International Journal of Plant & Soil Science

34(18): 39-44, 2022; Article no.IJPSS.86872
ISSN: 2320-7035

Evaluation of Growth, Physiological, and Quality Parameters on Seed Yield of Soybean [*Glycine max* (L.) Merrill]

Piyush Upadhyay [a], M. K. Shrivastava [a], Stuti Sharma [a], R. Shiv Ramakrishnan [b], Sachin Prakash Nagre [b*] and Salikram Mohare [b]

[a] Department of Genetics and Plant Breeding, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), 482004, India.
[b] Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), 482004, India.

Authors' contributions

This work was carried out in collaboration among all authors. The study was conceived by authors MKS and SS, who also organized the research materials, wrote the original draft of the publication, and prepared the protocol. Author PU managed the literature searches, data collection in the field, and data compilation. Authors RSR and SPN assisted with data collecting and compilation in the field, while author SM assisted with data design, analysis and interpretation. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1831050

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86872

Original Research Article

Received 20 February 2022
Accepted 30 April 2022
Published 02 May 2022

ABSTRACT

Fifty genotypes of Soybean, including two checks (JS 20-98 and JS 20-34), were evaluated to assess the effect of various growth parameters on the seed yield of soybean cultivars and to determine their variability in protein and oil content as well as the correlation between both qualitative characters and yield parameters. The study was carried out during the *Kharif* season of 2019 at Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, (MP). The experiment was laid out in a randomized complete block design (RCBD), having three replications. In the present studies, the data regarding Leaf area index (LAI), leaf area duration (LAD), Chlorophyll content index (CCI), oil, and protein percentage showed that there were significant differences among all varieties. The results from these data were analyzed using PCA and correlation analysis. There was a significantly positive correlation of LAI at 30, 45,

**Corresponding author: E-mail: sachinnagre92@gmail.com;*

and 60 DAS with seed yield. There was a significant positive correlation between LAD-1 (30-45DAS) and LAD-2 (45-60DAS) with seed yield and positive correlation between CCI to seed yield. Significantly negative correlation between oil and protein percent with the seed yield of the plant was observed. It was found that genotype EC 456615 had the highest protein content (41.62%), and genotype EC 389170 had the highest oil content (21.50%) among the studied genotypes.

Keywords: Growth parameters; Leaf Area Index (LAI); Leaf Area Duration (LAD); Chlorophyll Content Index (CCI); seed quality.

1. INTRODUCTION

Human and animal health requires soybean meals and oils. Because of its nutritional and economic value and its many applications, soybean farming in Madhya Pradesh has grown from last many years. It is the world's most important supplier of vegetable oil [1]. It's one of India's three most important oilseed crops. The reason for the low performance of soybean may be due to physiological parameters, and thus the study of evaluation of various growth parameters viz. LAI, LAD, and CCI were conducted. The leaf area of soybean is a crucial yield variable controlled by both abiotic (solar radiation and temperature) and biotic (pests and illnesses) variables; consequently, achieving optimal LAI is a first step in reducing soybean yield disparities.

Additionally, the research found that the optimal range for getting the maximum soybean yield was between 3.5 and 4.0 LAI in the early reproductive stage (R1, commencement of flowering) [2]. Similarly, developing nutritionally rich genotypes is another part of crop improvement. Soybean is among the most significant oilseed crops globally in terms of overall output and international commerce, accounting for 25% of global vegetable oil production and nearly two-thirds of protein concentrates for animal feeding. Soybean have brought significant economic benefits to small and marginal farmers as a short-duration, low-input income crop that fetches high prices. It accounts for 40% of overall oilseed output and 25% of total edible oil production. Soya protein and oils are critical for both children's and adults' health. It is also utilized to make a variety of healthy animal feeds available on the market. The importance of soybean in India's food security cannot be overstated. Farmers and breeders have a problem in selecting specific cultivars to cultivate for seed output, oil content, or both. A fast increase in LAI until a maximum value is attained, followed by a drop in LAI as leaves age and the plant reaches physiological maturity. Because chlorophyll is the primary driver of light absorption and conversion of absorbed light to chemical energy, it is an important (though not the only) element in determining plant photosynthetic potential. This study aimed to determine a link between soybean oil content and seed yield with physiological factors, i.e., the best leaf area index for achieving maximum production potential in the soybean (*Glycine max* (L.) Merrill). A typical LAI pattern starts with a lag rise early in the season.

