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Correlation and path analysis studies for seed yield and its related traits in soybean [*Glycine max* (L.) Merrill]

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Abstract
The present study was carried out to determine the correlation coefficients and path analysis among the seed yield and yield contributing characters in twenty-nine genotypes, at the experimental farm Oil seed Research Station, Latur, in randomized block design (RBD) with three replications According to correlation studies, seed yield per plant was significantly positively correlated with the number of mature pods per plant, the number of pods per cluster, the seed yield per row, and the oil content. The results of the path coefficient analysis at the phenotypic and genotypic levels showed a strong positive direct effect on the number of mature pods per plant, followed by the number of pods per cluster and seed yield per plant. These results lead to the conclusion that in breeding programs aimed at increasing soybean seed yield, more attention should be given to traits like 100 seed weight, number of pods per plant, number of pod clusters per plant, number of branches per plant, and oil content because these traits are positively correlated with seed yield per plant.

Keywords: Correlation, path analysis, seed yield, soybean

Introduction
The soybean, or *Glycine max* (L.) Merrill, is a self-pollinated plant that belongs to the Leguminaceae family, subfamily Papilionideae tribe phaseolae, and genus glycine. The Glycine genus contains 1200 different species. The plant is typically diploid, with 2n=40 chromosomes. With a high protein content (40-42%), high lysine content, and oil (20-22%) rich in essential fatty acids, soybeans are a significant oil seed crop. It also contains isoflavones, which guard the body against conditions like diabetes, cancer, osteoporosis, high blood pressure, and heart disease. The most widely used oil source in the world is soybean, and De Oil Cake (DOC) is used in animal feed and as a food processing unit for the creation of new food products. Due to its many uses, soybean is aptly known as the "Golden Bean" or "Miracle Crop" of the twentieth century. Soybean is classified as an oil seed crop as opposed to a pulse crop because it contains 40% protein and 20% oil. The increased demand for soya meals emphasizes the significance of locating and developing high-quality sources (Fasoula and Boerma 2007) [9].
While executing the selection programmes, analysis of the correlation coefficient between traits contributing directly or indirectly to grain yield is a matter of considerable importance. A precise picture of the relative importance of the direct and indirect influences of each of the component characters on the seed yield cannot be obtained from the study of correlation alone. Path coefficient analysis is a crucially important tool in this context for dividing correlation coefficients into unidirectional and alternative pathways, enabling a more in-depth analysis of the particular causes of a given correlation (Shrotri *et al.*, 2021) [17]. Using this knowledge, you can create a selection strategy that works (Kante *et al*., 2022) [12].

Materials and Methods
The present investigation was undertaken during the *Kharif* season in the year 2021. The ongoing research was carried out at Experimental Farm, Oil seed Research Station, Latur. The experiment was laid out in randomized block design (RBD) with three replications. The experimental material comprised of twenty-nine genotypes soybean.
Five plants at random from each row and replication were chosen and labeled for recording ten observations and the mean of five plants was used for statistical analysis. Ten observations on different morphological and qualitative characteristics were recorded on each germplasm accession at different stages of crop growth. the phenotypic and genotypic correlation

coefficients were computed by the formulae suggested by Falconer and Mackay (1964) [8] and path coefficient analysis was calculated as suggested by Wright (1921) [18] and elaborated by Dewey and Lu (1959) [6].

Results and Discussion

For the purpose of selecting the traits from the breeding material that has a clear bearing on influencing the yield, it is helpful to study the correlations between yield components and yield. Through correlation, one can gain a better understanding of how these traits contribute to the genetic makeup of the crop. In general, phenotypic correlations were lower than genotypic correlations. This might be because genotypes are generally stable. After all, most of them underwent some level of selection (Johnson *et al*., 1955) [11]. Since selection on one particular trait may result in unfavorable changes in other associated characters, the primary goal of correlation studies is to determine the suitability of various characters for indirect selection. The correlation estimates found in the current investigation for 10 soybean yield component characters are discussed below. Table 1 shows the correlations between pod yields per plant and various yield attributes as well as between the attributes themselves.

The character days to 50% had a non-significant association with the number of branches per plant, number of pods per cluster, seed yield per row, oil content, and seed yield per plant. Similar results were reported by Baraskar *et al*. (2015) [2]. The character of association of plant height is negatively non-significant with the number of branches per plant, number of pods per plant, number of pods per cluster, seed yield per plant, and positive and nonsignificant with oil content. Similar results were found by Balla *et al*. (2017) [1]. The character association of days to maturity had a positive and non-significant association with the number of branches per plant, number of pods per plant, and seed yield per plant. A negatively non-significant correlation was observed with 100 seed weights, Seed yield per row. Similar results were found by Dixit *et al*. (2002) [7].

