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Studies on Genetic variability of Metric Traits in Germplasm of Soybean (*Glycine max* L. Merrill)

Krishna Tandekar[1*], Sunil Kumar Nag[2], Rajeev Shrivastava[3], Priya Gupta[4] and Khemlata Thakur[4]

[1]Scientist, AICRP on MULLaRP, Department of Genetics and Plant Breeding, IGKV, Raipur (Chhattisgarh), India.

[2]Senior Scientist, AICRP on Soybean, Department of Genetics and Plant, Breeding, IGKV, Raipur (Chhattisgarh), India.

[3]Principal Scientist, AICRP on Safflower, Department of Genetics and Plant Breeding, IGKV, Raipur (Chhattisgarh), India.

[4]Ph.D. Research Scholar, Department of Genetics and Plant Breeding, IGKV, Raipur (Chhattisgarh), India.

(Corresponding author: Krishna Tandekar)*

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ABSTRACT: Genetic variability is derived from data on 14 yield-related traits in 200 genotypes of soybean. Results revealed that there were highly significant differences among genotypes for all the characters. Phenotypic coefficient of variance was greater than genotypic coefficient of variance, which indicates influence of environment in the expression of the characters. The highest PCV and GCV values were observed for seed yield/plant, pod bearing length, biological yield. High heritability was recorded in 100 seed weight, oil content, number of primary branches/plant, protein content, plant height, number of seed/plant, pod bearing length, days to maturity, number of seed/pod and harvest index indicating. High heritability coupled with high genetic advance as per cent of mean was observed for 100 seed weight, oil content, number of primary branches/plant, plant height, number of seeds/plant, pod bearing length and harvest index, which indicates presence of additive gene action and selection will be rewarding. In soybean breeding programs, diverse germplasm accessions boost genetic diversity and maintain the rare alleles that make up distinctive germplasm collections. Determining efficient methods to enhance economic features for crop production requires an understanding of the genetic diversity of germplasm sets.

Keywords: Soybean, heritability, genetic gain, phenotypic coefficient of variation, genotypic coefficient of variation.

INTRODUCTION

The world population is rising, and there is massive pressure on natural resources (Airoboman and Onobhayedo 2022). It is now becoming a challenge to feed the growing population (D'Esposito *et al.*, 2021). In case of oilseed crop, Soybean is important oilseed crop, which contributed 59% of the world's vegetable oilseed production (USDA, 2022). It contains about 37-42% of high quality protein, 6% ash, 29% carbohydrate and 17 to 24% oil, comprising 85% poly unsaturated fatty acids with two essential fatty acids (lenoleic & linolenic acid) (Balasubramaniyan and Palaniappan 2003). Soybean is vegetable oil crop, and in its raw form, or soy meal is also used as the main source of protein for farm animal; livestock, poultry, and pig feeding. Due to versatile nature of soybean, (*Glycine max* (L.) Merrill) crop it is referred to as a "miracle crop" or "golden bean". It is a self-pollinated crop with chromosomal number 2n = 2x = 40 and is a member of the Leguminosae family and subfamily Papilionoide. Additionally, in low-input farming systems, it is a perfect crop for enhancing and amending soil qualities through nitrogen fixation and the capacity to disrupt the lifecycles of pests and diseases in cereal rotation systems (Graham and Vance 2003). As a result, for the majority of developing nations that are struggling with severe malnutrition and food insecurity, soybeans are a crop with immense potential.

The major producing and supplying countries in the world are Brazil, USA, Argentina and China, accounting for more than 90% of the world production. India is leading soybean producing country in South Asia and 5th largest producer after USA, Brazil, Argentina and China in the world. In India, major soybean producing states are Madhya Pradesh, Maharashtra, Karnataka, Rajasthan, Gujarat, Andhra Pradesh, Uttar Pradesh, Uttarakhand and Chhattisgarh.