2. MATERIALS AND METHODS

The experiment was conducted at the Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur (M.P.), during the *Kharif* season of 2019. The annual rainfall of the experimental area is around 1200-1400mm, with most of it falling between June and September. Fifty genotypes were utilized in the study, including two control varieties (JS 20-98 and JS 20-34) acquired from the All India Coordinated Research Project on Soybean, Department of Plant Breeding and Genetics, JNKVV, Jabalpur, and the Indian Institute of Soybean Research, Indore (M.P.). A Randomized Complete Block Design was used to plan the experiment. To guarantee optimal germination and decrease weed infestation, the field was prepared using manual tillage. The rows were 40cm wide and the plants were 7cm apart. The plot was 1.2m x 3m in size. At 30, 45, and 60 days after sowing, the different growth observations (LAI and LAD) were recorded. OP-Stat software (http://14.139.232.166/opstat/) was used to conduct the statistical analysis. The leaf area index was computed using leaf area per plant data collected at 30, 45, and 60 days. The LAI was determined using Watson's [3] formula.

LAI = Total leaf area/ Land area

$LAI = [(LA_2 + LA_1)/ 2/p]$

Table 1. Eigen values of Correlation Matrix

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Eigen values	**5.326**	**1.391**	**0.757**	0.547	0.369	0.297	0.185	0.070	0.058
Proportion	0.592	0.155	0.084	0.061	0.041	0.033	0.021	0.008	0.006
Cumulative Proportion	0.592	0.746	0.830	0.891	0.932	0.965	0.986	0.994	1.000

Table 2. Loadings (Eigen-vectors) of Correlation Matrix

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
LAI 30DAS	0.205	**-0.561**	**-0.457**	**0.392**	**0.488**	0.132	-0.127	-0.049	-0.079
LAI 45DAS	**0.279**	**-0.422**	-0.313	**-0.491**	**-0.392**	**-0.494**	-0.087	-0.004	-0.009
LAI 60DAS	**0.383**	-0.077	-0.085	-0.210	-0.136	**0.533**	**0.693**	0.044	-0.110
LAD1	**0.371**	0.219	0.180	0.114	**0.364**	**-0.539**	0.279	**0.347**	**-0.383**
LAD2	**0.411**	0.121	0.107	0.069	0.187	-0.192	0.148	**-0.375**	**0.753**
CCI	**0.329**	0.125	-0.077	**0.673**	**-0.635**	-0.019	-0.096	0.033	-0.062
OIL %	-0.040	**-0.640**	**0.732**	0.140	-0.099	-0.016	0.080	0.112	0.068
PROTEIN %	**-0.396**	-0.074	-0.303	0.170	-0.067	-0.163	**0.372**	**0.587**	**0.450**
YIELD	**0.400**	0.088	0.093	-0.204	0.070	**0.317**	**-0.493**	**0.613**	0.239

Table 3. Pearson correlation matrix

	LAI-30DAS	LAI-45DAS	LAI-60DAS	LAD-1	LAD-2	CCI	OIL %	PROTEIN%	YIELD
LAI30	1.000	0.549**	0.442**	0.234^{NS}	0.351*	0.319*	0.212^{NS}	-0.264^{NS}	0.325*
LAI45	0.549**	1.000	0.622**	0.373**	0.494**	0.349*	0.120^{NS}	-0.493**	0.528**
LAI60	0.442**	0.622**	1.000	0.645**	0.783**	0.602**	-0.064^{NS}	-0.776**	0.809**
LAD1	0.234^{NS}	0.373**	0.645**	1.000	0.905**	0.635**	-0.172^{NS}	-0.796**	0.762**
LAD2	0.351*	0.494**	0.783**	0.905**	1.000	0.710**	-0.134^{NS}	-0.878**	0.858**
CCI	0.319*	0.349*	0.602**	0.635**	0.710**	1.000	-0.150^{NS}	-0.616**	0.626**
OIL%	0.212^{NS}	0.120^{NS}	-0.064^{NS}	-0.172^{NS}	-0.134^{NS}	-0.150^{NS}	1.000	0.010^{NS}	-0.134^{NS}
PROTEIN%	-0.264^{NS}	-0.493**	-0.776**	-0.796**	-0.878**	-0.616**	0.010^{NS}	1.000	-0.913**
YIELD	0.325*	0.528**	0.809**	0.762**	0.858**	0.626**	-0.134^{NS}	-0.913**	1.000

