Original Research Article

Genetic variability, association and path coefficient analysis for seed yield and physiological parameters in soybean.

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ABSTRACT

The present study was carried out to estimate the important genetic parameters, heritability, genetic advance correlation, and path coefficient analysis in fifty advanced breeding lines of soybean. Randomized Block design (RBD) with three replications was used to design this experiment at the Department of Plant Breeding and Genetics, JNKVV, Jabalpur in 2020. All statistical analysis was done in CRAN R. Genotypes were evaluated for eight characters based on important physiological growth parameters such as leaf area index 1 (30 DAS), leaf area index 2(45 DAS) leaf area index 3 (60 DAS), leaf area duration 1, (30-45 DAS), leaf area duration 2 (45-60 DAS), seed filling duration, harvest index, seed yield per plant. ANOVA revealed a sufficient amount of variability was found among soybean genotypes for all traits assessed, which gives an opportunity to plant breeders for the enhancement of these traits. The value of the phenotypic coefficient of variation (PCV) is greater than the genotypic coefficient of variation (GCV). The high GCV and PCV were observed for leaf Area Index 1, leaf Area Index 3, leaf Area Duration 2, seed filling duration, harvest index and seed yield. High heritability (0.8) coupled with high genetic advance as percentage mean (66.4) were recorded for leaf area 1 (30 DAS). It indicates that the trait is governed by additive gene action and directional selection for this trait would be more effective for desired genetic improvement. Correlation coefficient study indicated that Leaf area index 1, leaf area duration1 and harvest index showed a significant positive correlation with seed yield. Greater LAI of soybean genotypes would be enabled greater radiation absorption during the seed filling period. Harvest index showed a significant positive direct effect along with a positive correlation with seed yield, which can be considered as suitable selection criteria for the development of high-yielding soybean genotypes.

Keywords: Leaf area index, leaf area duration, correlation and path coefficient

1. INTRODUCTION

Soybean [Glycine max (L.) Merrill] is one of the most important oilseed crops in the world in terms of production and trade. It has been a dominant oilseed source since the 1960s [28]. Soybean is an essential source of protein, oil, and micronutrients in human and animal feed worldwide [9]. It contains 40–42% high-quality protein and 18–22% oil [2]. It also contains about 12% carbohydrate [35]. It is not only to supply food for humans and animals but also at the same time to serve as a means for improving the soil through their ability to fix atmospheric nitrogen. Due to the versatile nature of this crop, its contribution to the industrial, agricultural, and medicinal sectors is significantly increasing. As per AMIS, FAO estimates, among the major soybean growing countries, India ranks fourth in area and fifth in production. In India, the cultivation of soybean was undertaken in an area of 12.06 million hectares with a production of 13.58 million tons and productivity of 1126 kg/ha. [6]. Among the states, Madhya Pradesh is known as the “Soya State” of India, comprising 55% of the total national area of soybean cultivation. Apart from Madhya Pradesh, Maharashtra (46.01 lakh ha.) and Rajasthan (10.62 lakh ha) are major soybean-growing states in India.

The Leaf Area Index (LAI) is an important indicator of radiation, precipitation interception, energy conversion, and water balance in plants. It is a reliable parameter for plant growth. Several studies in agronomy and horticulture measure the results of interventions such as fertilizers and irrigation in terms of leaf area index. The relationship between leaf area index and yield is not simple and will vary with the kinds of crops and life-stages of a plant. Accurately simulating the leaf area index is necessary for the accurate simulation of biomass accumulation and transpiration. The opposite is also true, partitioning to the leaves to form a new leaf area is influenced by biomass accumulation. A typical leaf area index pattern begins with a lag increase early in the crop season followed by a rapid increase of leaf area index until a maximum value is reached and after that a sharp decline of leaf area index [14]. Therefore, the leaf area index could be measured in different phases of the plant cycle to accurately calculate the optimum yield of most seed crops, individual seed weight is commonly analyzed as the product of the individual seed growth rate by seed filling duration. In legume seeds, the active filling period begins when the pod wall has approximately reached its final size. Seed filling duration varies with changes in environmental conditions [4]. (1994). Leaf area duration is the ability of the plant to maintain the green leaves over a unit area of land throughout its life. and express in days. Seed yield is the product of total dry matter and harvest index. The seed filling duration of soybean is related to seed yield [1]. Soybean growth and development are the results of a genetic potential interacting with the environment and minimizing these stresses will optimize seed yield [16].