This crop's contribution to the industrial, agricultural, and healthcare sectors is significantly growing as a result of its adaptability. Due to the population's rapid increase and the steadily decreasing amount of arable land, human health has been confronted with increasing challenges. It supplies 25% of the world's edible oil,

and today's consumers are familiar with its processed commodities like soymilk and tofu paneer.

In Chhattisgarh, soybean is the only oilseed crop that can be grown successfully during *Kharif* season. Soybean farming is now becoming more and more popular in this state. In terms of acreage and soybean production, Chhattisgarh came in sixth. Kabirdham, Rajandgaon, Bemetara, Durg, Mungeli, and Raipur are soybean growing districts. The state's soybean crop covers about 80,000 hectares, producing 70,000 metric tons with an average productivity of 884 kg/ha (Anon., 2021).

Therefore, the evaluation of soybean germplasm is of great importance and scope for crop agronomic and genetic enhancement in the current and future time. The lack of genetic variability and unavailability of high-yielding cultivars are the main reasons for low seed production, hence, it is imperative to increase genetic variability to develop high-yielding soybean cultivars by evaluating available germplasm.

MATERIAL AND METHODS

The experimental material consists of two hundred germplasm of soybean including five checks obtained from AICRP on Soybean, Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. The experiment was grown during *Kharif* -2021 in the month of June in an augmented block design and plot divide into five blocks. Each block contains 20 genotypes and five checks. In augmented block design, each entry was grown in single row of 3 m length, spaced at 30 cm between rows and 20 cm between plants. Therefore, this present study aimed to explore genetic variation, h^2, and genetic advance for yield and yield-related traits in soybean to identify vigorous genotypes that would enhance seed production in Chhattisgarh and lead to self-sufficiency.

RESULT AND DISCUSSION

The phenotypic variability observed in a population is a combination of both genetic and environmental factors. By partitioning this phenotypic variability into heritable and non-heritable components, breeders can determine the proportion of variation that can be attributed to genetic factors. This information helps in identifying traits that are more likely to respond to selective breeding.

In the current study, analysis of variance revealed highly significant differences between genotypes for most traits, with the exception of the number of primary branches per plant and the number of seeds/pod, demonstrating the high degree of phenotypic variability among the genetic materials investigated (Table 1).

The estimates of mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance are presented in Table 2. Days to 50% flowering ranged from 38.6 to 53.8 days, with a mean value of 47.21 days. The maximum delayed flowering was recorded for genotype V 55 (53.8 days) followed by AMSS 34 (53 days) and NRC 51 (51.1 days). The early flowering was recorded for the genotype JS 20-72 (38.6 days).

Plant height varied widely, ranges from 19.68 cm to 142.75 cm which showed mean value of 65.23 cm. The maximum plant height (cm) was observed in AGS 156 (142.75 cm) followed by EC 325113 (123.5 cm) and EC 389173 (120.6 cm) whereas minimum plant height (cm) was recorded in JS20-98 (26.68 cm).

Number of primary branches per plant ranged from 2.2 to 6.83 with 4.24 mean values. The maximum value observed in RSC 10-52 (6.83) followed by NRC 2 (6.6) and EC 467282 (6.5) whereas the genotypes EC291397 (2.2) and TGX 560-20 D (2.3) were found with minimum number of primary branches/plant. The average value for number of pods/plant was recorded 64.83, ranged from 21.28 to 121.48. Genotypes EC291397 (21.28) and PK 262 (25.4) showed lowest number of pods/plant; while highest number of pods/plant was observed in Gujarat soybean 1 (121.48) followed by JS 97-52 (116) and RSC11-07 (108).