The number of branches per plant was negative and highly significantly correlated with 100 seed weight, and seed yield per row. While positive and non- significantly correlated at the phenotypic level and genotypic level with oil content, and seed yield per plant. Similar results were found with Showkat *et al*. (2010) [16]. The number of pods per cluster was positively and non-significantly correlated with seed yield per plant. Similar results were reported by Patil *et al.* (2011) [13]. The character number of pods per plant had negative and highly significantly correlated with 100 seed weight and seed yield per row, and oil content. The character number of pods per plant had a positive and non-significantly correlation with seed yield per plant. Similar results were noted by Dixit *et al*. (2002) [7]. The character 100 seed weight had a highly significant and positive correlation with seed yield per row and positive, non-significant association with oil content and negatively non-significant with seed yield per plant. Similar results were reported by Chavan *et al*. (2016) [5].

Correlation studies do not provide a complete picture, particularly when the causal factors are interconnected. Correlation coefficients are unreliable as selection indices because of the contributory factors' frequent interdependence, which negatively affects the direct relationship between those factors and yield. By partitioning correlation coefficients, path coefficient analysis enables the separation of direct effects from indirect effects via other related characters. Therefore, in the current study, the phenotypic and genotypic effects of various yield component traits on soybean seed yield per plant were estimated through path analysis and are shown in Table 2.

The net effect of that attribute's direct impact and its indirect impact through other yield-contributing traits was reflected in the correlation coefficient between yield and a specific yield component. A component trait's total correlation with yield can occasionally be deceptive because it may be over- or under-estimated. As a result, direct selection based on correlation response may be ineffective. Wright's proposed division of the total correlation coefficients into direct and indirect effects of cause is therefore required (1921).

Days to 50 percent flowering recorded a negative direct effect and positive correlation with seed yield. So, selection based on this character is desirable. These results were in acceptance by Bairav *et al*. (2006) [4]. Days to maturity had a positive direct effect than all the characters but the positive correlation with seed yield per plant is due to higher positive indirect effects of days to 50% flowering and number of branches per plant, number of pods per plant, and number of pods per cluster. The results were similar to Berhanu *et al*. (2021) [3]. Plant height exhibited a negative direct effect on the seed yield per plant but the negative correlations were due to undesirable negative indirect effects. Hence, the restricted simultaneous selection is made nullifying the undesirable indirect effects. These results were in concurrence with Jain *et al*. (2015) [10]. The number of branches per plant recorded a high positive direct effect and positive correlation with seed yield per plant. Indicating the effectiveness of selection through this trait. These results were in coincidence with Shilpashree *et al*. (2019) [15]. A number of pods per plant exhibited a positive direct effect on seed yield per plant and the positive correlations were due to desirable positive indirect effects. Hence, Indicating the effectiveness of selection through this trait. These results were in acceptance by Pawar *et al.* (2020) [14].

The number of pods per cluster had a positive direct effect and positive correlation with seed yield per plant indicating the effectiveness of selection through this trait. These results were in agreement with Chavan *et al.* (2016) [5] 100 seed weight showed a negative direct effect and a negative correlation with seed yield indicating undesirable negative indirect effects. Similar results were found by Berhanu *et al*. (2021) [3]. Seed yield per row showed a positive direct effect and negative correlation with seed yield per plant indicating undesirable negative indirect effects. Similar results were found by Bairav *et al*. (2006) [4]. Oil content recorded a positive direct effect on seed yield per plant and a positive correlation with seed yield per plant. So, selection through this character will be effective. These similar results were reported by Berhanu *et al*. (2021) [3]. A considerable amount of residual effects was observed at both genotypic and phenotypic levels indicating the contribution of other characters for seed yield per plant than the characters taken in the present study.

Table 1: Genotypic and Phenotypic correlation coefficient matrix for seed yield per plant (g) and other parameters

Characters		Days to 50% Flowering	Plant height (cm)	Days to maturity	No. of branches/ plant	No. of pods/ plant	No. of pods/ cluster	100 seed weight	Seed yield/ row (kg)	Oil content	Seed Yield/ plant (kg)
Days to 50% flowering	rP	1.0000	0.2685 *	0.6386 ***	0.0528	-0.0185	0.0843	-0.0670	0.1811	0.1257	0.0289
	rG	1.0000	0.3245	0.8146	0.0168	-0.0259	0.0713	-0.0766	0.2212	0.2154	0.0502
Plant height (cm)	rP		1.0000	0.2523 *	-0.1885	-0.1669	-0.1847	0.2517 *	0.4723 ***	0.2053	-0.1563
	rG		1.0000	0.2767	-0.2056	-0.1705	-0.1966	0.2532	0.4775	0.2154	-0.1574
Days to maturity	rP			1.0000	0.0924	0.1075	0.2288 *	-0.1336	-0.0362	0.2261 *	0.2360
	rG			1.0000	0.0918	0.1377	0.2287	-0.1489	-0.0356	0.2234	0.2513
No. of branches/ Plant	rP				1.0000	0.7085 ***	0.3821 ***	-0.3865 ***	-0.4358 ***	0.1000	0.3533
	rG				1.0000	0.7410	0.4434	-0.4131	-0.4662	0.1217	0.3717
No. of pods/ plant	rP					1.0000	0.6243 ***	-0.4847 ***	-0.5875 ***	-0.2078	0.4122
	rG					1.0000	0.6836	-0.4913	-0.5973	-0.2236	0.4813
No. of pods/ Cluster	rP						1.0000	-0.3069 **	-0.6271 ***	-0.0698	0.4251
	rG						1.0000	-0.3238	-0.6787	-0.1013	0.4618
100 seed weight	rP							1.0000	0.4767 ***	0.0955	-0.2417
	rG							1.0000	0.4781	0.1017	-0.455
Seed yield/ row (kg)	rP								1.0000	0.2806 **	-0.2850
	rG								1.0000	0.3024	-0.2930
Oil content	rP									1.0000	0.1317
	rG									1.0000	0.1490
Seed yield/ plant (kg)	rP										1.0000
	rG										1.0000

