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Variability, heritability and genetic advance of some soybean (*Glycine max* L. Merrill) parents and their f_1 in different environments

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Abstract
Forty five genotypes along with ten parents and three checks of Soybean were evaluated for 11 characters in four environments. The analysis of variance revealed significant differences among the genotypes for all the characters. Estimates of phenotypic coefficient of variation (PCV) were higher than their corresponding genotypic coefficient of variation (GCV) for all the characters. High phenotypic coefficient of variation (PCV) was found for clusters per plant followed by pods per cluster, plant height, seed yield per plant, pods per plant and biological yield per plant. A combination of high heritability and high genetic advance as percent of mean was noted for plant height, clusters per plant, pods per cluster, pods per plant, biological yield per plant and seed yield per plant which indicated that additive gene action might be operated predominantly in the inheritance of these characters. Thus the results suggested that significant improvement can be made by individual plant selection in early generations.

Keywords: *Glycine max* L., heritability, soybean, environments, GCV, PCV

Introduction
Variability is a measure by estimation of phenotypic and genotypic variance. Genotypic and phenotype coefficient of variation, heritability, genetic advance and genetic gain for different quantitative and qualitative traits deserve attention in selection for improvement in the concerned characters. The phenotypic variability which is observable includes both genotypic and environmental variation. It changes under different environmental conditions. Environmental variation is the non-heritable variation, which is slowly due to environmental effects and varies under different environmental conditions. Plant populations with higher variability provide greater opportunity for improvement. Hence, it is essential to study and utilize the existing variability in the population. Johnson *et al.* (1955) [9] gave the basic idea of variability, while developing the concept of pure lines. Greater the variability more the chance of obtaining the desirable types and provided it to be basic foundation for improvement of crop plants through selection. Heritability is in a measure of the efficiency of a selection system in separating genotypes Burton and De Vane (1953) [4]. Heritability (broad sense) is the ratio of total genotypic variance to the total phenotypic variance and provides a major of the overall importance of heredity determinative of a trait.

Materials and Methods
The experimental materials for the present study consist of 10 diverse parental lines, which were selected on the basis high yield, oil content, resistant to disease and pests from different parts of India. These lines were, crossed as per diallel mating design (Model-1 Method-II), where crossing programme includes one way crosses and parents. Crossing programme was taken during Kharif 2009 at BAU, Ranchi and SHIATS Allahabad, which results in 45 F_1s. These 45 F_1s along with parent's and checks, *viz.* Birsa Safed Soybean-2, JS-335 and JS80-21 were evaluated during Kharif 2010 in a randomized block design with three replications under four environments with full agronomic package and practices of this crop.

The four environments were E_1-Early sowing (20-6-2010) & E_2- Late sowing (20-7-2010) at Ranchi (BAU) whereas, E_3-Timely sown (5-7-2010) & E_4- Late sown (27-7-2010) at Allahabad (SHIATS). Data were recorded for days to 50% flowering, days to maturity, number of pods per plant, 100 grain weight, grain yield per plant, harvest index, protein content (%) and Oil content (%). High level of hybrid vigor was observed for number of pods per plant and grain yield per plant and 100 seeds weight protein content and oil content.

Results and Discussion

Estimates of phenotypic coefficient of variation were found higher than their corresponding genotypic coefficient of variation, indicating that the little influence of environment on the expression of these characters however, good correspondence was observed between genotypic coefficient of variation and phenotype coefficient of variation in all the characters (Table-1). The estimates of phenotype coefficient of variation (PCV) for all the traits ranged from 2.10 (days to maturity) to 23.16 (grain yield per plant). Higher magnitude of PCV was recorded for grain yield per plant (20.41, 20.61, 23.16 and 21.00) followed by number of pods per plant (22.49, 18.71, 18.20 and 16.59), number of branches per plant (20.34, 19.96, 18.40 and 18.50), plant height (19.05, 18.76, 21.74 and 18.16), number of seeds per pods (13.37, 13.21, 12.76 and 11.89), while moderate estimates of PCV was depicted by 100 seeds weight(11.29, 9.68, 11.31 and 11.00), and harvest index (8.34, 8.76, 8.83 and 9.89).oil content (5.31, 5.14, 5.04 and 4.98), days to 50% flowering (4.18, 3.68, 3.75 and 3.84) and protein content (4.39, 4.48, 4.54 and 4.57), whereas, days to maturity (2.70, 2.10, 2.17 and 2.46) depicted least phenotype coefficient of variation in environments E_1, E_2, E_3 and E_4 respectively.

