

ORIGINAL ARTICLE

Correlation and path coefficient studies on yield and yield attributing characteristics of rainfed Soybean (*Glycine max* L Mirrll) under Organic management

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ABSTRACT

Genotypic correlation and path coefficient studies were used to determine the effect of various traits as components of grain yield in 18 soybean genotypes grown in rainfed conditions under organic management. The trial was conducted at Organic Research Farm, Karguaji, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during kharif season 2021-22 in Randomized Block Design with three replications. Highly significant positive genotypic correlations were detected for grain yield with days to 50% flowering, 100 seed weight(g), harvest index, days to maturity, plant height, number of pods / plant, number of primary branches /plant, pod length (cm) and biological yield. Path analysis revealed that biological yield, plant height, number of pods/clusters and days to maturity had the highest positive direct effect on grain yield, while number of pods/plant via plant height gave the highest positive indirect effect on grain yield. These results indicate that biological yield, plant height, number of seed per pod, number of seed per plant and days to maturity can be used as selection criteria for the improvement of soybean grain yield.

Keywords: Soybean, Genotypes, Correlation, Rainfed, Organic.

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INTRODUCTION

Soybean (*Glycine max* L. Mirrill) is a member of Papilionaceae family and believed to have originated in North Eastern China and distributed in Asia, USA, Brazil and Argentina. The genus *Glycine* (Willd) is divided into two sub genera, *Glycine* and *Soja* (Moench) F.J. Herm. Soybean is a major oil seed crop in the world and called as "Golden Bean" or Miracle Crop" of the 20th century, because of its multiple uses.

In India, the cultivated area of soybean is 12.92 million hectares and production 12.61 million tonnes with average yield of 976 kg/ hectare (DES, 2021-22). Soybean is a prominent growing crop in central India. It can be grown successfully during *kharif* season in bundelkhand region. The important soybean growing districts in Bundelkhand regions are Jhansi, Jalaun, Lalitpur, Chitrakoot, Banda, Hamirpur, Kanpur and Mahoba [4].

Soybean yield components may influence productivity directly and indirectly; therefore, changes in a given trait have a direct function on yield or on another trait associated with it. Soybean yield is a poly genially controlled complex character and is determined by number of character components, which are also quantitatively inherited. The knowledge of the association between yield and its components and among components themselves is of immense practical value in crop improvement through selection. The heritability estimates and genetic advance proved to be the important parameters for isolating the desirable genotypes. Heritability provides information on contribution of genotypic variance to the corresponding phenotypic variance while, genetic advance reflects genetic architecture of any population. High genetic advance associated with high heritability gives an idea of true heritable traits for better selection during breeding programme [17, 18]. The measurement of phenotypic, genotypic and environmental correlations between yield and its components has basic and foremost endeavours to find

out guidelines for plant selection. The magnitude and direction of correlation offers an idea for future improvement in concerned traits. In situations where more variables are included in correlation studies, the indirect association becomes complex and the path analysis is proved to be useful tool in finding out the direct and indirect causes of association [1, 4, 5]. Path coefficient analysis brings out the direct and indirect effects of components traits on yield. Therefore, present study.

MATERIAL AND METHODS

The experimental materials consisted of 18 soybean genotypes obtained from ICAR - IISR, Indore (M.P.), raised under rainfed conditions in Randomized Block Design with three replications at the Organic Research Farm, Karguaji, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during *Kharif* season 2021-22. A basal dose of FYM 20 t/ha was applied during field preparation. The crop was sown on 27th July, 2021 and harvested in the month of October, 2021 on maturity. The total rainfall was received during cropping season 90, 174, 226 and 38 mm in the month of July, August, September and October, 2021 respectively. The genotypes were raised on following geometry of 45 X 10 cm and other recommended cultural practices as per organic management requirement. Observations were recorded on five randomly selected plants from each plot and replications. The data collected on thirteen quantitative traits viz., days to 50% flowering, days to maturity, plant height (cm), number of primary branches, pod length (cm), number of pods per cluster, number of pods per plant, number of seeds per plant, number of seeds per pod, seed yield per plant (g), 100 seed weight (g), biological yield per plant (g) and harvest index (%) were subjected to statistical analysis as per Panse and Sukhatme, [14] and the genetic association among the traits was estimated according to the formulae described by Johnson *et al*, [10] and Write, [19]. The genotypic, phenotypic, environmental variances and broad sense heritability were calculated based on the method described by Burton and Vane [7]. The path coefficient analysis was done according to Al-Jibouri *et al*, [3] and Dewey & Lu, [8] for assessing the direct and indirect effects of each trait on grain yield.