The mean value of number of seeds/pod was 2.00, with a range of 2.00 to 4.00. Highest number of seeds/pod was recorded in RSC11-07 (4.00) followed by JS 97-52 (3) and RSC10-71(3) whereas lowest number of seeds/pod was recorded in GC12 (2). Biological yield/plant showed wide range of variations from 11.66 g (SQL 5) to 79.0 g (RSC10-71) with a mean of 37.34g (TAMS 28). The minimum biological yield were recorded in genotype 11.66 g (SQL 5), MACS 250 (12.00g) TGX 297-16F (14.16), B 1667(14.00g) and EC 528622 (16.67g). The maximum biological yield were recorded in RSC 10-71 (79.0 g) followed by CG SOYA 11-15 (76.0g). Number of seeds per plant was ranged from 55.6g (EC 291397) to 350 (JS 97-52) with a mean of 158.34. 100 seed weight showed wide variation which ranges from 5g to 17.07g with a mean of 11.36 g. Largest seed size was observed in CAT 1149 (17.02g) followed by MAUS-61-2 (16.4g) and PK 262 (16.36g) whereas, smallest seed size was observed in EC 457475 (5.00g). Seed yield/plant (g) showed mean value of 15.59g with range varied from 4.93g to 35.62g. Genotype SQL 5 (4.93.00g) had the lowest seed yield/plant while it was recorded highest in JS75-46 (35.62g) followed by CG SOYA 11-15 (34.79g) and JS 335 (33.61g).

Harvest index showed a ranged from 16.63% to 74.55%with a mean of 39.54%. Highest harvest index was observed in EC 291397 (74.55%) followed by BR 15 (74.38%) and PK566 (72.63%) while lowest harvest index was observed in JS 97-52 (16.08%). Oil content showed variation from 10.1% to 33.4% with a mean of 16.2%. JS94-67 (33.27%) has highest oil content percentage followed by EC 341115 (23.3%) and TGX 824-35-E (23.1%) whereas genotype JS 97-52 (10.1%). Protein content showed a range from 26.81% to 44.58% with a mean of 38.00%. Genotype has high protein content EC 274683 (44.58%) followed by JS20-98 (43.4%) and TGX 822-10 E (43.3%) whereas lowest protein content was found possessed by the genotype JS 97-52 (26.81%).

The values of PCV and GCV were categorized as low (0-10%), moderate (10-20%) and high (>20%) according to Sivasubramanian and Menon (1973). In present study the phenotypic coefficient of variance was greater than genotypic coefficient of variance, which indicates the important role of environment in the expression of the characters. Similar result were obtained by Jain *et al.* (2018); Guleria *et al.* (2019); Jandong *et al.* (2020); Banerjee *et al.* (2022). Highest Genotypic coefficient of variance was estimated for pod bearing length (33.47) followed by plant height (31.4), seed yield/plant (28.71g), number of seeds/plant (28.07), biological yield/plant (24.38g), harvest index (23.15%) and oil content (20.33), while protein content (6.51%), days to maturity (4.45), number of seeds/pod (4.29) and days to 50% flowering (1.95) had low GCV values. The moderate GCV value was recorded for100 seed weight (19.01) and number of primary branches/plant (18.89). The seed yield/plant (40.86g) had the highest phenotypic coefficient of variance, pursued by pod bearing length (35.83) and biological yield/plant (34.11g). The highest PCV and GCV values were observed for (40.86 and 28.71 %) for seed yield/plant followed by pod bearing length (35.83 and 3.47%), biological yield (34.11 and 24.38g). The finding are accordance with the finding of Aditya *et al.* (2011); Banerjee *et al.* (2022); Amogne *et al.* (2020); Jandong *et al.* (2020); Sonkamble *et al.* (2020).

According to Burton and Dewane (1953), the predicted heritability values were divided into three categories: high (>70%), moderate (50-70%), and low (0-50%). High heritability values were observed for 100 seed weight (99.5%), oil content (96.69%), number of primary branches/plant (93.02%), protein content (91.26%), plant height (90.93%), number of seed/plant (89.62%), pod bearing length (87.27%), days to maturity (85.06%), number of seed/pod (85.05%) and harvest index (70.62%), while low heritability showed by seed yield/plant (49.4%), number of pod/plant (47.4%) and days to 50% flowering (11.32%). Moderate heritability showed by biological yield (51.07%). Similar finding observed for plant height by Pawar *et al.* (2020); Chandel *et al.* (2017), for 100 seed weight by Joshi *et al.* (2018) and high heritability for all the traits observed by Ali *et al.* (2016).