The knowledge of certain genetic parameters is essential for proper understanding and their manipulation in any crop improvement programme. Seed yield is the result of the expression and association of several plant growth components. Path analysis is used to partition the relative contribution of yield components through standardized partial regression coefficients [33]. Correlation and path coefficient analysis can be used as an important tool to bring information about appropriate cause and effects relationship between yield and some yield components [17],[32]. considering all these important traits investigations were undertaken to reveal the genetic association of physiological growth parameters and seed yield in advanced breeding lines of soybean

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The experimental material consists of fifty advanced breeding lines of soybean which developed at JNKVV, Jabalpur. The experiment was carried out in Randomized Block Design with three replications at Seed Breeding Farm, Jawaharlal Nehru Krishi Vishwavidyalaya. Each of the advanced Breeding lines was grown in three rows of 3-meter row length with row-to-row distance of 45 cm and plant to plant distance of 7 cm. The crop was raised with the following recommended packages and practices of soybean cultivation The experimental site is lies between 22°49' and 20°80' North latitude and 78°21' and 80°58' East longitude at an altitude of 411.78 meters above the mean sea level. The five plants were harvested and threshed separately from each entry and the seed yield of the individual plant was weighed in grams. The various growth observations were recorded at an interval of 30 DAS to harvest. Leaf area index and leaf area duration were calculated according to the formula given by Watson (1947).

Leaf area index and leaf area duration were calculated according to the formula given by Watson (1947). Three soybean plants were uprooted at 30, 60, 90 DAS and at harvest the observations were recorded timely based on collected data, various growth functions were calculated. All statistical analysis was done in the CRAN R package.

The leaf area index (LAI) was calculated from the data of leaf area per plant at 30, 60 and 90 days respectively. According to the formula given by Watson (1947).

$$LAI = \text{Total Leaf Area} / \text{total ground area}$$

The leaf area duration (LAD) was calculated by the formula given by Watson (1947).

$$LAD = LA2 + LA1\ (t2 - t1)/2$$

Where LA1 and LA2 represent the leaf area at two successive time intervals (t1 and t2).

The seed filling duration was calculated as the time from anthesis to physiological maturity. The Harvest index was worked out from the following formula:

$$HI = \text{Seed yield} / \text{biological yield} \times 100$$

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3. RESULTS AND DISCUSSION

Analysis of variance revealed that the mean sum of squares of various characters Viz. leaf area index, leaf area duration, grain filling duration, harvest index and seed yield per plant are significant and indicated a sufficient amount of variability. (Table 1). ANOVA indicated that mean sum of squares due to replications were significant at P=0.001 for Leaf area index 1, Leaf area index 2, leaf area duration 1, Leaf area duration 2, and seed yield per plant significant at P=0.05. On the other hand, mean sum of squares due to genotype was significant at P=0.001 for leaf area index 1, leaf area index 2, leaf area index 3, leaf area duration 1, leaf area duration 2, grain filling duration, harvest index, seed yield per plant.

Table 1. Analysis of variance for eight growth parameters of 50 Soybean genotypes

Source of variation	df	LAI 1	LAI 2	LAI 3	LAD 1	LAD 2	SFD	HI	SYPP
Replications	2	2.8***	2.8*	0.2	484.7*	346.6*	4.3	57.6	1.3*
Treatments	49	2.5***	2.3***	1.9***	897.5***	804.2***	45.7***	349.9***	23.6***
Error	98	0.2	0.7	0.1	153.3	83.6	2.4	20.2	0.4

*, **, *** significant difference at p=0.05, p=0.001, p=0.001, ANOVA: Analysis of variance DF: Degree of freedom, LAI: leaf area index, LAD: leaf area duration, HI: Harvest index, SYPP: seed yield per plan

Genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, heritability (broad sense), genetic advance and genetic advance expressed as a percent of mean for eight characters are presented in Table 2.