Where, LAD-1 means LAD at 30-45 DAS and LAD-2 means 45-60 DAS

Where,
LA_1 and LA_2 represent leaf area during two consecutive intervals and 'P' ground area.

The size and persistence of leaf area or leafiness during the crop growth phase are expressed by leaf area duration. It is connected to yield and indicates the magnitude of the seasonal integral of light interaction [3].

The LAD was calculated in the following way:

$$LAD = [(LA_2 + LA_1)/ 2] \times (t_2 - t_1) \text{ (cm}^2 \text{ days)}$$

Where, LA_1 and LA_2 represent the leaf area at two successive time intervals (t_1 and t_2).

Chlorophyll Content Index (CCI), measured in grams of chlorophyll per unit ground area, was determined in the fourth leaf of a five-week-old plant using a non-destructive procedure including a chlorophyll meter (Model: CCM 200 Made in the USA). The protein content of each sample was determined using a standard micro-Kjeldahl digestion and distillation method. The AOAC method was used to determine the fat content of the sample (1984). Correlation coefficients were determined using the software OP-stat to assess the degree of association between features and yield and yield components. The goal of principle component analysis is to find a limited number of linear combinations (principal components) of a collection of variables that preserve a lot of the original information. A limited number of main components are frequently used to substitute the original variables, create graphical representations, and do regression analysis, cluster analysis, and factor analysis. As a result, this study may be viewed as an attempt to demonstrate the nearly linear dependencies between variables. The obtained values were compared to Fisher and Yates's (1963) tabulated values at t-2 d.f. at two levels of probability, namely 5%, and 1%, to assess the significance of correlation coefficients.

3. RESULTS AND DISCUSSION

Principal Component Analysis, or PCA, is a dimensionality-reduction approach for reducing the dimensionality of big data sets by converting a large collection of variables into a smaller one that retains the majority of the information in the large set. Table 1 shows the current study's Eigen-values, percent variance, and cumulative Eigen-values. Only two of the nine principal components (PCs) had an Eigen-value greater than 1.00. They indicated roughly 74.60 percent diversity among the attributes investigated, and the rest of the principal components showed an Eigenvalue less than 1. PC1 showed the highest Eigenvalue (5.326), followed by PC2 (1.391). Based on Loadings (Eigen Vectors), LAI60, LAD1, LAD2, and CCI are some favorable characters in PCI and LAI30, and LAI45 are promising characters in PC2.

As a result, the relevance of these two main components was given significant consideration for further explanation. PC1 exhibited the most variability (59.20 percent), followed by PC2 (15.30 percent). As a result, choosing lines for characters in PC1 and PC2 may be beneficial. AGS 48 (genotype no.47) had the highest PC score in PC1 of the 50 genotypes studied, indicating that this genotype has a high value of traits such as LAI, LAD, and CCI (as shown in Table 2). AGS 76 (genotype 44) had the highest PC score in PC2 and was mostly associated with LAD and CCI (shown in Table 2). El-Hashash (2016), Manav et al. (2017), Dubey et al. (2018), and Liying (2018) reported similar results (2018).

LAI (30 and 45 days) showed a positive correlation with LAD, CCI, and yield per plant and negative with oil (%) and Protein (%) (shown in Table 3). Also, LAD showed a positive correlation with CCI and yield per plant and negative with oil% and protein%. CCI Showed a positive correlation with yield per plant and negative with oil% and protein%, oil% and protein% showed a negative correlation with LAI, LAD, CCI, and seed yield per plant. Similar results were obtained by Adetokunbo et al. [4], Upadhyay et al. [5], Mehra et al. [6], Weerasekara et al. [7], Ogunkanmi et al. [8], Soni et al. [9], showed similar results [10-33].

