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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): xxx-xxx

www.thepharmajournal.com
Received: 28-03-2023
Accepted: 30-04-2023

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Character association, its direct and indirect effects of yield and its attributing traits in groundnut (*Arachis hypogaea* L.) under controlled environmental conditions

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Abstract
During 2019-20, thirty-three groundnut genotypes were evaluated in completely randomized design with three replications in controlled environment facility, ICRISAT, Hyderabad. Observations were recorded on various characters such as days to 50% flowering, days to maturity, fresh pod yield per plant, dry pod yield per plant, hundred seed weight and shelling percentage on three plants per genotype per replication in controlled environment facilities and mean were calculated. Analysis of variance revealed significant differences among the genotypes for all the traits under controlled environment facility at 0.01 and 0.05 probability levels. The correlation studies revealed that dry pod yield per plant had significant positive genotypic and phenotypic association with shelling percentage. Path coefficient analysis revealed that fresh pod yield per plant followed by hundred seed weight and shelling percentage have positive and direct effect on dry pod yield per plant. Further, studies on correlation and path co-efficient analysis revealed the importance of fresh pod yield per plant, which showed highly significant positive correlation and positive direct effect with dry pod yield per plant followed hundred seed weight and shelling percentage, thus can be used as selection criteria for effective yield improvement.

Keywords: Groundnut, correlation, path analysis and controlled environment

Introduction
Groundnut (*Arachis hypogaea* L.) is autogamous legume crop with allotetraploid genome (2n=4x=40) having 10 as a basic chromosome number. Groundnut is known by many names such as peanut, earthnut, monkeynuts, mani and moongphali (Nigam, 2014). It is having high nutritional benefit in human life as it contains crude fibre (1.149%), lipid (46.224%), crude protein (25.20%), carbohydrate (21.26%), ash (2.577%), calcium (0.087%), phosphorus (0.29%) and energy (601.856%) (Ingale and Shrivastava, 2011) [11]. As it contains sufficient quantity of protein it is used to satisfy the protein needs of poor families who can't afford to purchase protein. Its oil also has very much nutritional importance now a day. Oleic acid content of oil determines its shelf life and usability with increased health benefits (Nawade *et al.*, 2018) [13]. Besides its nutritional importance this crop has many uses. Groundnut fixes atmospheric nitrogen as its legume crop and enrich soil microflora. Its above ground parts used as fodder. Groundnut plays an important role in the livelihood of poor farmers in developing countries like India and sub-Saharan Africa nations. Although India is a leading producer of groundnut, its productivity is very less as compared to USA and China (approximately 3 t/ha). Improvement in yield is ultimate goal of any breeding program, but yield is affected by environment in considerable extent and it also have low heritability. Due to this direct selection for yield is misleading. In such situations indirect selection for yield contributing character is effective for enhancement of yield. So, this study was framed to identify yield attributing traits and to study direct and indirect effect of yield contributing traits on yield.

Materials and Methods
The experimental material consists of thirty-three groundnut genotypes derived from different origins. The genotypes were obtained from Groundnut Breeding Unit, ICRISAT, Hyderabad. Selected groundnut genotypes were evaluated in completely randomized design with three replications at controlled environmental facility, ICRISAT, Hyderabad. For this experiment an eight-inch pot was taken and sterilized soil was filled in the pot. In each pot, eight seeds were

sown at depth of 2 cm and covered with soil. After germination in each pot five plants were maintained. Observations of yield and yield contributing traits were recorded on one randomly selected healthy plant in each pot per replication. Observations were recorded on six component characters *viz*. days to 50% flowering, days to maturity, fresh pod yield per plant, dry pod yield per plant, hundred seed weight and shelling percentage. Analysis of variance was performed to test the significance of difference among the genotypes for the characters studied. Correlation coefficients were calculated at genotypic and phenotypic level using the formulae suggested by Falconer and Mackay (1964) [8]. The direct and indirect contribution of various characters to yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) [7].