RESULT AND DISCUSSION

The analysis of variance related to thirteen agronomic traits (Table-1) in soybean showed significant differences in almost all traits. The highly significant differences for all the characters viz. days to 50% flowering, days to maturity, plant height (cm), number of primary branches, pod length (cm.), number of pods/cluster, number of pods per plant, number of seed per plant, number of seed per pod, seed yield per plant (g) biological yield per plant (g), 100 seed weight (g) and harvest index (%) were observed while non-significant differences due to replications were recorded.

Heritability

The values of environmental variance, genotypic variance, and phenotypic variance of thirteen agronomic traits of soybean are placed in Table 2. Based on the results of heritability calculations, it is seen that the heritability values ranged from 13.2 percent for number of seed per pod to 98.5 for number of seed per plant. High heritability estimates were found for number of seed per plant (98.5) followed by number of pods per plant (97.9), harvest index (95.4%), plant height (95.3), biological yield per plant (92.7), number of pods per cluster (91.7), seed yield per plant (g) (87.7), days to 50% flowering (78.5), days to maturity (77.1), 100 seed weight (g) (65.6), pod length (cm) (55.2) and number of primary branches per plant (48.4). Moderate heritability was found for days to 50% flowering (78.5) and days to maturity (77.1).

The expected genetic advance in percent of mean ranged from 2.10 percent for number of seeds per pod to 52.10 percent for number of seed per plant (Table 2). High estimates of expected genetic advance were found for number of seed per plant, number of pods per cluster, seed yield per plant, number of pods per plant, biological yield per plant, harvest index, plant height (cm), 100 seed weight, number of primary branches per plant, days to 50% flowering, pod length (cm) and days to maturity. The highest heritability value was recorded for days to 50% flowering followed by days to maturity and days to pod setting. Wide range of mean values was observed in all the characters evaluated. This indicates that the characters can be improved through selection.

Correlation analysis

Correlation coefficients as worked out at genotypic and phenotypic levels for all the thirteen traits of soybean are presented in Table 3 and 4. In general, genotypic correlations were higher than phenotypic ones in magnitude for all the characters. The character which showed negative association at genotypic level also showed negative association at phenotypic level. The seed yield per plant showed highly significant and positive correlation with number of pods per plant at genotypic level (0.985) and phenotypic level (0.941), biological yield per plant at genotypic level (0.899) and phenotypic level (0.875) and seed yield per plant at genotypic level (0.850) and phenotypic level (0.789) while with seed yield per

plant at genotypic level (0.765) showed significant and positive correlation. The results are similar to the findings of Akram, *et al*, [2]. The correlation coefficient of seed yield per plant showed negative and highly significant correlation with harvest index (-0.538) and (-0.467), pod length (-0.520) and (-0.394) at both genotypic and phenotypic level, respectively; while harvest index (%) showed highly significant and negative correlation at genotypic level (-0.538) and significant and negative correlation at phenotypic level. Hang, *et al* (1019) also reported that the correlations and path coefficients of measured traits, viz growth duration (days), plant height (cm), first pod insertion height (cm), ratio of first pod insertion height to plant height, total number of pods per plant, total number of seeds per plant, 100 seed weight (g). There were consistencies of correlations across generations and higher direct and indirect effects in F6 than in F7. Most direct effects were in agreement with correlations, indicating true associations.

