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GENETICS AND PLANT BREEDING

Determination of Significant Characters for Improving Seed Yield in Soybean (*Glycine max* L. Merrill) Via Correlation and Path Coefficient Analysis

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ABSTRACT

The present investigation was undertaken to determine the correlation coefficient analysis and path analysis for yield and its attributing thirteen characters among the forty-five soybean genotypes laid out in randomized block design (RBD) with three replications. The study was conducted at a Research Cum Instructional Farm under the Genetics and Plant Breeding Department, College of Agriculture, IGKV, Raipur, C.G. during the *Kharif* 2020. The correlation coefficient analysis revealed that the highest positive and significant correlation with seed yield per plant was found for the number of seeds per plant, followed by other characters at genotypic and phenotypic levels. Which indicates a genetically strong association. The path analysis revealed that the number of pods per plant shows the highest positive and significant direct effects on seed yield. It reveals the true association, and indirect selection for these traits will be rewarding for yield improvement.

HIGHLIGHTS

- A correlation coefficient is used to measure the relationship between two or more variables/characters. In plant breeding is helpful in determining yield components that can be used for genetic improvement of yield.
- Path Analysis is used to measure cause and effects between variables. It helps determine yield attributing characters and thus is valuable in indirect selection.

Keywords: Correlation coefficient, Path Analysis, Genotypic, Phenotypic, Yield, Soybean

Soybean (*Glycine max* (L.) Merrill) is a Leguminous and self-pollinated crop with the chromosome number is $2n = 40$ that belongs to the order Fabales, family Fabaceae (Leguminaceae), and sub-family Faboideae (Papilionoideae). It is also known as Wonder seed, Miracle Crop, and Golden Bean. Crop cultivars generally take 80–120 days from sowing to harvesting and reach a height of around 1 meter. It has a wide range of geographical tolerance, special chemical composition, strong nutritional value, practical health benefits, and several end-uses. It is an important crop worldwide (food, feed, and non-edible). Soybean is well known for its nutritional and health benefits. It contains about 37-42% good quality protein, 17-24% oil having about 85% unsaturated fatty acids, including 55% polyunsaturated fatty acids (PUFA) with two essential fatty acids (linoleic and linolenic acid), which are not synthesized by the human body (Balasubramaniyan and Palaniappan 2003).

Yield is a complicated polygenic variable that is the result of many interactions among various

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yield-contributing traits. Correlation analysis can be used to assess the relationship between various components, which helps in the simultaneous selection of many characters. A large amount of variability present in any genetic material indicates the scope for further crop improvement (Baig *et al.* 2018).

The correlation coefficient is a statistic for determining the degree and direction of a relationship between two or more variables. A positive correlation coefficient shows that changes in two variables are in the same direction, indicating that high values of one variable are associated with high values of the other and vice versa. Analyses of the correlation coefficient are useful in plant breeding for identifying yield components that can be utilized for yield improvement.

The path coefficient analysis is a standardized partial regression coefficient that splits the correlation coefficient into direct and indirect effects measures. This study facilitates the identification of yield-contributing traits, which is beneficial in indirect selection. It investigates the underlying cause of a relationship between two variables. This investigation provides data that may lead to the production of desirable genotypes in future breeding programs.

MATERIALS AND METHODS

The experimental material of the present study was content 45 soybean genotypes (Table 1) obtained from different sources; the experiment was carried out under the All India Coordinated Research Project on Soybean during *Kharif* 2020 at the Research Cum Instructional Farm under the Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, (C.G.). Soybean crops were grown in Randomized Block Design with three replications. Every genotype in each replication is grown in a plot of 2m × 2m with a spacing of 45 cm × 15 cm. five plants were selected randomly for observation from each replication for 12 characters. All the recommended package of practices was adopted to raise the usual crop. The crop was sown in the field on 26th June; 2020.

The observation was recorded for 12 characters, namely days to 50% flowering, days to maturity, plant height (cm), pod bearing length (cm), number of pod bearing nodes per plant, number of primary branches per plant, number of pods per plant, number of seeds per plant, 100 seed weight, oil content (%), protein content (%) and seed yield per plant (g). Correlation and path analysis was done using OPSTAT free online agriculture data analysis tool created by O.P. Sheoran.