* Indicates significance at 5% level. ** Indicates significance at 1% level.

Table 2: Estimates of genotypic and phenotypic path analysis for direct and indirect effects of yield components on seed yield per plant in soybean.

Characters		Days to 50% Flowering	Plant height (cm)	Days to maturity	No. of branches/ plant	No. of pods/ plant	No. of pods/ cluster	100 seed weight	Seed yield/ Row (kg)	Oil content (%)	Seed yield per plant (kg)
Days to 50% flowering	rP	-0.1543	-0.0414	-0.0985	-0.0081	0.0028	-0.013	0.0103	-0.0279	-0.0194	0.0289
	rG	-0.428	-0.1389	-0.3486	-0.0072	0.0111	-0.0305	0.0328	-0.0947	-0.0558	0.0502
Plant height(cm)	rP	-0.0441	-0.1644	-0.0415	0.031	0.0274	0.0304	-0.0414	-0.0777	-0.0338	-0.1563
	rG	-0.0595	-0.1834	-0.0508	0.0377	0.0313	0.036	-0.0464	-0.0876	-0.0395	-0.1574
Days to maturity	rP	0.1595	0.063	0.2497	0.0231	0.0268	0.0571	-0.0334	-0.009	0.0564	0.236
	rG	0.4169	0.1416	0.5119	0.047	0.0705	0.117	-0.0762	-0.0182	0.1144	0.2513
No. of branches/Plant	rP	0.0037	-0.0131	0.0064	0.0697	0.0494	0.0266	-0.0269	-0.0304	0.007	0.3533
	rG	0.0029	-0.0351	0.0157	0.171	0.1267	0.0758	-0.0706	-0.0797	0.0208	0.3717
No. of pods/plant	rP	-0.0044	-0.0398	0.0256	0.1688	0.2383	0.1488	-0.1155	-0.14	-0.0495	0.4122
	rG	-0.0015	-0.0102	0.0082	0.0444	0.0599	0.041	-0.0294	-0.0358	-0.0134	0.4183
No. of pods/Cluster	rP	0. 0220	-0.0483	0.0598	0.0999	0.1631	0.2613	-0.0802	-0.1639	-0.0182	0.4251
	rG	0.0305	-0.0839	0.0976	0.1893	0.2919	0.427	-0.1382	-0.2898	-0.0433	0.4618
100 seed weight	rP	0.0023	-0.0088	0.0046	0.0135	0.0169	0.0107	-0.0348	-0.0166	-0.0033	-0.2417
	rG	0.0063	-0.0209	0.0123	0.0341	0.0405	0.0267	-0.0825	-0.0395	-0.0084	-0.2455
Seed yield/row(kg)	rP	0.0249	0.0648	-0.005	-0.0598	-0.0806	-0.0861	0.0654	0.1373	0.0385	-0.285
	rG	0.0729	0.1574	-0.0117	-0.1537	-0.1969	-0.2237	0.1576	0.3296	0.0997	-0.293
Oil content (%)	rP	0.0193	0.0316	0.0348	0.0154	-0.032	-0.0107	0.0147	0.0432	0.1539	0.1317
	rG	0.0097	0.0161	0.0167	0.0091	-0.0167	-0.0076	0.0076	0.0226	0.0746	0.149

Dark figures denote direct effects.

Conclusions

According to correlation studies, seed yield per plant was significantly positively correlated with the number of mature pods per plant, the number of pods per cluster, the seed yield per row, and the oil content. The results of the path coefficient analysis at the phenotypic and genotypic levels showed a strong positive direct effect on the number of mature pods per plant, followed by the number of pods per cluster and seed yield per plant. Based on these findings, it can be concluded that in a breeding program for improving seed yield in soybean, more emphasis should be given to the traits *viz.*, 100 seed weight, number of pods per plant, number of pod clusters per plant, number of branches per plant and oil content as these characters are positively correlated with seed yield per plant.

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