According to the classification proposed by Johnson *et al.* (1955), the estimates of genetic advance as per cent of mean (GA) were divided into low (0- 10%), moderate (10-20%) and high (20% and above). Genetic advance as percent of mean was found high for the characters namely pod bearing length (64.5) followed by plant height (61.78), no. of seed/plant (54.83), seed yield/plant (41.63), oil content (41.23), harvest index (40.13), 100 seed weight (39.12), number of primary branches/plant (37.58), biological yield (35.94) and number of pods/plant (28.41), whereas genetic advance as percent of mean showed low for days to maturity (8.47) followed by No. of seed/pod (8.17) and days to 50% flowering (1.35).

Moderate genetic advance as percent of mean was reported for protein content (12.82). Similar findings for pod bearing length were reported by Guleria *et al.* (2019).

The genotypic coefficient of variation measures the amount of variation present in a particular character. However, it does not determine the proportion of heritable variation present in the total variation. Therefore heritability, which represents the heritable variation existing in the character, was calculated. High values of heritability in broad sense are helpful in identifying the appropriate character for selection and in enabling the breeder to select superior genotypes on the basis of phenotypic expression of quantitative traits (Robinson, 1955).

The heritability estimates along with genetic advance are more useful than the former alone in predicting the best individuals. If the heritability estimates, in broad sense, are owing to the non-additive gene effects, the expected gain would be low, but if they are due to additive gene effects, a high genetic advance may be expected. Genetic gain gives an indication of expected genetic progress for a particular trait under suitable selection pressure. In present study high value of heritability coupled with high genetic advance as percent of mean was observed for 100 seed weight (99.5%, 39.12) followed by oil content (96.69%, 41.25), number of primary branches/plant (93.02%, 37.58), plant height (90.93%, 61.78), number of seed/plant (89.62%, 54.83), pod bearing length (87.27%, 64.5) and harvest index (70.62%, 40.13) which indicates the presence of additive gene action and demands for population improvement by selection. Similar finding reported by Shruthi *et al.* (2021), Sonkamble *et al.* (2020); Kumar *et al.* (2020); Amogne *et al.* (2020); Jandong *et al.* (2020); Chandrawat *et al.* (2017); Chandel *et al.* (2017) for plant height and, number of primary branches/plant.

High value of heritability coupled with moderate genetic advance as percent of mean was observed for protein content (91.26, 12.82%) indicates presence of additive gene effect and less influence by environment. Similar result obtained by Khumukcham *et al.* (2022). High heritability with low genetic advance as % of mean was observed for days to maturity (85.06, 8.47%) followed by number of seeds/pod (85.05, 8.17%) indicates heritability is due to non-additive gene affect, selection may not be rewarding. Moderate heritability with high genetic advance as % of mean was observed for number of pods/plant (47.4, 28.41%) followed by biological yield (51.07, 35.92%), seed yield/plant (49.4, 41.63) indicated additive gene affect and less environmental influence.

Low heritability with low genetic advance as % of mean was observed for days to 50% flowering (11.32, 1.35%) which indicated the non additive gene affect and this character is more influence by environment and selection will be not effective.

Table 1 : Analysis of variance for seed yield and yield attributing traits of soybean in augmented block design.