A perusal of genetic coefficient of variation (GCV) revealed that it ranged from 2.02 (days to maturity in environment E_2) to 21.72 (grain yield per plant in environment E_3). Higher magnitudes of GCV were recorded for grain yield per plant (19.24, 19.0, 21.72 and 19.39) followed by plant height (15.85, 15.60, 17.85 and 14.05), number of pods per plant (14.57, 12.66, 11.56 and 10.97) and number of branches per plant (13.41, 13.83, 11.00 and 11.72).while character like number of seeds per pods (8.50, 6.36, 5.52 and 3.57), 100 seeds weight (8.84, 8.21, 9.71 and 9.63), harvest index (5.67, 6.56, 6.82 and 7.94), oil content (5.31, 5.14, 5.08 and 4.98), protein content (4.35, 4.44, 4.50 and 4.54) and days to 50% flowering (3.98, 3.38, 3.60 and 3.59) exhibited moderate estimates of genetic coefficient of variation, whereas days to maturity (2.67, 2.02, 2.13 and 2.42) exhibited least genotypic coefficient of variation in environments E_1, E_2, E_3 and E_4 respectively.

On an average, the higher magnitude of GCV and PCV were recorded for grain yield per plant, number of pods per plant, plant height and number of branches per plant. This means that the presence of sufficient variability and thus reveals the scope for genetic improvement through selection for these traits. These findings are agreement with those of Konwar and Talukdar (1984) [11], Bhandarkar (1999) [3], Rajanna *et al*. (2000) [16], Agarwal *et al*. (2001) [1], Bangar *et al*. (2003) [2], Karnwal and Singh (2009) [10] and Pandey et.al. (2010) [15] who have also observed the PCV value were higher than GCV value for different quantitative character in soybean.

Wide range of phenotypic (VP or σ^2_P) and genotypic variance (VG or σ^2_g) were observed for all the traits studied. The highest phenotypic variance were recorded for plant height (131.45, 102.98, 89.20 and 60.91) and variance (90.93, 71.18, 60.15 and 36.45) in environment E_1, E_2, E_3 and E_4, followed by number of pods per plant (80.21, 652.53, 547.67 and 38.29), in phenotypic variance and (33.68, 24.05, 19.21 and 16.74) in genotypic variance, followed by harvest index(16.44, 17.35, 17.09 and 20.66) in phenotypic variance and (7.59, 9.72, 10.21 and 13.35) in genotypic variance. The lowest phenotypic and genotypic variance was found in number of seeds per pods(0.09, 0.09, 0.08 and 0.07) and (0.04, 0.02, 0.01 and 0.01) in environment E_1,E_2,E_3 and E_4 followed by number of branches per plant (0.54, 0.50, 0.42 and 0.40) and (0.23, 0.24, 0.15 and 0.16), whereas, in grain yield phenotypic and genotypic variance was(5.02, 4.36, 5.61 and 4.27) and (4.46, 3.71, 4.94 and 3.64) respectively. Less difference in the estimates of genotypic and phenotypic variance and higher genotypic value compared to environmental variances for all the characters suggested that the variability present among the genotype were mainly due to genetic reason with minimum influence of environment and hence heritable. The genotypic of variability (VG, GCV) being the most important, help in the measurement of the contribution of the genotype to the expression of a particular character and gives clue to compare the genetic variability for different characters. These finding of genotypic and phenotypic variance for different quantitative characters in soybean are in accordance with the findings of Mahmood (1979) [12], Weilenmann and Luquez (1999) [19], Sahay *et al*. (2005) [18].

Heritability is a measure of the extent of phenotypic variation caused by the action of genes. According to Burton and De Vane (1953) [4] heritability is a measure of the efficiency of a selection system in separating genotypes. Heritability in broad sense is the ratio of total genotypic variance to phenotypic variance, expressed in percentage. The estimate of heritability are more advantageous when expressed in term of genetic advance, Johnson *et al*. (1955) [9] suggested that without genetic advance the estimates of heritability will not be practical value and emphasized the concurrent use of genetic advance along with heritability. Hanson (1963) [7] stated that heritability and genetic advance are two complementary concepts. Out of 11 quantitative and qualitative characters presented in table -1, high estimates of heritability (above 75%) in broad sense were recorded for 6 characters and rest have medium and low heritability. The highest heritability was recorded for proteins content (98, 98, 98 and 98%) followed by oil content (98, 97, 96 and 96%), days to maturity (98, 92, 96 and 97%), days to 50% flowering (91, 84, 93 and 88%), grain yield per plant (89, 85, 88 and 85%) and 100 seeds weight(61, 70, 74 and 77%) whereas plant height (69, 69, 67 and 60%), number of branches per plant (43, 48, 36 and 40%), number of pods per plant (42, 46, 40 and 44%) and harvest index (46, 56, 60 and 64%) have medium heritability. The character number of pods per plant (40, 23, 19 and 9%) have low heritability in environments (E_1, E_2, E_3 and E_4) respectively. High values indicate that heritability may be due to higher contribution of genotypic component. High heritability estimates were also reported by Ghatge and Kadu (1993) [6], Nehru *et al.* (1999) [13] for number of branches/plant, days to 50% flowering, days to maturity, 100-seeds weight, yield/plant,