1. Leaf area index 1

The range for leaf area index 1 was 0.3 to 5.4. with a 2.4 mean value (Table 2). The magnitude of genotypic coefficient of variance (36.6 %) while a phenotypic coefficient of variance (41.6%). The heritability in the broad sense (0.8 %), genetic advance (1.6) and genetic advance mean percent value was 66.4 %.

2. Leaf area index 2

The range for leaf area index 2 was 0.8 to 9.6 with the mean value 3.2 (Table 2). The magnitude of genotypic coefficient of variance (23.3 %) while the phenotypic coefficient of variance (34.3 %). The heritability in the broad sense (0.5 %), genetic advance (1.1) and genetic advance mean percent value was 32.6 %.

3. Leaf area index 3

The range for leaf area index 3 was 0.8 to 6.3 and mean value was 3.0 (Table 2). The magnitude of genotypic coefficient of variance (26.3 %) while the phenotypic coefficient of variance (29.5 %). The heritability in a broad sense (0.8 %), genetic advance (1.4) and genetic advance mean percent value was 48.1 %. Similar results were also reported by [25]. According to Pawar [22]. the leaf area index was less at the seedling stage and increased continuously up to 60 DAS and thereafter declined. These results are similar to the observations found in the present investigation. Likewise, Jain et al. [12]. and Ralebhat et. al. [23] obtained similar conclusions regarding leaf area index.

4. Leaf area duration 1

The range for leaf area duration 1 was 65.8 to 158.7 with the mean value 29.2 (Table 2). The magnitude of genotypic coefficient of variance (23.9 %) while the phenotypic coefficient of variance (30.4 %). The heritability in a broad sense (0.6 %), genetic advance (1.4) and genetic advance mean percent value was 48.1 %.

5. Leaf area duration 2

The range for leaf area duration 2 was 68.5 to 128.5 and the mean value was 28.6 (Table 2). The magnitude of genotypic coefficient of variance (22.6 %) while the phenotypic coefficient of variance (26.3 %). The heritability in a broad sense (0.7 %) and genetic advance (27.5) with genetic advance mean percent value was 40.1 %.

6. Seed filling duration

The range for seed filling duration was 56.6 to 70.0 with the mean value was 48.0 (Table 2). The magnitude of genotypic coefficient of variance (6.7 %) while the phenotypic coefficient of variance (7.2 %). The heritability in a broad sense (0.9 %) and genetic advance (7.3) with genetic advance mean percent value was 12.8 %.

7. Harvest index

The range for the Harvest index was 42.8 to 78.8. The mean value for grain filling duration was 16.6 (Table 2). The magnitude of genotypic coefficient of variance (24.5 %) while phenotypic coefficient of variance (26.6 %). The heritability in a broad sense (0.8 %) and genetic advance (19.9) with genetic advance mean percent value was 46.3 %.

8. Seed yield per plant

The range for seed yield per plant was 7.7 to 16.1 The mean value for grain filling duration was 3.6 (Table 2). The magnitude of genotypic coefficient of variance (36.1 %) while phenotypic coefficient of variance (37.1 %). The heritability in a broad sense (0.9 %) and genetic advance (5.6) with genetic advance mean percent value was 72.3 %. These findings were also recorded by Pandey et al. [21], Kumar et al. [13]. According to them, high heritability coupled with high genetic advance as percent of mean was observed by seed yield per plant and harvest index. Sonkamble et al. [29] were also found that the high values of GCV and PCV observed for seed yield and harvest index. And she also found that High heritability along with high genetic advance as percentage mean was observed for seed yield and harvest index.

Table 2. Range, mean, genotypic and phenotypic coefficients of variation, heritability, and genetic advance for different characters in Soybean

