 2004; Panse & Sukhatme, 1967). The yield had a negative correlation with specific leaf weight in soybean genotypes.

3.7 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 (Table 6). The soybean genotypes JS-335, Basara, and JS-93-05 exhibited a gradual decrease in growth from 15 DAS up to 75 DAS. In contrast, genotypes ACS-1460 and NRC-37 showed an increase from 15 DAS to 30 DAS before gradually decreasing until 75 DAS. Genotypes ASB-13, ASB-15, and ASB-16 decreased from 15 DAS to 45 DAS, then slightly increased at 60 DAS, followed by a decline. The highest Leaf Area

Table 4. Specific leaf area (cm^2 g^{-1}) in soybean genotypes during *kharif* season

		SLA Days after sowing				
S.No	**Genotypes**	**15**	**30**	**45**	**60**	**75**
1	JS-335	58.28	46.85	24.09	31.61	26.52
2	BASARA	80.38	58.67	36.14	37.86	25.66
3	JS-93-05	85.14	58.07	24.62	41.69	23.38
4	MACS-1460	62.13	82.55	49.29	43.13	36.93
5	NRC-37	60.53	80.63	58.36	36.82	32.12
6	ASB-13	53.68	56.61	21.24	31.37	27.07
7	ASB-15	59.05	55.69	19.21	33.92	29.16
8	ASB-16	69.26	53.71	25.37	30.45	24.91
	Mean	66.06	61.60	32.29	35.86	28.22
	SEd	4.20	3.28	5.14	2.36	2.36
	CD(p=0.05)	9.01	7.03	11.03	5.06	5.06

Table 5. Specific leaf weight (mg cm^{-2}) in soybean genotypes during *kharif* season

		SLW Days after sowing				
S.No	**Genotypes**	**15**	**30**	**45**	**60**	**75**
1	JS-335	17.17	21.49	41.53	31.65	37.71
2	BASARA	12.45	17.04	27.81	26.43	39.06
3	JS-93-05	11.76	17.28	40.97	24.02	42.97
4	MACS-1460	16.63	12.12	20.46	23.32	27.24

		SLW Days after sowing				
S.No	**Genotypes**	**15**	**30**	**45**	**60**	**75**
5	NRC-37	16.59	12.44	17.90	27.31	31.52
6	ASB-13	18.64	17.77	47.47	31.89	36.94
7	ASB-15	16.98	18.45	55.94	30.13	35.01
8	ASB-16	14.47	18.78	39.63	32.87	40.55
	Mean	15.59	16.92	36.47	28.45	36.37
	SEd	1.10	1.09	5.54	1.94	2.72
	CD(p=0.05)	2.37	2.34	11.89	4.15	5.83

Table 6. Leaf area ratio (cm^2 g^{-1}) in soybean genotypes during *kharif* season

		LAR Days after sowing				
S.No	**Genotypes**	**15**	**30**	**45**	**60**	**75**
1	JS-335	39.19	29.21	11.26	13.48	7.66
2	BASARA	52.36	34.91	14.92	13.59	7.61
3	JS-93-05	52.16	35.77	16.59	12.62	4.66
4	MACS-1460	41.42	49.12	18.97	14.79	8.12
5	NRC-37	41.17	48.63	18.83	13.38	7.74
6	ASB-13	34.61	33.22	11.98	12.99	7.19
7	ASB-15	41.43	33.28	11.80	13.33	7.42
8	ASB-16	42.90	33.74	11.63	12.32	7.18
	Mean	43.16	37.23	14.50	13.32	7.20
	SEd	2.79	1.97	2.04	0.88	0.58
	CD(p=0.05)	5.98	4.23	4.38	NS	1.24

Ratio (LAR) was recorded by genotype MACS-1460 (49.12 cm^2 g^{-1}), which was statistically similar to NRC-37 (48.63 cm^2 g^{-1}). The lowest LAR was recorded by JS-93-05 (4.66 cm^2 g^{-1}), followed by ASB-16 (7.18 cm^2 g^{-1}). Leaf area index of soybean genotypes varied from (3.13 to 4.54). The senescence of older leaves caused a drop in leaf area, which in turn caused an increase in dry weight, which resulted in a fall in LAR during the maturity stage.

4. CONCLUSION

Based on the results and discussion it can be concluded that maximum growth parameters and physiological parameters of soybean was found higher in MACS-1460, NRC-37 and basara soybean genotypes compared to other genotypes during *kharif* season. Hence, they can be recommended for cultivation in this region of Telangana. However, since these conclusions are based on only one year of experimentation, the study should be repeated for at least 2-3 years without altering the layout or crop varieties to confirm the consistency of the results.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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