Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 870-874
Received: 04-11-2017
Accepted: 05-12-2017

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Genetic variability, correlation and path analysis studies for yield and yield attributes in groundnut (*Arachis hypogaea* L.)

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Abstract
The genetic parameters like variability, heritability and genetic advance as the percent of mean were studied among 144 groundnut genotypes during *kharif* 2015. In all genotypes recorded the 13 different characters out of that plant height (cm), number of primary branches per plant, number of mature and immature pods per plant, kernel yield per plant, hundred kernel weight (g), haulm yield per plant and dry pod yield per plant had high GCV, PCV, heritability and genetic advance as the percent of mean. The high GCV, PCV, heritability in addition to genetic advance as per cent of mean for most of the characters was observed indicating the presence of considerable genetic variation and additive gene effects. Hence, the improvement of these characters could be effective through phenotypic selection. The phenotypic and genotypic correlation coefficient kernel yield per plant, mature pods per plant, sound mature kernel and haulm yield per plant had significant positive correlation with dry pod yield per plant. The kernel yield had high direct effect on dry pod yield.

Keywords: GCV, PCV, GAM, additive gene effect, phenotypic and genotypic correlation coefficient, direct effect

Introduction

The cultivated Groundnut or peanut (*Arachis hypogaea* L.) is an allotetraploid (2n = 4x = 40). It most probably originated in the region of eastern foothills of Andes (Southern Bolivia and Northern Argentina). Peanut is widely grown as an oil seed or food crop in more than 144 countries (includes tropical and warm temperate regions) of the world. The commercial production largely confined between 40^0N and 40^0S latitudes.

Groundnut is important oil seed crop and also utilized for different purposes like seed (kernel) consume directly raw, roasted and boiled or processed into confections and peanut flour for flavor enhancement or crush for oil for edible and industrial uses; source of high quality edible oil (44-56%), protein (22-30%) on a dry seed basis, carbohydrates (10-25%), vitamins (E, K, and B complex), minerals (Ca, P, Mg, Zn and Fe) and fibber; shell used as fuel and animal feed, cattle litter, filler in feed and fertilizer industry; Haulm used as animal fodder or in manuring; roots being legume add the nitrogen (100-152 kg ha^{-1}N) and organic matter to soil (Nigam, 2014) [18].

In India Groundnut occupy an area of 4.44 million hectare an annual production of 7.18 million tonnes (2015-16) with an average productivity level of 1615 kg ha^{-1} as compare to global productivity of 1675 kg ha^{-1}(Anon 2015) [2]. It indicates that there is more scope to improve in existing groundnut varieties. A critical analysis of the genetic of genetic variability is a pre requisite for initiating any crop improvement programme and for adopting of appropriate selection techniques (Dhanwani *et al*., 2013) [6].

The present investigation was carried with objectives to estimate the variability, character association and path analysis for yield and its components traits. This study will be helpful for harnessing present variability among them and helps in select the superior genotype through yield and related traits from correlation response which in turn can support the ongoing and future groundnut breeding programs.

Material and methods

The material for present study comprised of 144 groundnut genotypes (Supplement 1). The material was evaluated in simple lattice design with two blocks at Main Agriculture Research station, University of Agricultural sciences Raichur during rainy season (*kharif* 2015). Each blocks consisted of 144 genotypes. Each genotype in a block was grown in one row of 5 m length with spacing of 30 cm between rows and 10 cm between plants respectively. The recommended package of practices and plant protection measures were timely and uniformly applied to raise a good crop. The five plants were randomly selected from each genotype in both blocks. The selected plants were used for recording the fallowing observations like plant height (cm), number of primary branches per plant, days to physiological maturity, number of mature and immature pods per plant, shelling percentage, kernel yield per plant, sound mature kernels, hundred kernel weight (g), haulm yield per plant, oil percentage and dry pod yield per plant. The days to 50% flowering considered the whole genotypic line. The analysis of variance (Panse and Sukhatme, 1985) [20] was estimated using SAS 9.4 software (SAS, 2004). The mean, range, genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) were calculated by formula given by Burton (1952) [3], heritability (%) in broad sense was worked out by using formula suggested by Lush (1949) and genetic advance as per cent of mean were estimated by using the procedure given by Lush (1949) and Johnson *et al.* (1955) [10]. The genotypic and phenotypic correlations estimated by using procedure suggested by Al-Jibouri *et al.* (1958) [1].