S. No.	Character	Mean	Range Min.	Max.	PV	GV	PCV (%)	GCV (%)	h^2 b	GA	GA % of the mean	S. Ed ±	CD 5%	1%
1	Leaf Area Index 1	2.4	0.3	5.4	1.0	0.8	41.6	36.6	0.8	1.6	66.4	0.3	0.8	1.0
2	Leaf Area Index 2	3.2	0.8	9.6	1.2	0.6	34.3	23.3	0.5	1.1	32.6	0.5	1.3	1.7
3	Leaf Area Index 3	3.0	0.8	6.3	0.8	0.6	29.5	26.3	0.8	1.4	48.1	0.2	0.6	0.9
4	Leaf Area Duration 1	29.2	65.8	158.7	401.4	248.1	30.4	23.9	0.6	25.5	38.8	7.1	20.1	26.6
5	Leaf Area Duration 2	28.6	68.5	128.5	323.8	240.2	26.3	22.6	0.7	27.5	40.1	5.3	14.8	19.6
6	Seed Filling Duration	48.0	56.6	70.0	16.8	14.5	7.2	6.7	0.9	7.3	12.8	0.9	2.5	3.3
7	Harvest Index	16.6	42.8	78.8	130.1	109.9	26.6	24.5	0.8	19.9	46.3	2.6	7.3	9.6
8	Seed Yield Per Plant	3.6	7.7	16.1	8.2	7.7	37.1	36.1	0.9	5.6	72.3	0.4	1.1	1.4

PV= Phenotypic variance, GV= genotypic variance, GCV= Genotypic Coefficient of Variation, PCV= Phenotypic Coefficient of Variation, h2(b)= Heritability (Broad Sense) GA = Genetic Advance, SE standard error, CD = critical difference

Correlation coefficient

Correlation between different traits is generally due to the presence of linkage disequilibrium, pleiotropic gene actions and epistatic effect of different genes Falconer [5]. The environment also plays an important role in the correlation. Correlation analysis (Table 3) revealed that LAI 1 was highly significant positively associated with LAI 2, LAI 3, LAD1, LAD 2, and seed yield per plant. Board et al. [3]. also found that leaf area index (LAI) was positively correlated with seed yield.

The characters LAI 3, LAD1, LAD 2, and harvest index were also exhibited highly significant and positive correlation with LAI 2. LAI 3 showed a highly significant and positive association with LAD1, LAD 2, and harvest index. LAD1 revealed highly significant and positive associated with LAD 2, grain filling duration and harvest index, and seed yield per plant. Data regarding leaf LAD indicated that there were significant differences among all genotypes at 30-60, 60-90, and 90 DAS-at harvests of crops these findings are in agreement with the result of Xiaobing Liu et al. [34]. They also show a positive correlation between leaf area duration and seed yield. Similar results were also found by Martin et al. [15]. and Tandale and Ubale [30]. Harvest index is the largest contributor to soybean yield improvements. The finding is the following result of Ui and U [31]. and Nirmalakumari and Balsubramanian [20]. LAD 2 was found a positive and significant correlation with harvest index. whereas harvest index showed a positive and highly significant correlation only with seed yield per plant. It was revealed that LAI 1 (0.1958) and LAD 1 (0.1712) were found to be significantly and positively correlated with seed yield per plant.

Path Coefficient

Path coefficient analysis provides an effective way of finding out direct and indirect sources of correlations. Study revealed (Table 4) that LAD 1 recorded the highest positive direct effect on seed yield. LAI 3 also exhibited a maximum positive direct effect on seed yield. Trait Harvest Index exhibited a positive direct effect on seed yield and a strong association with seed yield (0.8197) indicated the true relationship therefore direct selection through this trait will be effective for yield improvement. However, LAI 1, LAI 2, LAD 2, SFD has a negative direct effect on seed yield. Since the direct effect was negative, the direct selection for this trait to improve yield will be undesirable. The indirect effect of these traits on seed yield was contributed via LAI 3, LAD 1, and harvest index.

In the current study, no obvious correlation was found between seed filling duration (SFD) and yield. And also, between SFD and leaf area duration (LAD) similar results were also found by Kumudini et al. [14]. phenotypic correlations indicate that that relationship can be altered by the environment in some genotypes. Hanway and Weber [11]. Gay et al. [8]. Hanson [10]. Smith and Nelson [27]. The lower residual effect (0.906) indicated that most of the variability in grain yield for the genotypes under the present has been explained by the independent variables included in the analysis Singh and Chaudhary [26].

