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CORRELATION COEFFICIENT AND PATH ANALYSIS IN GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

An investigation was carried out on groundnut (*Arachis hypogaea* L.) to study the correlation and path coefficient analysis for dry pod yield per plant and its component traits. The experimental material comprised 30 diverse genotypes along with 3 checks evaluated during *kharif* 2023 at Rajasthan College of Agriculture, Udaipur under field conditions. Genotypic and phenotypic correlation coefficients were estimated for 14 characters. In general, genotypic correlations were higher than phenotypic correlations, indicating strong inherent genetic associations among traits. Dry pod yield per plant exhibited significant and positive correlation with number of branches per plant, pods per plant, 100-kernel weight, biological yield per plant, harvest index, oil content and protein content, while kernels per pod showed significant negative association. Among the characters studied, pods per plant showed the highest positive direct effect (0.9136) on dry pod yield per plant followed by number of branches per plant (0.6681), protein content (0.3276) and days to maturity (0.2375), indicating their importance in yield improvement. Traits such as 100-kernel weight (-0.6062), days to 50 per cent flowering (-0.2721) and oil content (-0.2664) exhibited negative direct effects despite showing positive correlation with yield, indicating the importance of indirect effects through other characters. Pods per plant, number of branches per plant, oil content and protein content also exhibited substantial positive indirect effects *via* different traits. Thus, pods per plant, number of branches per plant, harvest index, oil content and protein content were identified as important yield contributing traits and can be effectively utilized in selection programmes for improvement of groundnut yield.

***Keywords*:** Groundnut, correlation coefficient, path coefficient analysis, dry pod yield, yield components, selection.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop. It is a self-pollinated, annual, herbaceous legume with cleistogamous flowers, belonging to the family fabaceae and has a chromosome number of $2n = 4x = 40$ It is mainly grown in tropical and subtropical regions of the world. Groundnut originated in Brazil and is widely known as peanut in America.

At the global level, the groundnut occupies about 25.44 million hectares worldwide, with a total production of 45.22 million tonnes and an average productivity of 1777.33 kg per hectare. The major groundnut producing countries are China, India, Nigeria, USA, Indonesia and Sudan.

In India, groundnut is grown over an area of 49.61 lakh hectares, producing around 102.97 lakh tonnes with an average productivity of 2075 kg per hectare (Anonymous, 2023). The major groundnut-growing states in the country are Gujarat, Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra, while other states such as Madhya Pradesh, Rajasthan, Uttar

Pradesh and Punjab also contribute significantly to its production.

In Rajasthan, groundnut is cultivated on about 8.05 lakh hectares, yielding 19.32 lakh tonnes with a productivity of 2400 kg per hectare (Anonymous, 2023). The major districts contributing to groundnut production in the state include Chittorgarh, Bhilwara, Jaipur, Tonk, Sawai Madhopur, Dausa, Bikaner and Hanumangarh.

Groundnut kernel is highly nutritious, containing 44-56% oil, 22-30% protein, 10-25% carbohydrates, along with vitamins (E, K, and B-complex), minerals (Ca, P, Mg, Zn, Fe) and dietary fibre. Its haulm is used as animal feed or manure and shells are utilized as fuel, cattle litter and as filler in feed and fertilizer industries. Groundnut roots in the field improves the soil fertility through nitrogen fixation (100-152 kg ha^{-1}) (Hampannavar *et al.*, 2018). It is popularly referred to as the "poor man's almond," as fats and proteins together constitute nearly 80% of the seed content and it is widely used in various commercial food products (Pandey *et al.*, 2012; Pandey and Varshney, 2018).

The economic importance and narrow genetic base of groundnut has motivated scientists to characterize available germplasm against current abiotic and biotic stresses based on its morphological characteristics (Reddy et al., 2023b). The selection of elite genotypes which ultimately depends on knowledge of variability and genetic diversity of the germplasm. Consequently, to assess the extent of variability present in the population for desired characters, genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were studied. Studies on correlation coefficients of different characters are useful to identify desirable traits that contribute to improve the grain yield and help to ascertain the degree to which these traits are assorted with economic productivity. Path coefficient analysis provide information about the direct and indirect effects of component characters on pod yield for enhancing the usefulness of selection for grain yield improvement in groundnut. Thus, the objective of the present study was to describe relationships between grain yield and its components, which can be helpful for the future planning of groundnut breeding programs" (Birthal *et al.*, 2010).