RESULTS AND DISCUSSION

Correlation analysis

The degree and direction of association between two or more characters on seed yield are given in Table 2. Days to maturity, plant height (cm) and pod bearing length (cm), number of pods per plant, and number of seeds per plant exhibited a significant and positive correlation with seed yield at both levels, genotypic and phenotypic.

At the phenotypic level, the degree of association was highest between plant height (cm) and pod bearing length (0.850), which was followed by the number of seeds per plant (0.829), several pods per plant (0.806) whereas, the number seed per plant (0.883) had a highly positive and significant correlation with seed yield per plant, the similar finding had been reported by Pawar *et al.* (2020) followed by the number of pods per plant (0.882) at the genotypic level. Similar findings were also reported by Nag *et al.* (2007), Pawar *et al.* (2020).

Days to 50% flowering: This character positively correlated with days to maturity (0.257) and (0.283) respectively at genotypic and phenotypic levels.

Days to maturity: This character recorded a positive and significant correlation with plant height (0.213) (0.172), pod bearing length (0.277) (0.230), number of seeds per plant (0.285) (0.225), and seed yield per plant (0.282) (0.191) respectively at the genotypic and phenotypic level and number of primary branches (0.227) at the genotypic level only. Days to maturity had negative and significant correlations with 100-seed weight (g) (-0.242) (-0.189) at both levels, whereas protein content (%) (-0.241) at the genotypic level.

Plant height (cm): Plant height (cm) had a positive and significant correlation with pod bearing length (0.862) (0.850) and seed yield per plant (g) (0.199) (0.183), respectively, at the genotypic and phenotypic level. Plant height was also found to be negatively significantly correlated with 100 seed weight (-0.179)

Table 1: Details about the materials used in the experiment

Sl. No.	Genotypes	Pedigree	Source
1	DSb-38	DSb 18 × EC 241780	UAS, Dharwad
2	CAUMS 2	From NRC 2012 M-120-B-2	CAU, Imphal
3	DLSb-2	DSb 21 × SL 958	UAS, Dharwad
4	RSC 11-39	JS 97-52 × JS 93-05	IGKV, Raipur
5	PS 1664	JS 97-52 × PS 1225	GBPUAT, Pantnagar
6	Hismo 1691	SL 295 × P 13-4	CSKKV, Palampur
7	DS 3144	DS 2207 × JS 335	IARI, Delhi
8	NRC 128	JS 97-52 × PBM-1-1-9-2-6-1	ICAR-IISR Indore
9	RSC 11-35	JS 97-52 × MAUS 504	IGKV, Raipur
10	Himso 1692	VLS 47 × Pb-1	CSKKV, Palampur
11	RVS 2012-10	JS 20-29 × PS 1475	RVSKV, Sehore
12	NRC 109	—	ICAR-IISR Indore
13	RVS 2011-10	JS 335 × PS 1042	RVSKV, Sehore
14	ASb 36	JS 93 -05 × Lsb 1	PJTSAU, Adilabad
15	AUKS 207	JS 20-29 × JS 20-22	AU, Kota
16	AUKS 206	JS 20-29 × JS 20-22	AU, Kota
17	KDS 1096	KDS 378 × DSb 21	MPKV, Digraj
18	KDS 1144	DS 228 × Type 49	MPKV, Digraj
19	BAUS 31-17	JS 335 × MACS 58	BAU, Ranchi
20	SL 1212	SL 955 × EC 34101	PAU, Ludhiana
21	DS 1312	SL 688 × DS 3047	IARI, Delhi
22	DS 3105	Pusa 9712 × JS 335	IARI, Delhi
23	JS 22-11	JS 97-52 × JS (IS) 90-5-12-1	JNKVV, Jabalpur
24	RVSM 2012-11	—	RVSKV, Morena
25	AS-15	(BR 13 × GJS 3) F2- 2013-5-1-3-2	JAU, Amreli
26	RSC 10-46	Bragg × JS 335	IGKV, Raipur
27	JS 22-14	JS 20-53 × JS 20-34	JNKVV, Jabalpur
28	DLSb-1	SL 979 × DSb 21	UAS, Dharwad
29	VLS 101	VLS 75 × VLS 69	VPKAS, Almora
30	PS 1661	JS 97-52 × JS 335	GBPUAT, Pantnagar
31	JS 20-116	JS 97-52 × JSM 120 A	JNKVV, Jabalpur
32	PS 1670	PS 1584 × JS 20-69	GBPUAT, Pantnagar
33	MAUS 806	—	VN MKV, Parbhani
34	MAUS 768	—	VN MKV, Parbhani
35	ASb 9	Lsb 3 × NRC 51	PJTSAU, Adilabad
36	MACS 1460	RKS 24 × JS 95-60	ARI (MACS), Pune
37	MACS 1701	RKS 24 × MACS 450	ARI (MACS), Pune
38	MACS 1691	MACS 450 × NRC 67	ARI (MACS), Pune
39	BAUS 96-17	Monneta × EC 34500	BAU, Ranchi
40	TS 20-5	—	BARC, Mumbai
41	SL 1250	DS 2614 × Himso 1677	PAU, Ludhiana
42	RSC 11-15	JS 335 × PS 1024	IGKV, Raipur
43	RSC 11-17	JS 97-52 × JS 93-05	IGKV, Raipur
44	RSC 11-22	JS 97-52 × JS 93-05	IGKV, Raipur
45	RSC 11-36	JS 97-52 × JS 93-05	IGKV, Raipur