4. CONCLUSION

The genotypes AGS 48 and AGS 76 were identified as prospective lines using principal component analysis. Based on correlation analysis, it is proposed that LAI, LAD, and CCI be given special attention to enhance seed yield. As a result, indirect selection based on these features will be particularly efficient in increasing seed production. In conclusion, these lines should be exploited in future breeding projects to generate more versatile, trait-specific soybean varieties.

ACKNOWLEDGEMENTS

I am expressing my venerable regards to Dr. M. K. Shrivastava for their guidance in preparing the manuscript and research. I am incredibly thankful to Mr. Sachin Nagre for his help with the design, data collecting, data analysis, and data interpretation. I am extremely grateful to all the respected authors for their valuable suggestions, continuous interest, encouragement, inspiring advice, and generous help carrying out the relevant experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dashiell KE. Soybean production andutilization in Nigeria. Paper presented at the National workshop on small scale and industrial level processing of Soybean, held at IITA, Ibadan; 1993.
2. Fehr WR, Caviness DT, Burmood, CE, Pennington JS. Stage of development descriptions for soybean, *Glycine max* (L.).Merrill. Crop Science. 1971;11(5):929–931.
3. Watson DJ. Physiological basis of varieties in yield. Advance in Agronomy. 1952;4(2):101-145
4. Adetokunbo AD, Esla AS, Esther I, Glory OE, Ebun A. Correlation between oil Content and Yield of Some early Maturing Soybean (Glycine max (l.)Merill) Genotypes in Keffi, Nasarawa State. International Journal of Environment, Agriculture and Biotechnology. 2019;4(3):1878-2456.
5. Upadhyay P, Shrivastava MK, Amrate PK and Yadav RB. Yield Determining Traits, Genetic Variability and Character Association in Exotic Lines of Soybean (*Glycine max* (L.) Merill). Soybean Research. 2020;18(2):95-102.
6. Mehra S, Shriavstava MK, Amrate PK, Yadav RB. Studies on variability, correlation coefficient and path analysis for yield associated traits in soybean (*Glycine max* (L.) Merill). Journal of Oilseeds Research. 2020;37(1):56-59.
7. Weerasekara I, Sinniah UR, Namasivayam P, Nazli MH, Abdurahman SA, Ghazali MN. The Influence of Seed Production Environment on Seed Development and Quality of Soybean (*Glycine max* (L.) Merrill). Agronomy. 2021;11(7):1430.
8. Ogunkanmi L, MacCarthy DS, Adiku SG. Impact of Extreme Temperature and Soil Water Stress on the Growth and Yield of Soybean (*Glycine max* (L.) Merrill). Agriculture. 2021 Dec 31;12(1):43.
9. Soni M, Shrivastava MK, Singh Y, Sharma S, Amrate PK, Banerjee J. Evaluation og Genetic Variability and Association Analysis of Soybean (*Glycine max* (L.) Merill) for Some Physiological Parameters. Internatonal Journal of Plant & Soil Science. 2022;34(10):17-26.
10. Acikgoz E, Sincik M, Wietgrefe G, Surmen M, Cecen S, Goksoy AT. Dry matter accumulation and forage quality characteristics of different soybean genotypes. Turkish Journal of Agriculture and Forestry. 2013;37(1):22-32.
11. Bang P, Xiao W, Xin J, Zhang H, Shuo X. Photosynthetic characteristics of soybean and mungbean in an agroforestry eco-system in the Loess area. Acta Botanica Boreali-Occidentalia Sinica. 2011;31(2):363-369.
12. Bisen A, khare D, Nair P, Tripathi N. SSR analysis of 38 genotypes (*Glycine max* L. Merr.) genetic diversity in India. Physiological and molecular Biology of plants. 2014.;21(1): 109-115.
13. Egli DB, Zhen-wen Y. Crop growth rate and seeds per unit area in soybean. Crop Science. 1991l31(3): 39-442.
14. Fritschi BF, Ray JD. Soybean Leaf Nitrogen, Chlorophyll Content and Chlorophyll a/b ratio. Photosynthetica. 2007;45(1):92-98.
15. Gardner FP, Pearecer RB, Mitchell RL. Growth and development in physiology and crop plants. The IOWA, State Univ. Press. 1985; 187-208.
16. Gupta VS, Olugbemi LB. Proving photosynthetic efficiency of crop. Crop Physical. 1978;12(2):189-238.
17. Hanson WR. Net photosynthesis and evapotranspiration of field grown soybean canopies. Ph.D. Thesis Iowa State University Library, Ames; 1972.
18. Hu Z, Chen LH, Yang SY. Chlorophyll content and photosystem II efficiency in soybean exposed to supplemental ultraviolet-B radiation. Photosynthetica. 2013;51(1):151-157.
19. Jha A. Genetic and Molecular Analysis for Phenological, Physiological and Yield Traits in Soybean. Ph.D (Ag.) Thesis, JNKVV, Jabalpur. 2016;145.
20. Liu C, Liu Yi, Lu Y, Liao Y, Chen F. Use of a leaf chlorophyll content index to improve the prediction of above-ground biomass