The correlation coefficient of harvest index showed positive and highly significant correlation with number of pods per cluster (0.756) and (0.727), 100 seed weight (0.667) and (0.513) while highly significant and negative correlation with 100 seed weight (-0.472) and (-0.326), pod length (-0.520) and (-0.394), number of seeds per pod (-0.319) and (-0.171) at both genotypic and phenotypic level, respectively. Harvest index showed Negative and significant correlation with 100 seed weight (-0.472) and (-0.335) at both genotypic and phenotypic level, respectively. Almost similar results were reported in Soybean by Mesfin, [12]. Biological yield per plant showed significant and positive correlation with number of pods per plant (0.899) and (0.899) at genotypic level only. The 100-seed weight exhibited highly significant and positive correlation at genotypic level (0.667) and significant and positive correlation at phenotypic level (0.513) with pod length.

Days to maturity exhibited highly significant and positive correlation with number of primary branches per plant (0.498) and (0.299) at both genotypic and phenotypic levels. Plant height showed highly significant and positive correlation with number of pod per cluster (0.756) and (0.727) at both genotypic and phenotypic levels. Number of primary branches per plant shows highly significant and positive correlation with number of seeds per pod (0.739) and (0.369), pod length (cm) showed highly significant and positive correlation with 100 seed weight (0.667) and (0.513) at both genotypic and phenotypic levels, respectively and highly significant and positive correlation at genotypic (0.985) and significant and positive correlation at phenotypic (0.941) levels with number of pods per plant while with harvest index (-0.538) and (-0.227), pod length (-0.520) and (-0.394) showed highly significant and negative correlation and with number of seeds per pod showed significant and negative (-0.319), (-0.122) at both genotypic and phenotypic levels, respectively. The results are in agreement with those obtained by Neelima *et al*, [13]; Koraddi and Basavaraja [11].

Path analysis

The genotypic and phenotypic correlation coefficient of seed yield with the remaining characters under study were further partitioned into direct and indirect effects using path coefficient analysis and are presented in Table 5 and 6. At genotypic level, the highest positive direct effect on seed yield per plant was exhibited by harvest index (1.003) followed by biological yield per plant (0.883), days to maturity (0.677), pod length (0.534), number of pod per cluster (0.211) and plant height (0.143). Negative direct effect was recorded in 100 seed weight (-0.543), primary branches per plant (-0.552) and days to 50% flowering (-0.129). Number of seed per pod (-0.057) and number of pods per plant (-0.048) contributed substantial negative direct effect on seed yield. The results are similar to the findings of Sharma and Maloo, [15]; Hang *et al*, [9].

At phenotypic level, the highest positive direct effect on seed yield per plant was exhibited by harvest index (0.477) followed by biological yield per plant (0.471), number of seed per plant (0.254) and number of pods per cluster (0.226).. The very low and positive direct effect was recorded in case of plant height (0.113), 100 seed weight (0.100) and number of pods per plant (0.010). Negative direct effect was recorded in days to 50% flowering (-0.222), pod length (-0.065), number of primary branches per plant (-0.047) and days to maturity (-0.002). These results are in conformity with the findings reported by Showkat and Tyagi [16].

Number of pods per cluster (0.749), number of pods per plant (0.737), number of seeds per pod (0.648), plant height (0.620), number of seeds per plant (0.568) and number of primary branches per plant (0.484) via harvest index; 100 seed weight (0.357), Days to maturity (0.283), Days to 50% flowering (0.278), 100 seed weight (0.263) and biological yield per plant (0.217), via number of cluster per plant; number of seeds per plant (0.167) and harvest index (0.084) via number of pods per plant have substantial positive indirect effects on seed yield per plant at genotypic level. These results are in full agreement with those reported by Tyagi and Sethi, (2011); Tambe *et al*, (2012). Number of pods per cluster (0.412), number of pods per plant (0.375), plant length (0.317), number of seed per plant (0.287), number of primary branches per plant (0.205) and biological yield per plant (0.198) via harvest index;

days to 50% flowering (0.154), number of seed per pod (0.132) and days to maturity (0.125) via biological yield per plant, 100 seed weight (0.074) and pod length (0.067) via number of pods per plant; harvest index (0.030), number of cluster per plant (0.182) and primary branches per plant (0.094) via days to 50% flowering exerted substantial positive indirect effects on seed yield per plant at phenotypic level.