Table 2: Genotypic and phenotypic correlation coefficient for seed yield and its contributing traits in Soybean

Characters		**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**Pod bearing length (cm)**	**Number of pod bearing nodes per plant**	**Number of primary branches per plant**	**Number of pods per plant**	**Number of seeds per plant**	**100-seed weight (g)**	**Protein content (%)**	**Oil content (%)**	**Seed yield per plant (g)**
Days to 50% flowering	G	1.000											
	P	1.000											
Days to maturity	G	0.257**	1.000										
	P	0.283**	1.000										
Plant height (cm)	G	0.057	0.213*	1.000									
	P	0.052	0.172*	1.000									
Pod bearing length (cm)	G	0.121	0.277**	0.862**	1.000								
	P	0.105	0.230**	0.850**	1.000								
Number of pod bearing nodes per plant	G	0.086	0.040	-0.045	-0.120	1.000							
	P	0.061	0.025	-0.044	-0.104	1.000							
Number of primary branches per plant	G	0.139	0.227**	-0.070	0.005	-0.010	1.000						
	P	0.102	0.153	-0.065	0.004	-0.017	1.000						
Number of pods per plant	G	0.052	0.158	0.138	0.145	0.231**	0.151	1.000					
	P	0.067	0.119	0.133	0.140	0.177*	0.156	1.000					
Number of seeds per plant	G	0.075	0.285**	0.113	0.095	0.135	0.252**	0.807**	1.000				
	P	0.046	0.225**	0.098	0.099	0.121	0.204*	0.743**	1.000				
100-seed weight (g)	G	-0.049	-0.242**	-0.179*	-0.128	-0.115	-0.179*	0.081	-0.039	1.000			
	P	-0.033	-0.189*	-0.170*	-0.126	-0.098	-0.160	0.82	-0.042	1.000			
Protein content (%)	G	0.138	-0.241**	-0.264**	-0.249**	-0.104	0.132	-0.157	-0.106	0.130	1.000		
	P	0.128	-0.141	-0.232**	-0.217*	-0.095	0.114	-0.123	-0.101	0.120	1.000		
Oil content (%)	G	0.150	-0.017	-0.043	-0.008	0.020	0.087	0.119	0.214*	0.032	-0.316**	1.000	
	P	0.158	0.011	-0.039	-0.007	-0.024	0.066	0.130	0.186*	0.039	-0.243**	1.000	
Seed yield per plant (g)	G	0.103	0.282**	0.199*	0.180*	0.126	0.178*	0.882**	0.883**	0.140	-0.100	0.144	1.000
	P	0.082	0.191*	0.183*	0.180*	0.081	0.152	0.806**	0.829**	0.129	-0.106	0.143	1.000

***Significant at 1% probability level; *Significant at 5% probability level.*

(0.170), protein content (-0.264) (-0.232), respectively, at the genotypic and phenotypic levels. A similar result had also reported by Nag (2007) for plant height.

Pod bearing length: Pod bearing length had a positive and significant association with seed yield per plant (g) (0.180) (0.180), respectively, at the genotypic and phenotypic levels. Pod bearing length was also found to be negative and significantly correlated with protein content (%) (-0.247) (-2.217) respectively at the genotypic and phenotypic levels. Cheverud (1984) suggests that most environmental effects often act in the same direction and through the same pathways as genetic effects, which leads to a similarity between phenotypic and genetic correlations.