Results and Discussion

Analysis of variance

Analysis of variance revealed significant differences among the genotypes for all the traits under study at 0.01 and 0.05 probability levels. The details are presented in table 1.

Table 1: Analysis of variance for yield and its component traits for controlled environment experiment of thirty-three groundnut genotypes studied during *kharif* (2019).

SV	df	DF	DM	FPD	DPP	HSW	SP
TRT	32	16.81**	61.95**	11.16**	4.72**	323.1**	255.4**
Error	66	0.42	1.72	0.66	0.22	1.06	1.18
Total	98	17.23	63.68	11.83	5.78	324.2	256.6

** indicate significance at 0.01 and 0.05 probability levels, DF- Days to 50 % flowering, DM- Days to maturity, FPD- Fresh pod yield per plant (g), DPP- Dry pod yield per plant (g), HSW- Hundred seed weight (g), SP- Shelling percentage (%) and SV- Source of variation.

Correlation Analysis

Estimates of phenotypic and genotypic correlation coefficients between each pair of characters are presented in table 2. The results showed that, in most cases, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients which indicated the inherent association among various characters independent of environmental influence.

Dry pod yield per plant had significant positive genotypic and phenotypic association with fresh pod yield per plant and, significant negative correlation with days to 50 % flowering. With days to maturity and hundred seed weight it is positively associated but non-significant and with shelling percentage it has non-significant negative association. The results were confirmed with Hampannavar *et al.* (2010) [10], Vaithiyalingan and Yogameenakshi P (2018) [26], Rao *et al*. (2019) [18], Rao *et al*. (2013) [15], Chishti *et al*. (2000) [5] and Sumathi *et al.* (2007) [25] for positive non-significant association between dry pod yield with days to maturity and hundred seed weight. The significant correlation indicates that there is strong association between fresh pod yield per plant and dry pod yield per plant. Kadam *et al.* (2018) [12] reported that dry pod yield per plant has significant positive association with fresh pod yield per plant.

Days to 50 % flowering had significant negative genotypic and phenotypic association with dry pod yield per plant and positive non-significant association with days to maturity and hundred seed weights. It had non-significant negative association with fresh pod yield per plant and shelling percentage both at genotypic and phenotypic levels. The results are confirmed with earlier studies (Gaikpa *et al*., 2015; Padmaja *et al*., 2013 and Rao *et al.*, 2014) [9, 15, 19] for negative and significant association of days to 50 % flowering with dry pod per plant.

Days to maturity had significant positive phenotypic and genotypic association with hundred seed weight. With shelling percentage, it was negatively associated but showing significant. It has non-significant positive correlation with fresh pod yield per plant, dry pod yield per plant both at phenotypic and genotypic level. As per the Rao *et al.* (2014) [19] days to maturity and dry pod yield per plant were non-significantly negatively associated.

Fresh pod yield per plant had significant positive genotypic and phenotypic association with dry pod yield per plant. It has significant negative correlation with hundred seed weight and shelling percentage both at phenotypic and genotypic level but at genotypic level, fresh pod yield per plant had significant negative genotypic association with shelling percentage. Similar results obtained by Kadam *et al.* (2018) [12] for positive significant association between fresh and dry pod yield per plant.

Hundred seed weight had significant negative phenotypic and genotypic association with shelling percentage, significant negative correlation with dry pod yield per plant. In a similar way, Hampannavar *et al*. (2010) [10] also reported negative correlation between hundred seed weight and shelling percentage.

Table 2: Genotypic and phenotypic correlation coefficients for six characters of thirty-three groundnut genotypes studied under controlled environment condition during *kharif* (2019).