In more recent studies, HI has been reported to be a significant contributor to yield improvement Frederick et al. [7]. Shiraiwa and Hashikawa [24]. Morrison et al. [19]. The greater LAI of soybean genotypes during the seed filling period indicates a delay in the rate at which the leaves senesced resulting in a longer stay green period. Greater LAI of soybean genotypes would be enabled greater radiation absorption during the seed filling period especially when LAI values are below the critical value for 95% radiation interception approx. 3-4 LAI Kumudini et al. [14]. Therefore, increase radiation interception by photo dynamically active leaves of the genotypes is postulated to have contributed to the greater continued dry matter accumulation. Therefore, longer leaf area duration plays an important role in yield improvement. Morrison et al. [19]. presented averaged LAI values. Under conditions of very high LAI, as reported in their paper, average LAI values may not be good representations of LAD.

Table 3 Genotypic and Phenotypic correlation coefficient of eight physiological growth characters in soybean

Character	Correlation	LAI 1	LAI 2	LAI 3	LAD1	LAD2	GFD	HI	SYPP
LAI 1	G	1**							
	P	1**							
LAI 2	G	0.5411**	1**						
	P	0.3459**	1**						
LAI 3	G	0.4338**	0.5564**	1**					
	P	0.3819**	0.3856**	1**					
LAD1	G	0.8023**	0.9362**	0.5823**	1**				
	P	0.622**	0.9453**	0.4558**	1**				
LAD2	G	0.5224**	0.7812**	0.9534**	0.7775**	1**			
	P	0.4372**	0.7409**	0.9054**	0.7668**	1**			
GFD	G	0.1721	0.1797	0.1177	0.2051	0.1537	1**		
	P	0.1158	0.1508	0.0759	0.1748*	0.1246	1**		
HI	G	0.1773	0.2622	0.2291	0.2585	0.2674	0.0966	1**	
	P	0.1565	0.1609*	0.1753*	0.1866*	0.2016*	0.0962	1**	
SYPP	G	0.2083	0.1201	0.1266	0.1694	0.1387	-0.023	0.8197**	1**
	P	0.1958*	0.1231	0.1121	0.1712*	0.1382	-0.013	0.7954**	1**

*, **, *** significant difference at P=0.05, P=0.001, P=0.001, LAI = Leaf Area Index, LAD = Leaf Area Duration, GFD = Grain Filling Duration, HI= Harvest Index, SYPP = Seed Yield Per Plant, G= Genotypic correlation, P= Phenotypic correlation

Table 4 Direct and indirect effect of eight physiological growth parameters on seed yield in soybean

	LAI 1	LAI 2	LAI 3	LAD1	LAD2	GFD	HI	Correlation with Seed yield
LAI 1	**-1.2839**	-0.54157	1.4355	2.82392	-2.35684	-0.02121	0.15245	0.2083

LAI 2	-0.69475	**-1.00082**	1.84146	3.29538	-3.52446	-0.02215	0.22541	0.1201
LAI 3	-0.5569	-0.55688	**3.30942**	2.04963	-4.3012	-0.0145	0.197	0.1266
LAD 1	-1.03002	-0.93697	1.92704	**3.51995**	-3.50754	-0.02528	0.22223	0.1694
LAD 2	-0.67072	-0.78186	3.15517	2.73666	**-4.51148**	-0.01894	0.22986	0.1387
GFD	-0.22101	-0.17987	0.38942	0.72201	-0.69332	**-0.12323**	0.08302	-0.023
HI	-0.22767	-0.2624	0.75832	0.90987	-1.20624	-0.0119	**0.85972**	0.8197**
SYPP	0.20834	0.12007	0.12656	0.16942	0.13869	-0.02298	0.8197	1**

Residual: - 0.2906

4. CONCLUSION

The present study revealed that genotypes were significantly associated with physiological growth parameters as well as seed yield. which gives an opportunity to plant breeders for the enhancement of these traits. The high heritability (0.8) values coupled with high genetic advance as percentage mean (66.4) were recorded for LAI 1 (30 DAS). It indicates that the trait is governed by additive gene action and directional selection for this trait would be more effective for desired genetic improvement. Correlation coefficient study indicated that important physiological traits i.e., LAI 1, LAD 1 and HI were found a significant positive association with seed yield. This suggests a common genetic or physiological basis among these traits. Hence, synchronized improvement of these traits would be possible. In this study, there is no consistent relationship was found between grain filling duration and seed yield. However, the harvest index showed a significant positive direct effect along with a positive correlation with seed yield and can be considered as suitable selection criteria for the development of high-yielding soybean genotypes.

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