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Spectrum of genetic variability, correlation and path analysis for yield and yield contributing traits in bunch groundnut (*Arachis hypogaea* L.)

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Abstract
In kharif 2018, fifty-eight genotypes of bunch groundnut were evaluated for genetic variability, correlation, and path analysis using Randomized Block Design (RBD) with three replications at the Instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, for fourteen agro-morphological characters. Characters such as the number of primary branches per plant, the plant height (cm), the days to flowering, the days to maturity, the 100 pods weight (g), the 100 kernels weight (g), the number of mature pods per plant, the kernel yield per plant (g), the pod yield per plant (g), the shelling out turn (%), the sound mature kernel, the biological yield per plant (g), the harvest index (%), and the oil content (%). With the exception of shelling out turn, analysis of variance indicated extremely significant genetic differences for all the characters under study. For almost all characters, PCV is greater than GCV, yet occasionally these two numbers are slightly different or equal. The biological yield per plant, harvest index, and number of mature pods per plant showed the greatest values, but the days to maturity, number of primary branches per plant, and oil content (%) showed the lowest values. The number of mature pods per plant, pod yield per plant (g), 100 pod weight (%), kernel yield per plant, 100 kernel weight, and biological yield per plant all exhibited higher heritability and genetic advance of percent mean, indicating the significance of additive gene action and the great potential for improvement in these genotypes through simple selection. Pod yield per plant (g) was highly influenced by harvest index (%), biological yield per plant (g), and kernel yield per plant (g).

Keywords: GCV, PCV, bunch groundnut, variability, correlation, path analysis, additive gene effect

1. Introduction
One of the most important legume crops in the world is groundnut (*Arachis hypogaea* L.). Greek terms "*Arachis*" (Legumes) and "*hypogaea*" (Below ground) are the roots of the word "Groundnut" (*Arachis hypogaea* L.). It has various names such as goobernut, monkey nut, and peanut. According to Kochert *et al.* (1996) [11], this crop is believed to have originated in southern Bolivia and northern Argentina, and the regions of Western Brazil, Bolivia, Paraguay, and Northern Argentina are the centres of variety for this genus. Peanuts are allotetraploid (2n=4x=40) with a basic chromosomal number of x=10 (Stalker, 1991) [25]. Crops with allopolyploid genomes are complex. Increased genetic diversity in groundnuts might result of this.

Any breeding effort begins with an assessment of genetic variability in the base population. The degree of variability is undoubtedly determined by the variability parameters.

Breeders can benefit greatly from understanding the relationship between yield and its component traits since it serves as a base for selection. It is a well-known fact that various yield components frequently show a significant degree of positive and negative correlation with yield as well as with each other. Plant breeders benefit from a positive correlation between desirable qualities since it facilitates the simultaneous enhancement of all the characters. Conversely, a negative connection will make it more difficult for all of the characteristics to express themselves at once. There must be some economic allowances offered in these situations.

Path analysis is based on all feasible simple correlations between different characteristics and quantifies the direct and indirect contribution of multiple independent characters to a dependent character (Singh and Narayanan, 2000) [18].

2. Materials and Methods

The goal of the current study was to evaluate genetic variability, correlation, and path analysis in 58 genotypes of bunch groundnut (*Arachis hypogaea* L.) that represented various Indian geographic origins. The Main Oilseeds Research Station at Junagadh Agricultural University provided a required quantity of seeds for this experiment, which were then seeded in *Kharif* 2018 at the Department of Agronomy's Instructional Farm at JAU, Junagadh. Thirteen Agro-morphological traits-days to flowering, days to maturity, plant height (cm), number of primary branches per plant, number of mature pods per plant, pod yield per plant (g), 100-pod weight (g), kernel yield per plant (g), 100-kernel weight (g), sound mature kernel (%), biological yield per plant (g), harvest index (%), and oil content (%) were used to qualify the diversity in fifty-eight genotypes of bunch groundnut.

Indostat software was used to estimate the analysis of variance. The formula provided by Burton (1952) [3] was used to calculate the mean, range, genotypic coefficient of variance (GCV), and phenotypic coefficient of variance (PCV). Lush (1940) [13] suggested a formula for calculating heritability (%) in a broad sense, and Johnson *et al.* (1955) [9] and Lush (1940) [13] provided a procedure for estimating genetic advance as a percentage of mean. the phenotypic and genotypic correlations calculated using the Al-Jibouri *et al.* (1958) [1] approach.