Traits	r	DF	DM	FPD	HSW	SP	DPP
DF	r_g	1.000	0.156	-0.127	0.025	-0.110	-0.233*
	r_p	1.000	0.139	-0.126	0.022	-0.113	-0.2164*
DM	r_g		1.000	0.104	0.208*	-0.359**	0.106
	r_p		1.000	0.100	0.201 *	-0.340 **	0.089
FPD	r_g			1.000	-0.010	-0.151	0.816**
	r_p			1.000	-0.014	-0.141	0.772**
HSW	r_g				1.000	-0.393**	0.042
	r_p				1.000	-0.3912**	0.037
SP	r_g					1.000	-0.111
	r_p					1.000	-0.108

DF- Days to 50 % flowering, DM- Days to maturity, FPD- Fresh pod yield per plant (g), DPP- Dry pod yield per plant (g), HSW- Hundred seed weight (g), SP- Shelling percentage (%), r_g- Genotypic correlation, r_p- Phenotypic correlation, r- Correlation, **- Significance at 0.01 probability level, *- Significance at 0.05 probability level

Shelling percentage had significant negative phenotypic and genotypic association with dry pod yield per plant. Similar results reported by Hampannavar *et al*. (2010) [10].

Path coefficient analysis

Days to 50 % flowering had negative and direct effect (-0.1362/-0.1239) on dry pod yield per plant at both genotypic and phenotypic level. It showed indirect negative effects on dry pod yield per plant through days to maturity (-0.0213/-0.0173) and hundred seed weight (-0.0034/-0.0027) at both genotypic and phenotypic levels. It had indirect positive effects on dry pod yield per plant through fresh pod yield per plant (0.0174/0.0156) and shelling percentage (0.0151/0.0140) at both genotypic and phenotypic levels.

Days to maturity had positive and direct effect (0.0438/ 0.0243) on dry pod yield per plant at phenotypic level and genotypic level. It showed indirect negative effects on dry pod yield per plant through shelling percentage (-0.0158/-0.0083) at both genotypic and phenotypic level. It had indirect positive effects on dry pod yield per plant through fresh pod yield per plant (0.0046/0.0024), days to 50 % flowering (0.0068/0.0034) and hundred seed weight (0.0092/0.0049) at both genotypic and phenotypic level.

Table 3: Phenotypic and genotypic path coefficients of yield and its component traits of thirty-three groundnut genotypes studied under controlled environment condition during *kharif* (2019).

Trait Name	G/P	DF	DM	FPD	HSW	SP	DPP
DF	G	-0.1362	-0.0213	0.0174	-0.0034	0.0151	-0.2335
	P	-0.1239	-0.0173	0.0156	-0.0027	0.0140	-0.2164
DM	G	0.0068	0.0438	0.0046	0.0092	-0.0158	0.1067
	P	0.0034	0.0243	0.0024	0.0049	-0.0083	0.0892
FPD	G	-0.1020	0.0838	0.7996	-0.0084	-0.1210	0.8160
	P	-0.0956	0.0762	0.7569	-0.0109	-0.1072	0.7724
HSW	G	0.0014	0.0121	-0.0006	0.0580	-0.0228	0.0425
	P	0.0011	0.0103	-0.0007	0.0511	-0.0200	0.0373
SP	G	-0.0036	-0.0118	-0.0050	-0.0129	0.0327	-0.1118
	P	-0.0014	-0.0044	-0.0018	-0.0050	0.0128	-0.1086

Bold values are direct effects; G – Genotypic correlation coefficient; P – Phenotypic correlation coefficient Residual effect (P) – 0.62; Residual effect (G) - 0.55

Fresh pod yield per plant had positive and direct effect (0.7996/0.7569) on dry pod yield per plant at both genotypic and phenotypic level. It showed indirect negative effects on dry pod yield per plant through days to 50 % flowering (-0.1020/-0.0956), shelling percentage (-0.1210/-0.1072) and hundred seed weight (-0.0084/-0.0109) both genotypic and phenotypic levels. It had indirect positive effects on dry pod yield per plant through days to maturity (0.0838/0.0762) both genotypic and phenotypic levels.