Source	Df	DF	PH	DM	NPB	PBL	NPP	NSPP	NSPP2	100SW	BY	HI	Oil	Protein	SYPP
Blocks	4	58.73 **	6006.82 **	17.08 **	1.59	4691.88 **	1521.79 **	0.01	7784.6 *	27.22 **	971.66 **	389.44 **	16.09 **	6.83 **	305.2 **
Genotypes	199	6.57	369.75 **	22.61 **	0.68	328.69 **	366.95	0.03	2558.16	4.33 **	193.67 *	120.42 **	11.66 **	6.86 **	43.3 *
Checks	4	**12.2**	1930.76 **	44.86 **	0.94	1518.16 **	1094.26 **	0.31 *	11027.06 **	13.59 **	751.84 **	356.08 **	4.08 **	0.78	97.38 **
Genotypes vs. Check	195	6.46	337.73 **	22.15 **	0.68	304.29 **	352.03	0.02	2384.44	4.14 **	182.22 *	115.59 **	11.82 **	6.98 **	42.19 *
Residuals (error)	16	6.65	41.84	3.26	1.84	50.89	186.66	0.1	2165.53	0.02	79.37	34.86	0.36	0.58	18.3
SEd for checks		1.63	4.09	1.14	0.86	4.51	8.64	0.2	29.43	0.1	5.63	3.73	0.38	0.48	2.71
CD at 5 % for check		3.46	8.67	2.42	1.82	9.56	18.32	0.43	62.39	0.21	11.94	7.92	0.8	1.02	5.74

** significance at 1% level of significance, *significance at 5% level of significance

DF: Days to 50% flowering, DM: Days to maturity, PH: Plant height(cm), NPB: Number of primary branches/plant, PBL: Pod bearing length, NPP: No of pods/plant, NSPP: No. of seeds/pod, NSPP2: no of seeds/plant(g), BY: Biological yield(g), 100SW: 100 Seed weight(g), HI: Harvest index, SYPP: Seed yield/plant

Table 2: Genetic parameters of variation among quantitative characters in soybean germplasm accessions.

Sr. No.	Characters	Mean	Range		GCV	PCV	h2bs	GAM
			Min	Max				
1.	Days to flowering	47.21	38.6	53.8	1.95	5.8	11.32	1.35
2.	Days to maturity	96.79	83.92	108.92	4.45	4.83	85.06	8.47
3.	Plant height (cm)	65.23	19.68	142.75	31.4	32.93	90.93	61.78
4.	Pod bearing length (cm)	55.81	22	126	33.47	35.83	87.27	64.5
5.	No. of primary branches	4.24	2.2	6.83	18.89	19.58	93.02	37.58
6.	No. of pods/plants	64.83	21.28	121.48	20	29.06	47.4	28.41
7.	No. of seeds /pod	2	2	4	4.29	4.81	85.05	8.17
8.	No. of seeds /plant	158.34	55.6	350	28.08	29.66	89.62	54.83
9.	100Seed weight (g)	11.36	4.95	17.07	19.01	19.06	97.5	39.12
0.	Biological Yield (g)	37.34	11.67	79	24.38	34.11	51.07	35.94
10.	Seed yield/plant (g)	14.72	2.00	35.62	28.71	40.86	49.4	41.63
11.	Harvest Index %	39.54	16.63	74.55	23.15	27.55	70.62	40.13
12.	Oil %	15.92	9.52	33.27	20.33	20.67	96.69	41.24
13.	Protein%	37.81	26.81	44.58	6.51	6.81	91.26	12.82

CONCLUSIONS

The analysis of variance revealed significant variation in the genetic materials studied, with a wide range of phenotypic variability. Environmental factors seemed to have a stronger influence, as indicated by higher values of the phenotypic coefficient of variation (PCV) compared to the genotypic coefficient of variation (GCV) for all traits.

Several traits, including number of primary branches/plant, plant height, number of seeds/plant, pod bearing length, 100 seed weight, oil content and harvest index, exhibited both high heritability estimates and a substantial genetic advance expressed as a percentage of the mean. This suggests that these traits are predominantly influenced by additive gene action and have a great potential for improvement through selective breeding.

Based on their average performance for seed yield per plant, the genotype JS 75-46 (35.62g), CG soya 11-15 (34.79g) and JS 335 (33.61g) were found to be highly productive. Therefore, these genotypes may be utilized in the future to create new cultivars that contain favorable yield-contributing traits.

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Conflict of Interest. None.

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