Results and discussion

Analysis of variance revealed highly significant difference among the genotypes for all traits indicating thereby sufficient variability present in the material studied (Table 1).

Table 1: Analysis of variance for different characters in 144 groundnut genotypes.

Characters	Mean square with level of significance				
	Source of variation				
	Replications (1 df)	Blocks (22 df)	Treatments (143 df)	Error (Intra Block) (121 df)	Total (287 df)
Days to 50% flowering	5.84	0.38	5.42**	0.26	2.86
Plant height (cm)	48.92	0.62	58.20**	0.34	29.36
No. of primary branches/plant	35.42	0.47	4.10**	0.47	2.39
Days to physiological maturity	1.53	0.14	9.24**	0.05	4.64
No. of mature pods/plant	833.68	7.67	19.49**	4.43	15.07
No. of immature pods/plant	32.67	0.84	1.93**	0.33	1.28
Shelling percentage	0.05	1.1	67.17**	1.12	34.02
Kernel yield (g/plant)	0.68	0.02	4.81**	0.02	2.41
SMK (%)	19.01	1.81	31.42**	3	17.12
Hundred kernel wt (g)	14.99	0.52	127.23**	0.41	63.66
Haulm yield (g/plant)	3.26	0.14	79.11**	0.09	39.47
Oil percentage	16.88	0.64	26.91**	0.46	13.71
Dry pod yield (g/plant)	1.32	0.04	10.68**	0.03	5.34

In all the characters phenotypic coefficient of variance (PCV) was more than genotypic coefficient of variance (GCV) indicated larger influence of environment for the expression of these characters (Table 2). The estimation of genotypic and phenotypic coefficient of variation indicates the amount of genetic and non-genetic present for different desirable characters. The high and moderate GCV and PCV was observed in plant height (cm), number of primary branches per plant, number of mature and immature pods per plant, kernel yield per plant, hundred kernel weight (g), haulm yield per plant and dry pod yield per plant. The results were in accordance with Parameshwarappa *et al*. (2005) [21], John *et al*. (2008) [8], Zaman *et al*. (2011) [32], John *et al*. (2012) [9], Mukesh *et al*. (2014) [16], Narasimhulu *et al*. (2012) [17], Salih *et al*. (2014) [22], Yadav *et al*. (2014) [30], Vasanti *et al*. (2015) [27]. It indicates that good scope for yield improvement through phenotypic selection. The low GCV and PCV was observed in days to 50% flowering, days to physiological maturity, shelling percentage, sound mature kernels (%) and oil content (%) whereas; similar results reported by Jayalakshmi (1997) [7], Khangura and Sandhu (1973) [12], John *et al*. (2008) [8] and Yadav *et al*. (2014) [30]. The low GCV was indicating the large influence of environment for the expression of these traits.

Table 2: Genetic parameters for 13 morphological yield and yield attributes of 144 groundnut genotypes.