3. Results and Discussion

With the exception of shelling out turn, analysis of variance indicated extremely significant genotype differences among the characters tested, exhibiting great variability in the material studied (Table 1). The estimates of genotypic coefficient of variation (GCV) were higher than the estimates of phenotypic coefficient of variation (PCV) for most of the characters studied (Table 2), indicating the presence of inherent association in various characters. Presence of inherent association among various traits and phenotype of the genotypes indicates these characters are less influenced by the environment. There is a wide variation for the character under study, which allows for further improvement by selecting individual characters. High and moderate GCV and PCV were observed in biological yield per plant (g), number of mature pods per plant, harvest index (%), kernel yield per plant (g), 100 kernel weight (g), pods yield per plant (g), 100 pod weight (g), and plant height (cm). The results were in accordance with Yadav *et al.* (2014) [24] and Vasanthi *et al.* (2015) [21]. The low GCV and PCV were observed for days to 50% flowering, number of primary branches per plant, days to maturity, oil content and sound mature kernel whereas; similar result reported by Yadav *et al.* (2014) [24]. The low GCV suggests that the environment has a significant impact on how these features manifest.

The ratio of genetic variance to phenotypic variance, which is heritable, is known as heritability in the broadest sense. High heritability in broad sense does not always mean better response to selection, since it is also inclusive of non-additive genetic factors. Thus, the reaction of selection is further restricted by the estimation of genetic advancement. A strong indicator of natural inheritance and the efficacy of selection for a given characteristic is provided by the combination of heritability and genetic advancement expressed as a percentage of mean (Johnson *et al.* 1955) [9]. In the current study, Table 2 displays the strong genetic advance as a percentage of mean (> 20%) and high heritability (> 60%) in the following traits: Number of mature pods per plant, pod yield per plant (g), weight of 100 pods (g), kernel yield per plant (g), 100 kernels weight (g), and biological yield per plant (g). The findings were consistent with the observations made in several groundnut characters by Vasanthi *et al.* (2003) [20], Mukesh *et al.* (2014) [15], Salih *et al.* (2014) [17], Yadav *et al.* (2014) [24], and Vasanti *et al.* (2015) [21]. The high heritability along with genetic advance as per cent mean are a sign of additive gene action and the ensuing high extended genetic gain from selection of superior genotypes. The high heritability and low genetic advance as per cent mean were observed for days to maturity and oil content (%) while, high heritability and moderate genetic advance as per cent mean was observed for days to flowering, plant height (cm), number of primary branches per plant and sound mature kernel (%). It was proposed that phenotypic selection is ineffective because high heritability does not always imply substantial genetic gain and prevalence of non-additive gene activity governing the inheritance of these traits. Similar findings were published by Suneetha *et al.* (2004) [19] for sound mature kernels (%) and Yadav *et al.* (2014) [24] for days to 50% flowering and days to maturity.

A complex quantitative character, yield is heavily influenced by the environment and controlled by a multitude of genes. Therefore, choosing better genotypes just on the basis of yield will not be beneficial. The relationship between yield components and yield consequently gained significance as the foundation for choosing the right strains. Correlation among characters may result from pleiotropy, linkage or physiological associations among characters. Transit correlations are caused by the linkage, especially in populations that are descended from crossings between divergent strains. The net effect of the segregating genes is known as the correlation; some genes might improve both characters, resulting in a positive correlation, while other genes may increase one character and decreasing the other, resulting in a negative correlation (Falconer, 1981) [6].

The correlation response of several characters with pod yield per plant (g) was examined using the phenotypic and genotypic correlation coefficients shown in Table 3. The number of mature pods per plant, kernel yield per plant (g) and harvest index (%) all showed highly significant and positive associations with the pod yield per plant (g) at both the genotypic and phenotypic levels. The positive genotypic association has been also reported between pods yield per plant (g) and number of mature pods per plant by Vaithiyalingan *et al.*, 2018 [26]; Vasanthi *et al.*, 2016 [22]; Hampannavar *et al.*, 2017 [8]; Kadam *et al.*, 2018 [10]; Rathod and Taprope, 2018 [16]; Wadikar *et al.*, 2018 [23], for kernel yield per plant by Mehta and Monpara, 2010 [14]. There was a negative but significant pod yield per plant with respect of days to maturity. Other characteristics that were positively but not significantly correlated with pod yield per plant at the genotypic and phenotypic levels included plant height, the 100 pods weight (g), the 100 kernels weight (g), sound mature kernel (%), biological yield per plant (g), and oil content (%). At both the genotypic and phenotypic levels, there was a negative connection between the traits such as the number of primary branches per plant and the days to flowering and the pod yield per plant (g). In these types of situations, certain economic concessions must be made because the negative connection will impede improvement. For days to flowering, the results align with those of Lakshmidevamma *et al.* (2004) [12].