plant height and number of pods/plant. Jagtap and Mehetre (1994) [8], Bhandarkar (1999) [3], Dhillon *et al*. (2005) [5] and Karnwal and Singh (2009) [10] studied has also observed high value of heritability for grain yield and its components in soybean. Heritability alone provides no indication of amount of genetic improvement that would result from selection of individual genotypes; hence knowledge about genetic advance coupled with heritability is most useful genetic advance is the improvement in the mean of selected family over the base population

Table 1: Estimation of component of variance and genetic parameters for different characters in soybean

Sl. No.	Characters	Environment	VG	VP	ECV	GCV	PCV	h^2 (b s)	GA 5%	GA as% of mean 5%
1.	Days to 50% Flowering	E1	3.38	3.73	1.27	3.98	4.18	91	3.61	7.81
		E2	2.31	2.73	1.46	3.38	3.68	84	2.87	6.39
		E3	3.05	3.29	1.02	3.60	3.75	93	3.46	7.14
		E4	2.71	3.10	1.35	3.59	3.84	88	3.118	6.93
2.	Days to maturity	E1	8.54	8.76	0.42	2.67	2.70	98	5.95	5.54
		E2	4.83	5.26	0.60	2.02	2.10	92	4.34	3.98
		E3	5.37	5.57	0.42	2.13	2.17	96	4.68	4.31
		E4	6.79	7.04	0.46	2.42	2.46	97	5.28	4.90
3.	Plant height (cm)	E1	90.93	131.45	10.58	15.85	19.05	69	16.34	27.15
		E2	71.18	102.98	10.43	15.60	18.76	69	14.45	26.71
		E3	60.15	89.20	12.41	17.85	21.74	67	13.12	30.20
		E4	36.45	60.91	11.51	14.05	18.16	60	9.60	22.38
4.	Number of pods per plant	E1	33.68	80.21	17.31	14.57	22.49	42	7.75	19.46
		E2	24.05	52.53	13.78	12.66	18.71	46	6.83	17.64
		E3	19.21	47.67	14.06	11.56	18.20	40	5.73	15.11
		E4	16.74	38.29	12.45	10.97	16.59	44	5.57	14.94
5.	Number of branches per plant	E1	0.23	0.54	15.30	13.41	20.34	43	0.66	18.20
		E2	0.24	0.50	14.38	13.83	19.96	48	0.70	19.75
		E3	0.15	0.42	14.75	11.00	18.40	36	0.48	13.54
		E4	0.16	0.40	14.31	11.72	18.50	40	0.53	15.31
6.	100 seeds wt.(g)	E1	1.18	1.92	7.02	8.84	11.29	61	1.75	14.26
		E2	1.03	1.46	5.27	8.21	9.68	70	1.75	17.98
		E3	1.29	1.75	5.79	9.71	11.31	74	2.01	17.19
		E4	1.20	1.56	5.31	9.63	11.00	77	1.97	17.38
7.	Grain yield/ plant(g)	E1	4.46	5.02	6.82	19.24	20.41	89	4.10	37.36
		E2	3.71	4.36	7.99	19.0	20.61	85	3.66	36.08
		E3	4.94	5.61	8.02	21.72	23.16	88	4.30	41.98
		E4	3.64	4.27	8.06	19.39	21.00	85	3.63	36.89
8.	Harvest index	E1	7.59	16.44	6.12	5.67	8.34	46	3.86	7.93
		E2	9.72	17.35	5.81	6.56	8.76	56	4.81	10.11
		E3	10.21	17.09	5.60	6.82	8.83	60	5.09	10.87
		E4	13.35	20.56	5.90	7.94	9.89	64	6.02	13.13
9.	Number of seeds per pods	E1	0.04	0.09	10.32	8.50	13.37	40	0.26	11.13
		E2	0.02	0.09	11.59	6.36	13.21	23	0.14	6.30
		E3	0.01	0.08	11.50	5.52	12.76	19	0.11	4.92
		E4	0.01	0.07	11.34	3.57	11.89	9	0.05	2.21
10.	Protein content (%)	E1	2.71	2.76	0.58	4.35	4.39	98	3.36	8.89
		E2	2.84	2.89	0.58	4.44	4.48	98	3.44	9.08
		E3	2.96	3.01	0.58	4.50	4.54	98	3.51	9.20
		E4	3.04	3.09	0.57	4.54	4.57	98	3.57	9.28
11.	Oil content (%)	E1	1.09	1.12	0.83	5.25	5.31	98	2.13	10.67
		E2	1.01	1.04	0.96	5.05	5.14	97	2.03	10.23
		E3	1.00	1.05	1.04	4.97	5.08	96	2.02	10.02
		E4	0.98	0.02	0.95	4.89	4.98	96	2.00	9.89