Materials and Methods

The present investigation was conducted during *kharif* 2023 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan (India), which is situated at an elevation of 579.5 meter above the mean sea level on latitude of 24º35' North and longitude of 73°42' East. The climate of Udaipur is tropical, summer is tolerably hot and winters are quite pleasant. The region experiences scanty rainfall in monsoon season. The experimental material consisted of 30 diverse genotypes (Spanish bunch) along with 3 check varieties of groundnut, representing variability in adaptability, morphological traits, and geographical origin. These genotypes were evaluated for correlation coefficient and path analysis involving 14 economically important traits. The experiment was conducted under field conditions following recommended agronomic practices and observations were recorded on various quantitative traits.

The genotypic and phenotypic correlation coefficients were calculated from the genotypic and phenotypic components of variance and covariance as described by Singh and Choudhary (1985) and as per formula given by Jibouri *et al.* (1958). Path coefficient analysis is a statistical technique that measures the direct and indirect effects of one variable on another through standardized partial regression coefficients. It enables the partitioning of the correlation coefficient into its direct and indirect components, thereby providing a clearer understanding of the relationship among traits. The path coefficient is defined as the ratio of the standard de*via*tion of the effect due to a specific cause to the total standard de*via*tion of the effects. This concept of partitioning correlation into direct and indirect effects was originally proposed by Wright (1921), and later applied in plant breeding studies by Dewey and Lu (1959) for selection purposes, based on the principle of solving simultaneous equations.

Result and Discussion

The estimates of genotypic and phenotypic correlation coefficients among fourteen traits in sorghum are presented in Table 1. In the present study, genotypic and phenotypic correlation coefficients were estimated among fourteen characters in thirty genotypes of groundnut. In general, genotypic correlations were higher than the corresponding phenotypic correlations, indicating strong inherent genetic associations among traits, whereas lower phenotypic correlations suggested environmental influence on trait expression. Similar findings were reported by Upadhayay *et al.* (2020), indicating that genotypic correlations are more reliable for selection.

The results revealed that days to 50 per cent flowering exhibited a significant and positive correlation with days to maturity (rg = 0.89*, rp = 0.76*), indicating that early flowering genotypes tend to mature earlier. Number of branches per plant showed highly significant and positive association with pods per plant (rg = 0.83*, rp = 0.79*), 100-kernel weight (rg = 0.90**, rp = 0.84**) and dry pod yield per plant (rg = 0.93**, rp = 0.82**), suggesting its importance as a major yield contributing trait.

Pods per plant exhibited strong positive and significant correlation with 100-kernel weight (rg = 0.97**, rp = 0.86**) and dry pod yield per plant (rg = 0.96**, rp = 0.85**), while it showed a significant negative association with kernels per pod (rg = -0.44**, rp = -0.39**). Similarly, 100-kernel weight was positively and significantly correlated with dry pod yield (rg = 0.95**, rp = 0.85**), indicating its direct contribution to yield improvement, whereas it had a negative association with kernels per pod (rg = -0.36**, rp = -0.32**).

Kernels per pod showed a significant negative correlation with dry pod yield (rg = -0.41**, rp = -0.34**) and pods per plant, indicating a trade-off among these traits. Biological yield per plant exhibited positive and significant correlation with dry pod yield (rg = 0.35**, rp = 0.79**) and other yield contributing traits, while showing negative association with kernels per pod (rg = -0.38**, rp = -0.31**).

Harvest index demonstrated strong positive and significant correlation with dry pod yield (rg = 1.00**, rp = 0.87**) and other contributing traits, highlighting its importance in improving yield efficiency. Oil content also showed highly significant and positive association with dry pod yield (rg = 0.89**, rp = 0.78**), while protein content exhibited a very strong positive correlation with dry pod yield (rg = 0.98**, rp = 0.84**), indicating the possibility of simultaneous improvement of yield and quality traits.