Sl. No	Characters	Mean	Range		GCV %	PCV %	h^2 (bs)	GA as % of Mean
			Min.	Max.				
1	Days to 50% flowering	26.87	23.00	30.00	5.97	6.28	90	11.68
2	Plant height (cm)	22.36	9.65	39.2	22.83	25.35	81	42.36
3	No. of primary branches/plant	5.46	3	10.5	24.59	27.61	79	45.13
4	Days to physiological maturity	116.28	112	123	1.84	1.86	99	3.77
5	No. of mature pods/plant	12.88	6.5	23.5	20.96	27.14	60	33.35
6	No. of immature pods/plant	1.68	0	4.5	55.58	59.9	86	106.24
7	Shelling percentage	65.95	45.48	74.94	6.19	8.53	53	9.27
8	Kernel yield (g/plant)	7.95	4.65	12.2	18.2	20.82	76	32.75
9	SMK (%)	85.07	75.5	94.5	4.45	4.86	84	8.37
10	Hundred kernel weight (g)	36.95	24.97	64.4	21.55	21.62	99	44.24
11	Haulm yield (g/plant)	19.94	10.35	39.24	28.4	30.79	85	53.95
12	Oil percentage	40.13	30.36	48.94	9.06	9.22	96	18.32
13	Dry pod yield (g/plant)	12.1	7.16	17.84	17.44	20.71	71	30.27

Heritability in broad sense is the ratio of genetic variance to the phenotypic variance which is heritable. High heritability in broad sense does not always mean better response to selection, since it is also inclusive of non additive genetic factors. Thus, estimation of genetic advance further narrow down the response of selection. Heritability coupled with genetic advance as per cent of mean gives a very good indication of nature inheritance and effectiveness of selection for a particular trait (Johnson *et al.* 1955) [10]. In present study, high heritability (>60%) and high GAM (>20%) observed (Table 3) in fallowing traits like, plant height (cm), number of primary branches per plant, number of mature and immature pods per plant, kernel yield per plant, hundred kernel weight (g), haulm yield per plant and dry pod yield per plant. The result was conformed to those observations by Vasanthi *et al*. (2003) [26], John *et al*. (2008) [8], Zaman *et al*. (2011) [32], Narasimhulu *et al*. (2012) [17], Mukesh *et al*. (2014) [16], Salih *et al*. (2014) [22], Yadav *et al.* (2014) [30] and Vasanti *et al*. (2015) [27] in different groundnut trails. The high heritability and GAM is a sign of additive gene action and the ensuing high extended genetic gain from selection of superior genotypes. Oil percent had high heritability and moderate GAM. The moderate heritability and low GAM was observed in shelling percentage, the similar finding reported by Manoharan and Ramalingam (1993) [15]. Days to 50% flowering, days to physiological maturity and sound mature kernels had high heritability and low GAM. It suggested that high heritability does not always indicate high genetic gain and preponderance of non-additive gene action governing the inheritance of these traits so phenotypic selection is not effective. The similar results reported by Yadav *et al*. (2014) [30] for days to 50% flowering and days to maturity and Suneetha *et al*. (2004) [24] for sound mature kernels.

Yield is a complex quantitative character governed by large number of genes and is greatly affected by environment. Hence, the selection of superior genotypes based on yield will not give a fruitful result. Association of yield components and yield thus, assumed special importance as the basis for selecting desired strains. Genetic correlation between different characters often arises due to its tight linkage or pleiotropy.

The phenotypic and genotypic correlation coefficients are presented in Table 3. When considered the correlation response of various traits with dry pod yield per plant. Both at phenotypic and genotypic level kernel yield per plant, mature pods per plant, sound mature kernel and haulm yield per plant had significant positive correlation with dry pod yield but hundred kernel weights shown the significant positive correlation with yield only at genotypic level. Other characters like plant height, primary branches per plant and hundred.