The remaining estimates of the indirect effects in the present analysis were too low for consideration. The estimate of residual factors (0.484) at genotypic and (0.412) at phenotypic level was moderate indicating that some of characters affecting seed yield has to be included in the future study.

S.No.	Character	Mean sum of square		
		Replication (d.f.=2)	Treatment (d.f.=17)	Error (d.f.=34)
1	Days to 50% flowering	6.50	20.50	1.71
2	Days to maturity	9.50	30.62	2.75
3	Plant height (cm)	5.40	150.66	2.42
4	No. of primary branches	0.10	0.61	0.16
5	Pod length (cm)	0.10	0.45	0.33
6	No. of pods/clusters	3.53	93.48	2.74
7	No. of pods per plant	14.47	404.65	2.82
8	No. of seed per plant	10.75	3919.66	20.18
9	No. of Seed per pod	0.87	1.53	0.36
10	Seed yield/plant (g)	0.26	28.11	1.25
11	Biological yield/plant (g)	0.45	211.04	5.39
12	100 Seed Weight (g)	0.78	0.93	0.13
13	Harvest index (%)	4.30	118.00	1.87

Table-1: Analysis of variance for thirteen characters of soybean genotypes.

Table-2: Heritability (%) in broad sense, Genetic advance, Genetic advance in % mean for 13 quantitative characters soybean.

S.No.	Characters	mean	Heritability (h^2)	Genetic advance	Genetic advance in % of mean
1	Days to 50% flowering	43.66	78.5	4.57	10.46
2	Days to maturity	83.88	77.1	5.51	6.56
3	Plant height (cm)	46.41	95.3	14.14	30.46
4	No. of primary branches	3.86	48.4	0.56	14.50
5	Pod length (cm)	3.75	55.2	0.31	8.26
6	No. of pods/clusters	22.49	91.7	10.85	48.24
7	No. of pods per plant	54.18	97.9	23.59	43.54
8	No. of seed per plant	141.45	98.5	73.70	52.10
9	No. of Seed per pod	2.85	13.2	0.06	2.10
10	Seed yield/plant (g)	13.04	87.7	5.77	44.24
11	Biological yield/plant (g)	39.21	92.7	16.42	41.87
12	100 Seed Weight (g)	1.74	65.6	0.27	15.51
13	Harvest index (%)	32.98	95.4	12.52	37.96

Table -3: Estimates of genotypic correlation coefficient for 13 characters in soybean

S.N	character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branch	Pod length (cm)	No. of pods/ clusters	No. of pods / plant	Biological yield per plant (g)	Seed / plant (Nos)	Seeds per pod (Nos)	100 Seed weight (g)	Harvest index (%)	Seed yield/ plant (g)
1	Days to 50% flowering	1.000	0.371	0.344	0.388	-0.520	0.366	0.266	0.325	0.691	-0.319	-0.472	-0.125	0.115
2	Days to maturity		1.000	0.077	0.498	-0.056	0.080	-0.012	0.320	0.141	-0.171	0.389	-0.538	-0.118
3	Plant height (cm)			1.000	0.318	0.104	0.756	0.620	0.702	0.708	0.200	-0.198	-0.222	0.587
4	No. of primary branches				1.000	0.251	0.497	0.484	0.548	0.352	0.739	0.179	0.006	0.314