Number of bod bearing nodes per plant: It had a positive and significant association with the number of pods per plant (0.231) (0.177) respectively at the genotypic and phenotypic levels.

Number of primary branches per plant: It had a positive and significant association with the number of seeds per plant (0.252) (0.204) respectively at the genotypic and the phenotypic level and seed yield per plant (0.178) at the genotypic level. This character was recorded negative and significantly correlated with 100- seed weight (g) (-179) at the genotypic level.

Number of pods per plant: It had a positive and significant correlation with the number of seeds per plant (0.807) (0.743) and seed yield per plant (g) (0.882) (0.806), respectively, at the genotypic and phenotypic levels. A similar finding was observed by Mahbub *et al.* (2015) and Chavan *et al.* (2016).

Number of seeds per plant: The number of seeds per plant had a positive and significant association with oil content (0.214) (0.186) and seed yield per plant (g) (0.883) (0.829), respectively at the genotypic and phenotypic levels. A similar finding was reported by Painkra *et al.* (2018).

Protein content (%): The protein content (%) negatively significantly correlated with oil content (%) (-0.316) (-0.243) respectively at both levels. The quality characters, both oil and protein content, exhibited no significant correlation with the dependent variable, similar result reported by Ganeshmurthy and Seshadri (2004).

Path analysis

Direct and indirect effects of independent characters on dependent characters. Path coefficient analysis is given in Table 3 considering seed yield per plant as dependent character revealed that several pods per plant (0.475) showed the highest positive direct effect followed by several seed per plant (0.474), plant height (0.159), 100-seed weight (0.153), days to maturity (0.106), protein content (0.049) oil content (0.003), days to 50% flowering (0.02). These results are in contrast with the finding of Gireesh *et al*. (2012) for 100- seed weight, Nag *et al.* (2007) for oil content, Pawar *et al.* (2020) for the number of pods plant per plant, number of seeds pod per plant and 100- seed weight. The other important characters showed negative direct effects on the dependent variable like pod bearing length (-0.075) showed the highest negative direct effect followed by a number of pod bearing nodes per plant (-0.033), number of primary branches per plant (-0.008). A similar finding was found for the number of pod-bearing nodes per plant by Thakur (2013). Days to 50% flowering independent variable exhibited a positive indirect effect on dependent variable was observed, via days to maturity (0.027), plant height (0.009), number of pods per plant (0.025) and number seed per plant (0.035), protein content (0.007) and oil content (0.001). A similar finding had been reported by Mishra (2019). Days to maturity showed the positive indirect effect on seed yield per plant was observed, *via* days to 50% flowering (0.005), plant height (0.034), number of pods per plant (0.075), and number of seeds per plant (0.135). Plant height (cm) had an indirect favorable effect on seed yield *via* days to 50% flowering (0.001), days to maturity (0.023), number of pod bearing nodes (0.002), number of primary branches per plant (0.001), number of pods per plant (0.066), number seed per plant (0.054), protein content (0.003) and oil content (0.003). Pod bearing length (cm) showed the highest negative direct effect (-0.075) on seed yield per plant. The character pod bearing length (cm) showed a positive indirect effect on seed yield *via* days to 50% flowering (0.002), days to maturity (0.029), plant height (0.137), number of pod bearing nodes (0.004), and number of pods per plant (0.069) along with number seed per plant (0.045). The number of pod-bearing nodes recorded a positive indirect effect *via* days to 50% flowering (0.002), days to maturity (0.004), pod bearing length (0.009), number of primary branches per plant (0.000), number of pods per plant (0.110) and number seed per plant (0.064). The number of primary branches per plant showed a positive indirect effect on seed yield which, were days to 50% flowering (0.003), days to maturity (0.024), number of pod bearing nodes (0.000), number of pods per plant (0.072), number seed per plant (0.119), protein content (0.006) and oil content (0.000). Those indirect effects were, recorded (0.000) which, had very less, effects on seed yield. The number of pods per plant expressed a positive indirect effect on seed yield per plant was observed via. Days of 50% flowering (0.001), days to maturity (0.017), number of seeds per plant (0.382), plant height (0.022), and oil content (0.001). The number of seeds per plant expressed a positive indirect effect on seed yield per plant was observed through days to 50% flowering (0.002), days to maturity (0.030), plant height (0.018), number of pods per plant (0.383), along with oil content (0.001). A similar finding had been reported by Hang Vu *et al.* (2019). As a result, indirect selection of these characteristics may improve the volume of seeds per pod, leading to the emergence of high-yielding genotypes. 100 seed weight showed indirect positive effects on