Table 3: Correlation co-efficient between yield and yield attributing traits in 144 groundnut genotype, during kharif season

Character	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	1	-0.378**	0.135	0.308**	-0.1	0.12	0.058	-0.026	-0.085	-0.0236	0.364**	0.366**	-0.046
X_2	-0.43**	1	0.13	-0.216*	-0.05	0.052	-0.146	-0.033	0.083	-0.074	-0.013	-0.249**	0.022
X_3	0.183*	0.185*	1	0.162	0.023	0.167	-0.188*	-0.016	-0.057	-0.1644	0.350**	0.033	0.062
X_4	0.330**	-0.247**	0.177*	1	-0.218*	-0.034	0.134	0.05	0.037	0.1612	0.299**	0.018	-0.001
X_5	-0.115	-0.091	0.08	-0.265**	1	0.065	-0.087	0.392**	0.057	-0.305**	0.037	0.064	0.427**
X_6	0.13	0.045	0.229**	-0.035	0.096	1	-0.035	-0.049	-0.267**	-0.1899*	0.208*	0.08	-0.04
X_7	0.112	-0.149	-0.212*	0.203*	-0.121	-0.063	1	0.197*	-0.023	-0.0125	-0.116	0.055	-0.227**
X_8	-0.053	-0.022	-0.044	0.059	0.606**	-0.058	0.273**	1	0.244**	0.149	0.198*	-0.009	0.905**
X_9	-0.091	0.097	-0.073	0.041	0.032	-0.331**	-0.031	0.337**	1	0.210*	0.017	0.0218*	0.260**
X_{10}	-0.049	-0.079	-0.182*	0.164	-0.391**	-0.208*	-0.004	0.166	0.234**	1	0.001	0.058	0.154
X_{11}	0.406**	-0.01	0.425**	0.323**	0.044	0.235**	-0.151	0.245**	0.015	-0.002	1	0.248**	0.250**
X_{12}	0.335**	-0.278**	0.049	0.021	0.102	0.083	0.103	-0.025	0.029	0.044	0.267**	1	-0.037
X_{13}	-0.094	0.03	0.03	-0.008	0.674**	-0.043	-0.092	0.930**	0.372**	0.174*	0.311**	-0.07	1
Significant at 5% = * and significant at 1%= **, Genotypic level = down ward left side of diagonal, Phenotypic level = upward ward right side of diagonal													

Where, X1=Days to 50% flowering, X2= Plant height (cm), X3= No. of primary branch per plant, X4= Days to physiological maturity, X5=No. of mature pods per plant, X6= No. of Immature pods per plant X7= Shelling Percentage, X8= Kernel yield, X9= Sound Mature Kernel, X10= Hundred Kernel Weight, X11= Haulm yield per plant (g), X12= oil content (%) and X_{13}= Dry pod yield per plant

Table 4: Phenotypic (P) and genotypic (G) path coefficient among dry pod yield and its attributing traits in 144 groundnut genotypes during *kharif* season