5	Pod length (cm)					1.000	0.180	0.227	0.169	-	0.087	0.667	-	0.144
6	No. of pods/clusters						1.000	0.985	0.899	0.765	0.271	-	-	0.813
7	No. of pods per plant							1.000	0.834	0.685	0.437	-	-	0.850
8	Biological yield/plant(g)								1.000	0.643	0.019	0.074	-	0.796
9	No. of seed per plant (g)									1.000	0.263	-	-	0.680
10	No. of Seed per pod										1.000	-	-	0.389
11	100 Seed Weight (g)											1.000	-	-
12	Harvest index (%)												1.000	0.410
13	Seed yield/plant (g)													1.000

Table-4: Estimates of phenotypic correlation coefficient for 13 characters in soybean.

S.N	character	Day to 50% flowering	Day to maturity	Plant height (cm)	No. of primary branches	Pod length (cm)	No. of pods/clusters	No. of pods / plant	Biological yield per plant (g)	Seeds / plant (Nos)	No. of Seed per pod	100 Seed Weight (g)	Harvest index (%)	Seed yield/plant (g)
1	Days to 50% flowering	1.000	0.389	0.292	0.231	-	0.305	0.223	0.271	0.605	-	-	-	0.081
2	Days to maturity		1.000	0.064	0.299	-	0.089	-	0.265	0.112	-	0.305	-	-
3	Plant height (cm)			1.000	0.292	0.061	0.727	0.608	0.673	0.685	0.039	-	-	0.566
4	No. of primary branches				1.000	0.238	0.415	0.369	0.436	0.240	0.368	0.111	0.018	0.302
5	Pod length (cm)					1.000	0.163	0.136	0.143	-	0.296	0.513	-	0.137
6	No. of pods/clusters						1.000	0.941	0.875	0.717	0.111	-	-	0.767
7	No. of pods per plant							1.000	0.797	0.672	0.141	-	-	0.789
8	Biological yield/plant(g)								1.000	0.609	0.053	0.079	-	0.731
9	No. of seed per plant									1.000	0.127	-	-	0.642
10	No. of Seed per pod										1.000	-	-	0.196
11	100 Seed Weight (g)											1.000	-	0.023
12	Harvest index (%)												1.000	0.375
13	Seed yield/plant (g)													1.000

Table-5: Direct and Indirect effects for 13 characters on seed yield per plant at genotypic level in soybean

S.N	character	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branch/plant (nos.)	Pod length (cm)	No. of pods/clusters	No. of pods / plant	Biological yield per plant (g)	Seed yield / plant (g)	No. of Seed per pod	100 Seed Weight (g)	Harvest index (%)
1	Days to 50% flowering	-	0.251	0.049	-	-	0.077	-	0.278	-	0.018	0.256	-
2	Days to maturity	0.129	-	0.011	0.214	0.278	0.013	0.278	0.065	0.018	0.256	-	0.126
3	Plant height (cm)	0.048	0.677	-	0.275	0.030	0.017	0.283	0.013	0.010	0.211	-	0.539
4	No. of primary branches	0.044	0.052	0.143	-	0.056	0.160	0.620	0.067	0.011	0.107	-	0.222
5	Pod length (cm)	-	0.050	0.337	0.046	-	0.105	0.484	0.033	0.042	0.097	-	0.006
6	No. of pods/clusters	0.067	-	0.038	0.015	-	0.138	0.534	0.038	-	0.362	-	0.111
7	No. of pods per plant	0.038	0.015	-	0.138	0.534	0.038	0.011	0.149	0.005	0.005	-	-
8	Biological yield/plant(g)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
9	Seeds / plant (Nos)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
10	No. of Seed per pod	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
11	100 Seed Weight (g)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
12	Harvest index (%)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
13	Seed yield/plant (g)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

