Growth and Physiological Trait Analysis of Soybean Genotypes in the Kharif Season

Commented [n1]: Change to
Analysis of the difference in growth and physiological characteristics of soybean genotypes in the fall season

Commented [n2]: In which area

Abstract

The present investigation was conducted at the Students' Farm, College of Agriculture, Rajendranagar, Hyderabad, during *kharif* 2017-2018. Results of morphological characteristics 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.

Commented [n3]: What this study included

Introduction

Soybean, is a significant oil seed crop that is produced all over the world. 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. Depending on environmental and genetic variables, 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 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. 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

Commented [n4]: What is the significance of soybean crop?

Commented [n5]: What are the environmental requirements for soybeans?

Commented [n6]: What climate do soybeans grow best in?

Commented [n7]: What is the problem with soybean production?

Commented [n8]: What is the most important factor for soybean growth?

environmental conditions for optimal growth, a field experiment was conducted to study growth and physiological trait analysis of soybean genotypes in the kharif season in telangana state.

Commented [n9]: What are the growth parameters of soybeans?

Commented [n10]: Add the aim of the study

Material and methods

Site Details

The investigation was carried out at at Students farm, College of Agriculture, Rajendranagar, and Hyderabad.

Soil Status

The soil of the experimental site was sandy loam with good drainage. The soil was slightly alkaline in reaction (pH 7.6) 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}).

Commented [n11]: Why alkaline

Commented [n12]: Is this the most important factor for soybean growth?

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. 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 with factorial concept as suggested by Gomez and 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.

Commented [n13]: What the difference between this genotypes?

Commented [n14]: What is marker assisted selection in soybeans?

Net assimilation rate (g dm^{-2} day^{-1})

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e A_2 - Log_e A_1}{A_2 - A_1}$$

Specific leaf area (cm^2 g^{-1})

$$SLA = \frac{LA}{LW}$$

Specific leaf weight (mg cm^{-2})

$$SLW = \frac{LW}{LA}$$

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

$$LAR = \frac{LA}{W}$$

Where the symbols represent:

A_1 : Total leaf area at initial

timeA_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

Results and discussion

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).

Commented [n15]: What is the average height of a soybean plant?

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).

Commented [n16]: How long do soybeans take to mature?

Commented [n17]: What is the spacing of soybeans in CM?

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 days respectively. The days to maturity in soybean genotypes varies according to its genetic makeup. Bange and 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)

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

Net assimilation rate (NAR) for all soybean genotypes are presented in Table 3. 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 and Ubale (2007).

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. 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.

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

Specific leaf weight (SLW) for all soybean genotypes are presented in Table 5. 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). The yield had a negative correlation with specific leaf weight in soybean genotypes.

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 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}). The senescence of older

Commented [n18]: How long do soybeans take to mature?

Commented [n19]: What is the net assimilation rate?

Commented [n20]: What is the formula for crop growth rate?

Commented [n21]: What is the leaf area of soybeans?

Commented [n22]: How to calculate specific leaf area?

Commented [n23]: What is specific leaf mass?

Commented [n24]: What is the leaf area index of soybeans?

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.

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.

Reference

Agarwal DK, Billore SD, Sharma AN, Dupare B U and Srivastava S K. Soybean: Introduction, improvement, and utilization in India - Problems and Prospects. Agricultural Research. 2013. 7(2) 2: 293–300.

Bange MP and Milroy, S.P. Growth and dry matter partitioning of diverse cotton genotypes. Field Crop Research. 2004; 87 (1): 73-87.

Cruz JL, Coelho EF, Pelacani CR, Coelho MA, Dias AT and Santos MT. Growth and partition of dry matter and carbon in papaya in response to nitrogen nutrition. Bragantia. 2004;63 (3): 351-361.

Furuhata, M., Adachi, K and Ohono, S. 2011. Influence of field drainage on dry matter and seed production of soybean in the Hokuriku district of Japan. Japanese Journal of Crop Science. 80 (1): 65-72.

Gomez.,K. A and Gomez.,A. A. (1984).Statistical Procedures in Agricultural Research, New York, Wiley 2nd edition, paperback, pp. 680.

Joshi MA, Sahu RP, Jamre PS, Ahirwal A, Prajapati R, Priya, Gulaiya S and Sharma A. Effect of Different Nutrient Management Practices on Crop Growth, Yield and Yield Attributes of Soybean (Glycine max L.) under Kymore Plateau and Satpura Hillsagro-Climatic Zone. international Journal of Environment and Climate Change. 2023;13(11): 3852-3858,

Kuldeep SC, Baig KS, Sarang DH, Kiihne D, Dhone U and Anil K. Association analysis for yield contributing and quality parameters in soybean. The Ecosan. 2015; 7: 113-118.

Kumar S, Rana SS and Ramesh. Weed management strategies in Soybean (Glycine max) - A review. Indian Journal of Agricultural Sciences. 2022. 92(4): 438–44.

Neenu S, Ramesh K, Ramana S and Somasundaram J. Dry Matter Partitioning and Yield of Different Varieties of Soybean (Glycine max (L.) Merrill) under Aberrant Climatic Conditions in Central India. International Journal of Plant & Soil Science. 2017; 14(6): 1-9, Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Second Enlarged Edition, ICAR, New Delhi. 1967;5-6.

Patil SR, Jadhav MG and Jadhav JD. Impact of sowing windows and varieties on canopy temperature (CT), stress degree days (SDD) in soybean. International Journal of Plant Sciences. 2014; 9 (2): 342-348.

Shadakshari TV, Yathish KR, Kalaimagal T, Gireesh C, Gangadhar K and Jaggal S. Morphological response of soybean under water stress during pod development stage. Legume Research. 2014; 37 (1): 37–46.

Tandale MD and Ubalen SS. Evaluation of effect of growth parameters, leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR) on seed yield of soybean during kharif season. International Journal of Agricultural Sciences. 2007; 3 (1): 119-123.

Vahid Y, Amin F, Abbas M, Meysam M, Rahim N, Mahboubeh G and Ahmad L. Yield and yield Components of Soybean Cultivars as Affected by Planting Date. Bulletin of Environment, Pharmacology and Life Sciences. 2013; 2 (7): 85- 90.

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**

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
	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**

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
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**