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	P	0.004	-0.0015	0.0005	0.0012	-0.0004	0.0005	0.0002	-0.0001	-0.0003	-0.0001	0.0015	0.0015	-0.0466
	G	0.0069	-0.0030	0.0013	0.0023	-0.0008	0.0009	0.0008	-0.0004	-0.0006	-0.0003	0.0028	0.0023	-0.0943
X_2	P	0.0028	-0.0074	-0.001	0.0016	0.0004	-0.0004	0.0011	0.0003	-0.0006	0.0005	0.0001	0.0018	0.0221
	G	-0.0029	0.0067	0.0012	-0.0016	-0.0006	0.0003	-0.0010	-0.0001	0.0006	-0.0005	-0.0001	-0.0019	0.0297
X_3	P	-0.0001	-0.0001	-0.0008	-0.0001	0	-0.0001	0.0002	0	0	0.0001	-0.0003	0	0.0625
	G	-0.0025	-0.0026	-0.0139	-0.0025	-0.0011	-0.0032	0.0029	0.0006	0.0010	0.0025	-0.0059	-0.0007	0.0300
X_4	P	0.0001	-0.0001	0.0001	0.0004	-0.0001	0	0.0001	0	0	0.0001	0.0001	0	-0.0019
	G	0.0036	-0.0027	0.0019	0.0108	-0.0029	-0.0004	0.0022	0.0006	0.0004	0.0018	0.0035	0.0002	-0.0078
X_5	P	-0.0007	-0.0004	0.0002	-0.0016	0.0073	0.0005	-0.0006	0.0029	0.0004	-0.0022	0.0003	0.0005	0.4278**
	G	-0.0083	-0.0066	0.0057	-0.0191	0.0721	0.0069	-0.0087	0.0437	0.0023	-0.0282	0.0032	0.0073	0.6741**
X_6	P	-0.0007	-0.0003	-0.0009	0.0002	-0.0004	-0.0055	0.0002	0.0003	0.0015	0.001	-0.0011	-0.0004	-0.0405
	G	-0.0003	-0.0001	-0.0005	0.0001	-0.0002	-0.0023	0.0001	0.0001	0.0008	0.0005	-0.0005	-0.0002	-0.0432
X_7	P	-0.0247	0.0617	0.0791	-0.0567	0.0369	0.0149	-0.4205	-0.0831	0.0099	0.0053	0.0488	-0.0231	-0.2274**
	G	-0.0383	0.0509	0.0725	-0.0693	0.0412	0.0215	-0.3415	-0.0933	0.0105	0.0014	0.0515	-0.0350	-0.0922
X_8	P	-0.0256	-0.0332	-0.0165	0.0498	0.3846	-0.0484	0.1939	0.9809	0.2399	0.1463	0.1947	-0.0093	0.9057**
	G	-0.0507	-0.0208	-0.0416	0.0561	0.5798	-0.0556	0.2614	0.9563	0.3220	0.1591	0.2340	-0.0236	0.9303**
X_9	P	-0.0008	0.0008	-0.0006	0.0004	0.0006	-0.0026	-0.0002	0.0024	0.0096	0.002	0.0002	0.0002	0.2608**
	G	-0.0025	0.0027	-0.0020	0.0011	0.0009	-0.0092	-0.0009	0.0094	0.0279	0.0065	0.0004	0.0008	0.3721**
X_{10}	P	-0.0001	-0.0002	-0.0004	0.0004	-0.0007	-0.0004	0	0.0003	0.0005	0.0022	0	0.0001	0.1547

	G	-0.0016	-0.0026	-0.0059	0.0053	-0.0126	-0.0067	-0.0001	0.0054	0.0075	0.0323	-0.0001	0.0014	0.1737*
X_{11}	P	0.0033	-0.0001	0.0032	0.0027	0.0003	0.0019	-0.0011	0.0018	0.0002	0	0.0091	0.0023	0.2505**
	G	0.0121	-0.0003	0.0127	0.0096	0.0013	0.0070	-0.0045	0.0073	0.0005	-0.0001	0.0298	0.0080	0.3109**
X_{12}	P	-0.0041	0.0028	-0.0004	-0.0002	-0.0007	-0.0009	-0.0006	0.0001	-0.0002	-0.0007	-0.0028	-0.0113	-0.0378
	G	-0.0096	0.0080	-0.0014	-0.0006	-0.0029	-0.0024	-0.0029	0.0007	-0.0008	-0.0013	-0.0076	-0.0286	-0.0699
Residual effect at phenotypic level = 0.086														

Where, X_1=Days to 50% Flowering, X_2= Plant Height, X_3= Primary Branch, X_4= Days to Maturity, X_5= Mature pods, X_6= Immature pods, X_7= Shelling Percentage, X_8= Kernel yield, X_9= Sound Mature Kernel, X_{10}= Hundred Kernel Weight, X_{11}= Haulm Yield, X_{12}= Oil %, X_{13}= Dry Pod yield, P= phenotypic level, G=genotypic level,

Significance at 5% = *

Significance at 1% = **

kernel yields had positive correlation but not significant with dry pod yield per plant both al genotypic and phenotypic level. The significant correlation indicates that there is strong association between various traits and dry pod yield per plant. A positive correlation between desirable characters is favorable to the plant breeder because it helps in simultaneous improvement of both characters.