Dry pod yield per plant, being the most important economic trait, exhibited highly significant and positive correlation with number of branches per plant (rg = 0.93*and rp = 0.82*), pods per plant (rg = 0.96** and rp = 0.85**), 100-kernel weight (rg = 0.95** and rp = 0.85**), biological yield per plant (rg = 0.35** and rp = 0.79**), harvest index (rg = 1.00** and rp = 0.87**), oil content (rg = 0.89** and rp = 0.78**) and protein content (rg = 0.98** and rp = 0.84**), while it was negatively associated with kernels per pod(rg = -0.41** and rp = -0.34**). These findings suggest that selection based on these positively associated traits would be effective in improving yield.

The present findings are in agreement with earlier reports of Rao (2016), Singh *et al.* (2017), Kadam *et al.* (2018), Tirkey *et al.* (2018), Godhani *et al.* (2020), Pachauri and Sikarwar (2022), Reddy *et al.* (2023) and Yadav *et al.* (2023), who also observed similar relationships among yield and its component traits in groundnut.

Correlation alone does not provide a complete understanding of the relationship between yield and its contributing traits; therefore, path coefficient analysis was employed to partition the correlation into direct and indirect effects. This approach, helps in identifying traits with true causal influence on yield. In the present study, path coefficient analysis for dry pod yield per plant was carried out at the genotypic level (Table 2).

Among the traits studied, pods per plant exhibited the highest positive direct effect (0.9136) on dry pod yield per plant, followed by number of branches per plant (0.6681), protein content (0.3276), days to maturity (0.2375), and sound mature kernel per cent (0.0825), indicating their strong and direct contribution towards yield improvement. Similar findings have been reported by Babariya and Dobariya (2012), Tirkey *et al.* (2018), Mitra *et al.* (2021) and Shrotri *et al.* (2021). In contrast, maximum negative direct effects were recorded for 100-kernel weight (-0.6062), days to 50 per cent flowering (-0.2721), oil content (-0.2664), plant height (-0.0765), shelling percentage (-0.0467), and kernels per pod (-0.0057), which is in agreement with Patel *et al.* (2021) and Kannappan *et al.* (2022).

With respect to indirect effects, 100-kernel weight showed the highest positive indirect effect *via* pods per plant (0.8887), followed by protein content through pods per plant (0.8599), oil content *via* pods per plant (0.8235) and number of branches per plant through pods per plant (0.7610). Similarly, protein content also exhibited a substantial positive indirect effect *via* number of branches per plant (0.6605). These findings are in accordance with Singh *et al.* (2017) and Tirkey *et al.* (2018). On the other hand, the highest negative indirect effects were observed for pods per plant *via* 100-kernel weight (-0.5896), protein content through 100-kernel weight (-0.5796), oil content *via* 100-kernel weight (-0.5604), and number of branches per plant through 100-kernel weight (-0.5466), supporting the findings of Bodke *et al.* (2020) and Mitra *et al.* (2021).

Among the key traits, number of branches per plant showed a significant positive correlation with dry pod yield and exerted a strong positive direct effect (0.6681), along with substantial positive indirect effects through pods per plant (0.5565), 100-kernel weight (0.6024), oil content (0.5902) and protein content (0.6605). Pods per plant also had a strong positive correlation and the highest direct effect (0.9136), along with positive indirect effects through number of branches (0.7610), 100-kernel weight

(0.8887), oil content (0.8235) and protein content (0.8599).

Although 100-kernel weight showed a strong positive correlation with yield, it exhibited a negative direct effect (-0.6062), indicating that its positive association with yield is mainly due to indirect effects through other traits such as pods per plant and number of branches. Similarly, oil content also showed a negative direct effect (-0.2664) despite having a positive correlation with yield, suggesting the importance of indirect pathways. In contrast, protein content had a positive direct effect (0.3276) along with strong indirect contributions *via* number of branches, pods per plant and 100-kernel weight.