The present investigation employed path coefficient analysis, as laid out by Dewey and Lu (1959) [5], to determine the direction and magnitude of the direct and indirect effects of different yield-contributing traits on dry pod yield. Any character's direct effect on yield provides insight into how a particular character can be selected with confidence to increase yield. The harvest index (%) (0.3572), biological yield per plant (g) (0.3248), and kernel yield per plant (g), (0.7717) all had a significant direct effect on the pod yield per plant. Characters such as harvest index (%), number of mature pods per plant, and kernel yield per plant (g) all showed a strong, positive indirect effect on the number of pods yield per plant (g), (Table 4, Figure 1). On the other hand, the number of primary branches per plant, the number of days to flowering, and the days to maturity all had a negative indirect effect on the number of pods per plant. According to studies by Babariya *et al.* (2012) [2], Chaudhary *et al.* (2013) [4], and Gupta *et al.* (2015) [7], the biological yield per plant has a maximum and positive direct effect.

Table 1: Analysis of variances showing mean square for fourteen characters

Sr. No.	Characters	MSS		
		Treatments	Replication	Error
1	Days to flowering	23.99**	34.35**	7.46
2	Days to maturity	62.75**	31.45**	4.12
3	Plant height (cm)	54.57**	41.93**	11.42
4	No. of primary branches per plant	0.10**	0.00^{NS}	0.00
5	No. of mature pods per plant	12.52**	0.55^{NS}	0.85
6	Pods yield per plant (g)	9.85**	16.34**	1.63
7	100 pods weight (g)	829.64**	83.74**	26.02
8	Kernel yield per plant (g)	5.58**	2.91^{NS}	1.15
9	100 kernel weights (g)	145.53**	23.91**	4.32
10	Shelling out turn (%)	71.70^{NS}	250.38**	79.08
11	Sound mature kernel (%)	190.08**	5.74*	6.26
12	Biological yield per plant (g)	101.82**	118.22**	6.97
13	Harvest index (%)	268.02**	501.24**	111.20
14	Oil content (%)	9.22**	1.77^{NS}	0.62

**, ^{NS} significant at 1% level and non-significant, respectively.

Table 2: Range of variation, general mean, phenotypic and genotypic coefficients of variation, heritability (B.S.), genetic advance and genetic advance expressed as per cent of mean for 14 characters in 58 genotypes of bunch groundnut (*kharif*)

Sr. No.	Characters	Range	General mean	PCV	GCV	Heritability (B.S.) %	GA	GA as per cent mean
1	Days to flowering	25.66 - 37.00	32.2126	8.77	7.28	68.91	4.01	12.46
2	Days to maturity	93.33 - 113.66	102.4195	4.46	4.31	93.42	8.80	8.59
3	Plant height (cm)	25.66 - 43.66	37.5230	11.36	10.10	79.06	6.94	18.51
4	No. of primary branches per plant	3.00 - 4.00	3.0345	6.06	6.06	98.07	0.55	18.20
5	No. of mature pods per plant	6.00 - 14.66	9.2529	22.08	21.31	93.17	3.92	42.39
6	Pods yield per plant (g)	5.33 - 13.33	9.7931	18.51	16.90	83.45	3.11	31.82
7	100 pods weight (g)	61.66 - 138.00	99.7816	16.66	16.40	96.86	33.18	33.25
8	Kernel yield per plant (g)	3.66 - 10.00	7.0920	19.24	17.13	79.25	2.22	31.41
9	100 kernel weights (g)	26.66 - 54.33	40.5517	17.17	16.91	97.03	13.92	34.32
10	Shelling out turn (%)	60.33 - 83.66	72.8908	-	-	-	-	-
11	Sound mature kernel (%)	54.33 - 90.66	80.0000	9.94	9.78	96.71	15.85	19.82
12	Biological yield per plant (g)	12.66 - 41.66	24.3908	23.88	23.05	93.15	11.17	45.83
13	Harvest index (%)	23.66 - 62.00	39.4770	23.94	18.31	58.51	11.39	28.85
14	Oil content (%)	44.33 - 53.00	48.5690	3.61	3.48	93.24	3.36	6.93