and productivity. Peer Journal. 2019;10(3):56-62.
21. Liu X, Jin J, Herbert S, Zhang Q. Yield components, dry matter, LAI and LAD of soybean in northeast china. Field Crops Research. 2005;93(1):85-93.
22. Mishra A. Genetic and Molecular Analyses for Phenological, Physiological and Yield Traits in Soybean. Ph.D. Thesis, JNKVV, Jabalpur. 2016;198.
23. Mottaghian A, Pirdashti H, Bahmanyar MA. Dry matter accumulation and physiological indices of two soybean cultivars in response to enriched sewage sludge compost. World Applied Sciences Journal. 2010;8(5):578-588
24. Richter GL, Junior AZ, Augusto N. Estimating leaf area of modern soybean cultivars by a non-destructive method. Bragantia. 2014;73(4):34-39.
25. Sarma BK, Sarma CM. Association of some physiological determinants with seed yield in soybean [*Glycine max* (L.) Merrill]. Indian Journal Hill Farming. 1992;5(2):113-117.
26. Setiyono TD, Weiss A, Specht JE, Cassman,KG, Dobermann A. Leaf Area Index Simulation in Soybean grown under near-optimal conditions. Field Crop Research. 2008;108(5):82-92.
27. Sharma JP, Sharma SP. Influence of genotype and plant densities on physiological parameters, grain yield and quality of soybean. Indian Journal Agron. 1993;38(2):311-314.
28. Tagliapietra EL, Streck NA, Thiago S, Richter GL, Silva MR, Alencar J. Optimum Leaf Area Index to Reach Soybean Yield Potential in Subtropical Environment. Crop Ecology and Physiology. 2018;9(2):57-63.
29. Tandale MD, Ubale SD. 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 agriculturae Sciences. 2007;3(1):119-123.
30. Tantway S. Genetic Studies Based on Physiological and Economic Traits in Advanced Breeding Genotypes of Soybean. M.Sc. Thesis, JNKVV, Jabalpur. 2015;72.
31. Vyas MD, Khandwe R. Effect of row spacing and seed rate on morpho-physiological parameters, yield attributes and productivity of soybean (*Glycine max* L. Merrill) cultivars under rainfed condition of vindhyan plateau of Madhya Pradesh. Soybean Research. 2014;12(1):82-91.
32. Xiaobing L, Jian SJ, Herbert. Yield Components, Dry matter, LAI and LAD of Soybean in North east China. Field Crops Research. 2005;93(1):85-93.
33. Yadav US, Mishra S, Shrivastava AN. Genetic diversity analysis based on seedling and physiological traits in advance generations of soybean [*Glycine max* (L.) Merril]. Frontiers in Crop Improvement. 2017;5(Spl.):307-310.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86872