Kernels per pod exhibited a negative correlation and negligible direct effect (-0.0057) on yield, indicating its limited role in direct yield improvement. Overall, traits such as number of branches per plant, pods per plant, 100-kernel weight, oil content and protein content showed significant association with yield, with pods per plant emerging as the most important trait due to its high direct and indirect effects.

The residual effect (0.7198) indicated that about 28.02 per cent of the variation in dry pod yield was explained by the traits included in the study, while the remaining variation may be attributed to other factors not considered. The present findings are in close agreement with earlier reports of Babariya and Dobariya (2012), Kamdi *et al.* (2017), Rao and Venkanna (2019), Patel *et al.* (2021), Shrotri *et al.* (2021), Sudhishna *et al.* (2021), Reddy *et al.* (2023) and Yadav *et al.* (2023).

Conclusion

The present study was conducted to evaluate the relationship among yield and its component traits in groundnut through correlation and path coefficient analysis. The results of correlation analysis indicated that genotypic correlations were generally higher than phenotypic correlations, suggesting that most of the traits were predominantly governed by genetic factors with relatively less environmental influence. Important yield contributing traits such as number of branches per plant, pods per plant, 100-kernel weight, biological yield, harvest index, oil content and protein content showed strong positive association with dry pod yield, whereas kernels per pod exhibited a negative association, indicating a possible trade-off among traits. Path coefficient analysis provided a clearer understanding of the direct and indirect effects of different traits on yield. Traits like pods per plant, number of branches per plant, protein content and days to maturity showed strong positive direct effects on dry pod yield, indicating their major role in yield determination. On the other hand, some traits, despite showing positive correlation with yield, had negative direct effects, suggesting that their influence on yield is mainly through indirect pathways. Kernels per pod showed a negligible and negative direct effect, indicating its limited importance in direct yield improvement.

Overall, the study highlighted those traits such as pods per plant, number of branches per plant, harvest index, oil content, and protein content are important for improving yield and can be effectively utilized in selection programmes. The findings suggest that emphasis on these traits would be beneficial for developing high yielding groundnut genotypes. The results are in agreement with earlier studies, confirming the reliability of these traits in groundnut breeding programmes.

Table 1: Estimation of genotypic (rg) and phenotypic (rp) correlation coefficient for different characters in groundnut

S. No.	Character		Days to 50% flowering	Days to maturity	Plant height	No. of branches per plant	Pods per plant	Shelling per cent	100-kernel weight	Kernels per pod	Sound mature kernel	Biological yield per plant	Harvest index	Oil content	Protein content	Dry pod yield per plant
1.	Days to 50% flowering	rg		0.89**	-0.11	0.03	-0.01	-0.30	-0.03	-0.05	0.20	0.07	-0.08	0.05	0.01	-0.01
		rp		0.76**	-0.06	0.03	0.01	-0.22	-0.01	-0.03	0.19	0.06	-0.04	0.03	0.05	0.00
2.	Days to maturity	rg			-0.04	-0.19	0.02	-0.20	-0.05	-0.25	0.19	-0.06	-0.11	-0.05	-0.12	-0.08
		rp			-0.03	-0.16	0.03	-0.17	-0.03	-0.22	0.14	-0.06	-0.06	-0.06	-0.15	-0.06
3.	Plant height	rg				-0.02	-0.04	0.28	-0.05	-0.32	0.04	-0.08	-0.17	-0.06	-0.12	-0.11
		rp				-0.02	-0.03	0.23	-0.04	-0.27	0.04	-0.07	-0.08	-0.05	-0.09	-0.09
4.	No. of branches per plant	rg					0.83**	-0.05	0.90**	-0.29	0.04	0.91**	0.96**	0.88**	0.99**	0.93**
		rp					0.79**	-0.03	0.84**	-0.25	0.05	0.77**	0.62**	0.83**	0.87**	0.82**