VG= Genotypic Variance, VP=Phenotypic Variance, GCV=Genotypic Coefficient of Variation, PCV=Phenotypic Coefficient of Variation, ECV=Environmental Coefficient of Variation, h^2 (b s) = Heritability (broad sense), GA= Genetic Advance

Characters exhibiting high Heritability may not be necessarily gives high genetic advance. Johnson *et al.* (1955) [9] showed that high heritability should be accompanied by high genetic advance to arrive at more reliable conclusion. The breeder should cautious in making selection based on heritability as it includes both additive and non-additive gene effect. A perusal of genetic advance (table -1) revealed that it was high for plant height (16.34, 14.45, 13.12 and 9.60), followed by number of pods per plant (7.75, 6.83, 5.73 and 5.57), harvest index (3.86, 4.81, 5.09 and 6.02), grain yield per plant (4.10, 3.66, 4.30 and 3.63), protein content (3.36, 3.44, 3.51 and 3.57), days to maturity(2.70, 2.10, 2.17, and 2.46), days to 50% flowering (3.61, 2.87, 3.46 and 3.11), oil content (2.17, 2.03, 2.02 and 2.00), and 100 seeds weight (1.75, 1.75, 2.02 and 1.97). Low genetic advance was observed for number of seeds per pods (0.26, 0.14, 0.11 and 0.05) followed by number of branches per plant (0.66, 0.70, 0.48 and 0.53) in environments (E_1, E_2, E_3 and E_4) respectively. The heritability estimates coupled with expected genetic advance indicates the mode of gene action in the expression of traits which helps in choosing an appropriate breeding

methodology. High heritability along with high genetic advance were registered for plant height (69 and 16.34, 69 and 14.45, 67 and 13.12, 60 and 9.60), grain yield per plant (89 and 4.10, 85 and 3.66, 88 and 4.30, 85 and 3.63), and days to maturity (98 and 5.95, 92 and 4.34, 96 and 4.68, 97 and 5.28) in environments (E_1, E_2, E_3andE_4) respectively, suggesting predominance of additive gene action in the expression of these traits. High heritability along with low genetic advance was registered for days to 50% flowering (91 and3.61, 84 and 2.87, 93 and 3.46, 88 and 3.11), followed by oil content(98 and 2.13, 97 and 2.03, 96 and 2.02, 96 and 2.00), in environments (E_1, E_2, E_3 and E_4) respectively, suggesting predominance of additive and non-additive gene action in the expression of these traits therefore, these character can be improved by mass selection and other breeding method based on progeny testing. Similar results in soybean have been also reported by Oliveira *et al*. (2001) [14].

High heritability coupled with high genetic advance was observed for seed yield per plant indicating the presence of additive gene action in the expression of this character. Non-additive heritability was observed in the expression of days to 50% flowering and protein content, these traits had high heritability estimates coupled with low genetic advance. Similar results were reported by Dhillon *et al*. (2005) [5] for seed yield per plant, plant height, days to 50% flowering and protein content.

Conclusion

The study reveals notable variations in both phenotypic and genotypic coefficients of variation across several agronomic traits in soybean. Phenotypic coefficient of variation (PCV) consistently exceeded genotypic coefficient of variation (GCV), suggesting a significant influence of environmental factors on trait expression. Nevertheless, there was generally good agreement between PCV and GCV for all traits assessed. Traits such as grain yield per plant, number of pods per plant, plant height, and number of branches per plant exhibited substantial variability, primarily due to genetic factors, indicating potential for effective genetic improvement through selective breeding methods. These findings underscore the importance of considering both heritability and genetic advance in optimizing breeding strategies for soybean improvement.

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