Table 3: Genotypic (r_g) and phenotypic (r_p) correlation coefficients among 13 characters in 58 genotypes of bunch groundnut (*kharif*)

Characters		Days to flowering	Days to maturity	Plant Height (cm)	No. of primary branches per plant	No. of mature pods per plant	100 pods weight (g)	Kernel yield per plant (g)	100 kernel weights (g)	Sound mature kernel (%)	Biological yield per plant (g)	Harvest Index (%)	Oil Content (%)
Pods yield per plant (gm)	r_g	-0.0844	-0.3302*	0.0054	-0.0146	0.6987**	0.1781	1.0161**	0.1804	0.0264	0.2820	0.5172**	0.1177
	r_p	-0.0361	-0.2898*	0.0185	-0.0133	0.6390**	0.1558	0.9549**	0.1732	0.0108	0.2677	0.5149**	0.1076
Days to flowering	r_g		0.5885**	-0.6379**	0.0910	-0.0055	0.0494	-0.0337	0.1145	-0.0873	0.4050**	-0.5132**	0.0175
	r_p		0.4969**	-0.4350**	0.0755	0.0084	0.0554	0.0075	0.1058	-0.0604	0.3124*	-0.2559	-0.0185
Days to maturity	r_g			0.1197	0.1760	-0.1225	-0.1738	-0.2924*	-0.1115	0.2673	-0.0907	-0.2455	-0.0320
	r_p			0.0749	0.1701	-0.1056	-0.1657	-0.2480	-0.1128	0.2479	-0.0910	-0.1659	-0.0349
Plant height (cm)	r_g				0.0240	-0.0350	0.1876	-0.0617	0.0815	0.5906**	-0.2500	0.1580	-0.3680*
	r_p				0.0213	-0.0228	0.1651	-0.0349	0.0873	0.5108**	-0.1933	0.1302	-0.3050*
No. of primary branches per plant	r_g					-0.0083	-0.0343	0.0902	0.0819	-0.0487	-0.1489	0.2423	0.0485
	r_p					-0.0080	-0.0338	0.0803	0.0807	-0.0479	-0.1437	0.1853	0.0469
No. of mature	r_g						-0.0465	0.7409**	-0.0792	0.0203	0.3277*	0.3458*	0.2198

pods per plant	r_p						-0.0465	0.6701**	-0.0731	0.0182	0.3064*	0.3043*	0.2137
100 pods weight (g)	r_g							0.1177	0.8060**	0.1446	-0.0928	0.4050**	0.0122
	r_p							0.1005	0.7792**	0.1414	-0.0847	0.2998*	0.0110
Kernel yield per plant (g)	r_g								0.1261	0.0074	0.2395	0.5533**	0.1727
	r_p								0.1217	-0.0059	0.2312	0.4947**	0.1480
100 kernel weights (g)	r_g									0.1465	-0.1569	0.4648**	0.0015
	r_p									0.1367	-0.1450	0.3626*	-0.0044
Sound mature kernel (%)	r_g										-0.1633	0.1706	-0.0999
	r_p										-0.1644	0.1354	-0.0915
Biological yield per plant (g)	r_g											-0.7175**	-0.0351
	r_p											-0.5809**	-0.0239
Harvest index (%)	r_g												0.2052
	r_p												0.1384

*, ** significant at 5% and 1% levels, respectively.

Table 4: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on pod yield in bunch groundnut (*kharif*)