6	No. of pods/clusters	-0.047	0.054	0.108	-0.274	0.096	0.211	-0.048	0.749	-0.072	-0.016	0.076	-0.070
7	No. of pods per plant	-0.0034	-0.008	0.089	-0.267	0.121	0.208	0.048	0.737	-0.065	-0.025	0.062	0.079
8	Biological yield/plant(g)	-0.042	0.217	0.100	-0.302	0.090	0.190	-0.040	0.883	-0.061	0.001	0.040	-0.199
9	No. of seed per plant	-0.089	0.095	0.101	-0.194	0.030	0.162	-0.033	0.568	-0.094	-0.015	0.167	0.042
10	No. of Seed per pod	0.041	-0.116	0.029	-0.408	0.046	0.057	-0.021	0.017	-0.025	0.057	0.177	0.648
11	100 Seed Weight (g)	0.061	0.263	-0.028	-0.099	0.357	-0.029	0.006	0.065	0.029	0.019	-0.543	-0.156
12	Harvest index (%)	0.016	-0.364	-0.032	-0.003	-0.059	-0.015	-0.004	-0.175	-0.004	0.037	0.085	1.003

Residual Value = -0.0815

Table-6: Direct and Indirect effects for 13 characters on seed yield per plant at phenotypic level in soybean

S.N	character	Flowering	Days to 50% maturity	Days to maturity	Plant height (cm)	Primary branch/plant (nos.)	Pod length (cm)	No. of pods/clusters	No. of pods / plant	Biological yield per plant (g)	No. of Seed plant (g)	No. of Seed per pod	100 Seed Weight (g)	Harvest index (%)
1	Days to 50% flowering	-0.222	-0.001	0.033	-0.011	0.026	0.069	0.002	0.128	0.154	0.000	-0.033	-0.064	
2	Days to maturity	-0.086	0.002	0.007	-0.014	0.004	0.020	0.000	0.125	0.028	0.000	0.030	-0.223	
3	Plant height (cm)	-0.065	0.000	0.113	-0.014	-0.004	0.164	0.006	0.317	0.174	0.000	-0.018	0.108	
4	No. of primary branches	-0.051	-0.001	0.033	0.047	-0.015	0.094	0.004	0.205	0.061	0.000	0.011	0.008	
5	Pod length (cm)	0.087	0.000	0.007	-0.011	0.065	0.037	0.001	0.067	-0.013	0.000	0.051	-0.025	
6	No. of pods/clusters	-0.068	0.000	0.082	-0.019	-0.011	0.226	0.010	0.412	0.182	0.000	-0.009	0.038	
7	No. of pods per plant	-0.049	0.000	0.069	-0.017	-0.009	0.212	0.010	0.375	0.171	0.000	-0.011	-0.038	
8	Biological yield/plant(g)	-0.060	-0.001	0.067	-0.020	-0.009	0.198	0.008	0.471	0.155	0.000	0.008	-0.094	
9	No. of seed per plant	-0.134	0.000	0.078	-0.011	0.003	0.162	0.007	0.287	0.254	0.000	-0.023	0.021	
10	No. of Seed per pod	0.013	0.000	0.004	-0.017	-0.019	0.025	0.001	0.025	0.032	0.000	0.000	0.132	
11	100 Seed Weight (g)	0.074	-0.001	-0.020	-0.005	0.033	-0.021	-0.001	0.037	-0.060	0.000	0.100	-0.047	
12	Harvest index (%)	0.030	0.001	-0.026	0.001	0.003	-0.018	-0.001	-0.093	0.011	0.000	-0.010	0.477	

Residual Value=0.1064

CONCLUSION

Estimates of heritability (broad sense) ranged from 78.5 percent for days to flowering to 98.5 for number of seed per plant. The genetic advance in percent of mean ranged from 4.57 percent for days to flowering to 73.70 percent for number of seed per plant. In general, genotypic correlations were higher than phenotypic ones in magnitude for all the characters.

The results indicated that additive gene effects appeared more important than non-additive gene effects for plant height, number of pod per cluster, days to 50% flowering, number of pods per plant and biological yield, thus selection may be an effective for the genetic improvement of soybean crop.

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