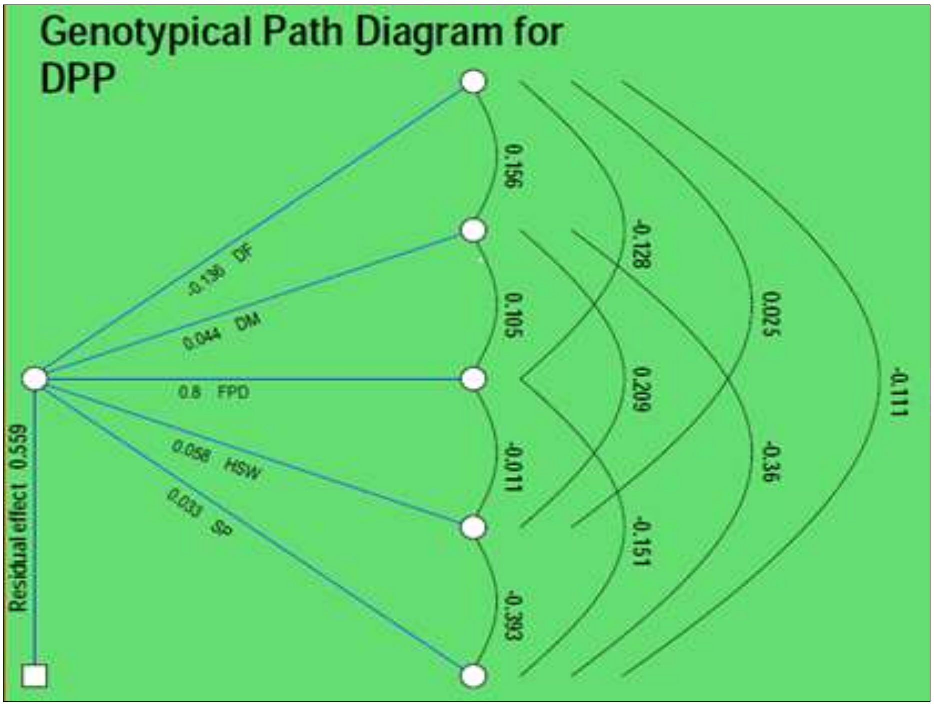

Fig 1: Genotypic path diagram for dry pod yield per plant for controlled environment experiment of thirty-three groundnut genotypes studied during *kharif* (2019).