Table 3: The genotypic path coefficient (direct and indirect effects) of different traits influencing seed yield per plant

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Pod bearing length (cm)	Number of pod bearing nodes per plant	Number of primary branches per plant	Number of pods per plant	Number of seeds per plant	100-seed weight (g)	Protein content (%)	Oil content (%)	Seed yield per plant (g)
Days to 50% flowering	0.020	0.027	0.009	-0.009	-0.003	-0.001	0.025	0.035	-0.007	0.007	0.001	0.103
Days to maturity	0.005	0.106	0.034	-0.021	-0.001	-0.002	0.075	0.135	-0.037	-0.012	-0.000	0.282**
Plant height (cm)	0.001	0.023	0.159	-0.065	0.002	0.001	0.066	0.054	-0.027	-0.013	-0.000	0.199*
Pod bearing length (cm)	0.002	0.029	0.137	-0.075	0.004	-0.000	0.069	0.045	-0.020	-0.012	-0.000	0.180*
Number of pod bearing nodes per plant	0.002	0.004	-0.007	0.009	-0.033	0.000	0.110	0.064	-0.018	-0.005	0.000	0.126
Number of primary branches per plant	0.003	0.024	-0.011	-0.000	0.000	-0.008	0.072	0.119	-0.027	0.006	0.000	0.178*
Number of pods per plant	0.001	0.017	0.022	-0.011	-0.008	-0.001	0.475	0.382	0.012	-0.008	0.000	0.882**
Number of seeds per plant	0.002	0.030	0.018	-0.007	-0.005	-0.002	0.383	0.474	-0.006	-0.005	0.001	0.883**
100-seed weight (g)	-0.001	-0.026	-0.028	0.010	0.004	0.001	0.039	-0.018	0.153	0.006	0.000	0.140
Protein content (%)	0.003	-0.025	-0.042	0.019	0.004	-0.001	-0.075	-0.050	0.020	0.049	-0.001	-0.100
Oil content (%)	0.003	-0.002	-0.007	0.001	-0.001	-0.001	0.057	0.101	0.005	-0.016	0.003	0.144

The diagonal values in bold figures represent the direct effect; The Residual effect: G = 0. 10086.

dependent variable was observed via. Pod bearing length (0.01), number of pod bearing nodes (0.004), number of primary branches per plant (0.001), number of pods per plant (0.039), protein content (0.006), and oil content (0.000). Protein content had recorded indirect positive effects on the seed yield which, were days to 50% flowering (0.003), pod bearing length (0.019), number of pod bearing nodes/plant (0.004), and 100-seed weight (0.02). Oil content was found a positive relationship with the seed yield per plant, with a direct effect (0.003). Oil content showed positive indirect effects on seed yield observed via. Days to 50% flowering (0.003), pod bearing lengths (cm) (0.001), number of pods per plant (0.057), number seed per plant (0.101) and 100-seed weight (g) (0.005).

Path coefficient analysis results presented in Table 3 revealed that pod bearing length (cm), number of pod bearing nodes per plant, and number of primary branches per plant negatively affected seed yield. The selection based on these features might lead to the loss of soybean yield. This result is under the finding of Karnwal and Singh (2009), Iqbal *et al.* (2010), Datt *et al.* (2011).

CONCLUSION

Correlation studies show the number of pods per plant and the number of seeds per plant had a significant correlation and the highest positive direct effect on seed yield per plant. It reveals the strong relationship between them, and natural selection for yield improvement may be rewarding. Path coefficient analysis reveals that the of pod bearing nodes and the number of primary branches per plant had negatively direct effects on seed yield; hence, the selection based on these features might lead to the loss of soybean seed yield. The characters number of pods per plant and number of seeds per plant exhibited the highest positive direct effects and significant correlation with seed yield, so these characters concluded that the primary seed yield contributing components in soybean. Selection for improvement of such characters may be rewarding.

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