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of mature pods per plant	100 pods weight (g)	Kernel yield per plant (g)	100 kernel weights (g)	Sound mature kernel (%)	Biological yield per plant (g)	Harvest Index (%)	Oil Content (%)	Phenotypic correlation with pod yield/plant (g)
Days to flowering	-0.0223	0.0030	-0.0264	-0.0075	-0.0007	-0.0018	0.0058	0.0026	0.0010	0.1015	-0.0914	0.0002	-0.036
Days to maturity	-0.0111	0.0061	0.0045	-0.0169	0.0087	0.0055	-0.1914	-0.0028	-0.0040	-0.0296	-0.0593	0.0003	-0.29*
Plant height (cm)	0.0097	0.0005	0.0607	-0.0021	0.0019	-0.0054	-0.0269	0.0021	-0.0083	-0.0628	0.0465	0.0026	0.0185
No. of primary branches per plant	-0.0017	0.0010	0.0013	-0.0995	0.0007	0.0011	0.0619	0.0020	0.0008	-0.0467	0.0662	-0.0004	-0.0133
No. of mature pods per plant	-0.0002	-0.0006	-0.0014	0.0008	-0.0826	0.0015	0.5171	-0.0018	-0.0003	0.0995	0.1087	-0.0019	0.6388**
100 pods weight (g)	-0.0012	-0.0010	0.0100	0.0034	0.0038	-0.0330	0.0776	0.0190	-0.0023	-0.0275	0.1071	-0.0001	0.1558
Kernel yield per plant (g)	-0.0002	-0.0015	-0.0021	-0.0080	-0.0553	-0.0033	0.7717	0.0030	0.0001	0.0751	0.1767	-0.0013	0.9549**
100 kernel weights (g)	-0.0024	-0.0007	0.0053	-0.0080	0.0060	-0.0257	0.0939	0.0244	-0.0022	-0.0471	0.1295	0.0000	0.173
Sound mature kernel (%)	0.0013	0.0015	0.0310	0.0048	-0.0015	-0.0047	-0.0046	0.0033	-0.0162	-0.0534	0.0483	0.0008	0.0106
Biological yield per plant (g)	-0.0070	-0.0006	-0.0117	0.0143	-0.0253	0.0028	0.1785	-0.0035	0.0027	0.3248	-0.2075	0.0002	0.2677
Harvest index (%)	0.0057	-0.0010	0.0079	-0.0184	-0.0251	-0.0099	0.3818	0.0089	-0.0022	-0.1887	0.3572	-0.0012	0.515**
Oil content (%)	0.0004	-0.0002	-0.0185	-0.0047	-0.0176	-0.0004	0.1142	-0.0001	0.0015	-0.0078	0.0494	-0.0087	0.1075

*, ** Significant at 5% and 1% levels, respectively

Residual effect, R = 0.2133

Note: Values at diagonal indicate direct effects of respective character.

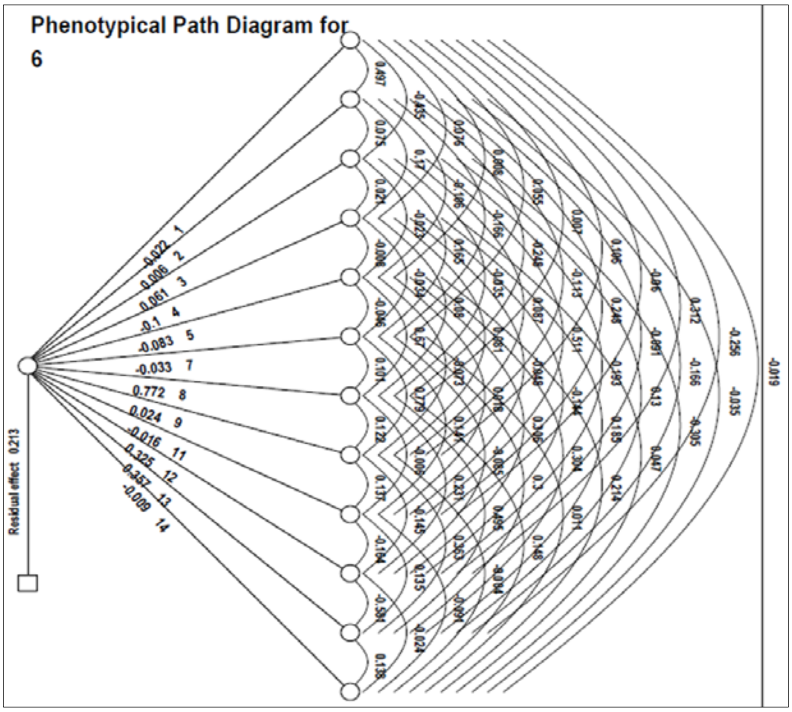

Fig 1: Diagrammatic representation of phenotypic path analysis in bunch groundnut (*kharif*)

4. Conclusion

The findings suggest that phenotypic selection would be more successful in increasing the biological yield per plant (g), number of mature pods per plant, harvest index (%), kernel yield per plant (g), 100 kernel weight (g), pod yield per plant (g), 100 pod weight (g), and plant height (cm) because the aforementioned characters have high GCV, PCV, heritability and genetic advance as per cent mean. Certain characters, such as the number of mature pods per plant, the harvest index (%) and the kernel yield per plant, have a significant and positive correlation with the number of pods yield per plant (g), both phenotypically and genotypically. The harvest index (%), biological yield per plant (g), and kernel yield per plant (g) all had a significant direct effect on the pod yield per plant (g).

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