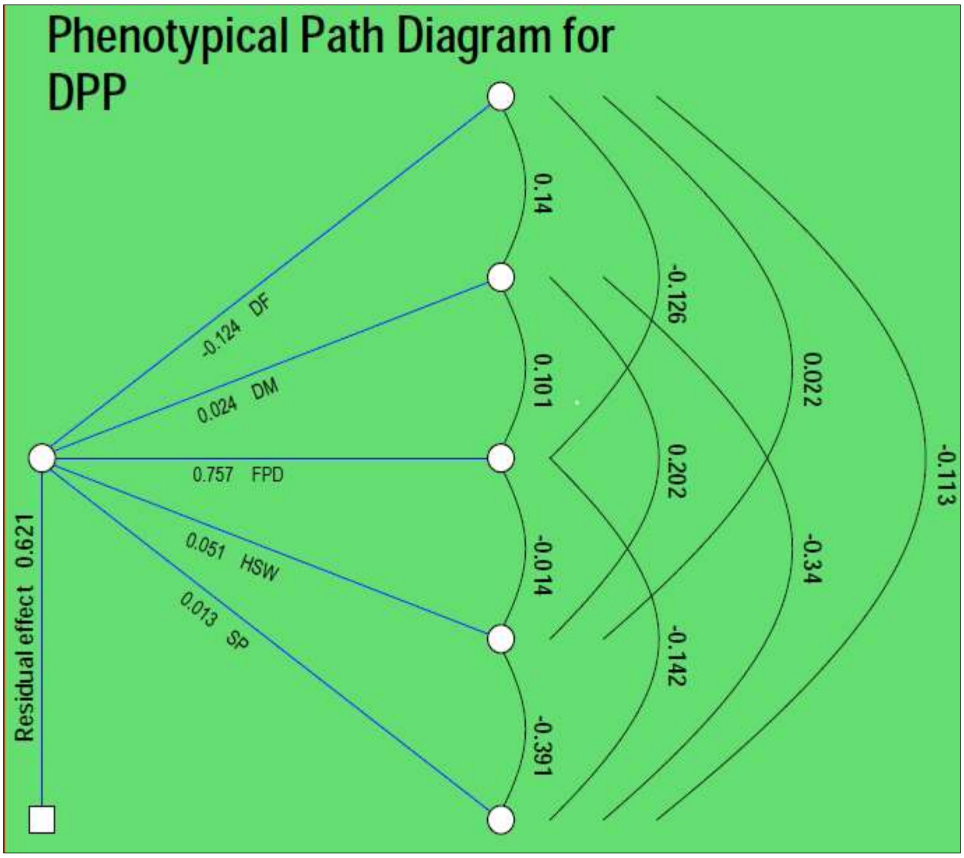

Fig 2: Phenotypic path diagram for dry pod yield per plant for controlled environment experiment of thirty-three groundnut genotypes studied during kharif (2019).

Hundred seed weight had positive and direct effect (0.0580/0.0511) on dry pod yield per plant at both genotypic and phenotypic level. It showed indirect negative effects on dry pod yield per plant through fresh pod yield per plant (-0.0006/-0.0007), shelling percentage (-0.0228/-0.0200) at both genotypic and phenotypic levels. It had indirect positive effects on dry pod yield per plant through days to 50 % flowering (0.0014/0.0011) and days to maturity (0.0121/0.0103) both genotypic and phenotypic levels.

Shelling percentage had positive and direct effect (0.0327/0.0128) on dry pod yield per plant at both genotypic and phenotypic level. It showed indirect negative effects on dry pod yield per plant through days to 50 % flowering (-0.0036/-0.0014), days to maturity (-0.0118/-0.0044), fresh pod yield per plant (-0.0050/-0.0018) and hundred seed weight (-0.0129/-0.0050) both genotypic and phenotypic levels. Positive direct effect on dry pod yield per plant were reported by Rao *et al.* (2019) [18], Rao *et al.* (2014) [19], Siddiquey *et al* (2006) [22], Deshmukh *et al* (1986) [6], Awatade *et al.* (2009) [2], Arunachalam and Bandyopadhyay (1984) [1], Vaithiyalingan and Yogameenakshi (2018) [26], Badwal and Singh (1973) [4], Parameshwarappa *et al.* (2008) [16], Sardar *et al.* (2017) [21] and Kumar *et al.* (2018) [13] for hundred seed weight and by Singh *et al.* (2017) [24], (2010) [10] and Awatade *et al.* (2009) [2] for shelling percentage. Positive direct effect on dry pod yield per plant was reported by Babariyl and Dobariya (2012) [3], Awatade *et al*. (2009) [2], Vekariya *et al.* (2010) [27] and Raut *et al.* (2010) [22] for days to maturity. Positive direct effects on dry pod yield per plant were reported by Kadam *et al*. (2018) [12], Patel and Shelke (1992) [17] for fresh pod yield per plant. Negative direct effects on dry pod yield per plant were reported by Awatade *et al*. (2009) [2], Venkataravana *et al*. (2000) [28], Singh and Singh (2001) [23] for days to 50 % flowering.

Conclusion
The findings of the present investigation revealed that fresh pod yield per plant exerted highest positive direct effect followed by hundred seed weight and shelling percentage and days to maturity on the dry pod yield per plant indicating that selection for these characters is likely to bring about an overall improvement in dry pod yield per plant directly. Further, studies on correlation and path co- efficient analysis revealed the importance of fresh pod yield per plant and hundred seed weight, which showed highly significant positive correlation and positive direct effect with dry pod yield per plant, thus can be used as selection criteria for effective yield improvement.

Acknowledgments
The authors are highly grateful for financial support provided by Indian Council of Agriculture Research for carrying out research work.

Conflict of interest: None

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