5.	Pods per plant	rg						-0.11	0.97**	-0.44**	-0.07	0.90**	0.92**	0.90**	0.94**	0.96**
		rp						-0.05	0.86**	-0.39**	-0.04	0.74**	0.68**	0.82**	0.80**	0.85**
6.	Shelling per cent	rg							-0.08	-0.27	0.15	-0.14	-0.17	-0.05	-0.13	-0.13
		rp							-0.05	-0.22	0.10	-0.15	-0.05	-0.05	-0.09	-0.09
7.	100-kernel weight	rg								-0.36*	-0.06	0.90**	0.89**	0.92**	0.96**	0.95**
		rp								-0.32*	-0.07	0.75**	0.67**	0.85**	0.83**	0.85**
8.	Kernels per pod	rg									0.07	-0.38*	-0.40*	-0.26	-0.28	-0.41*
		rp									0.08	-0.31*	-0.24	-0.25	-0.20	-0.34*
9.	Sound mature kernel	rg										0.01	0.09	-0.07	-0.03	0.07
		rp										0.04	0.02	-0.04	-0.01	0.05
10.	Biological yield per plant	rg											0.69**	0.84**	0.96**	0.79**
		rp											0.39**	0.72**	0.73**	0.35**
11.	Harvest index	rg												0.99**	0.73**	0.87**
		rp												0.61**	0.68**	1.00**
12.	Oil content	rg													0.56**	0.89**
		rp													0.86**	0.78**
13.	Protein content	rg														0.98**
		rp														0.84**
14.	Dry pod yield per plant	rg														
		rp														

*,** Significant at 5 and 1 per cent, respectively.

Table 2: Genotypic path analysis for dry pod yield per plant in groundnut

S No.	Character	Days to 50% flowering	Days to maturity	Plant height	No. of branches per plant	Pods per plant	Shelling per cent	100-Kernel weight	Kernels per pod	Sound mature kernel	Oil content	Protein content	with dry pod yield
1.	Days to 50% flowering	**-0.2721**	0.2121	0.0082	0.0200	-0.0109	0.0140	0.0178	0.0003	0.0167	-0.0145	0.0022	-0.0063
2.	Days to maturity	-0.2431	**0.2375**	0.0034	-0.1246	0.0195	0.0094	0.0295	0.0014	0.0157	0.0129	-0.0380	-0.0764
3.	Plant height	0.0291	-0.0106	**-0.0765**	-0.0149	-0.0376	-0.0130	0.0293	0.0018	0.0035	0.0168	-0.0407	-0.1129
4.	No. of branches per plant	-0.0081	-0.0443	0.0017	**0.6681**	0.7610	0.0023	-0.5466	0.0016	0.0036	-0.2353	0.3239	0.9280**
5.	Pods per plant	0.0033	0.0051	0.0032	0.5565	**0.9136**	0.0050	-0.5896	0.0025	-0.0057	-0.2401	0.3084	0.9620**
6.	Shelling per cent	0.0816	-0.0477	-0.0213	-0.0324	-0.0970	**-0.0467**	0.0509	0.0015	0.0124	0.0146	-0.0425	-0.1265
7.	100-Kernel weight	0.0080	-0.0116	0.0037	0.6024	0.8887	0.0039	**-0.6062**	0.0020	-0.0052	-0.2463	0.3133	0.9528**
8.	Kernels per pod	0.0140	-0.0600	0.0246	-0.1936	-0.3979	0.0127	0.2167	**-0.0057**	0.0054	0.0682	-0.0913	-0.4067*
9.	Sound mature kernel	-0.0550	0.0451	-0.0032	0.0289	-0.0626	-0.0070	0.0379	-0.0004	**0.0825**	0.0176	-0.0110	0.0728
10.	Oil content	-0.0148	-0.0115	0.0048	0.5902	0.8235	0.0026	-0.5604	0.0015	-0.0054	**-0.2664**	0.3306	0.8945**
11.	Protein content	-0.0018	-0.0276	0.0095	0.6605	0.8599	0.0061	-0.5796	0.0016	-0.0028	-0.2687	**0.3276**	0.9847**

Residual = 0.7198

*, ** Significant correlation with dependent character at 5 and 1 per cent, respectively.

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