The traits like days to 50% flowering, days to maturity, number of immature pods per plant and shelling percentage had negative correlation with dry pod yield per plant at both phenotypic and genotypic level where as shelling percentage had significant positive correlation at phenotypic level. The negative correlation will hinder the improvement in such situations some economic comprises has to be made. The results are in consonance with those of lakshmidevamma *et al*. (2004) [13] for days to 50% flowering, plant height, primary branches per plant and shelling percentage. Vasanti *et al*. (2015) [27] for primary branches per plant and mature pods per plant. Kavani *et al*. (2004) [11] for kernel yield per plant, haulm yield per plant and hundred kernel weights. Yoa *et al*. (1982) and Pallas *et al.* (1979) [19] for immature pods per plant. Dobaria *et al*. (2004) for oil content.

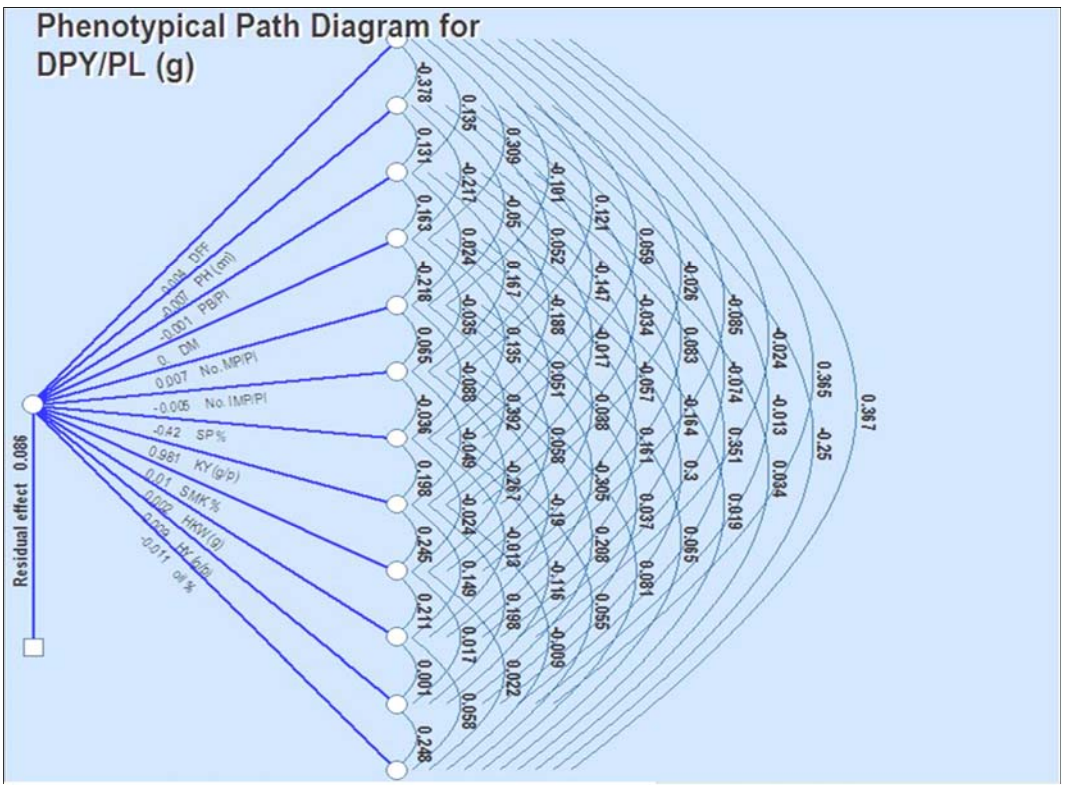

Fig 1

The path coefficient analysis suggested by Dewey and Lu (1959) specified the effective measure of direct and indirect causes of association and also depicts the relative importance of each factor involved in contributing to the final product that is yield. Due to more negligible value in genotypic level, only path analysis at phenotypic level is discussed below. The kernel yield per plant (0.9809) had highest direct effect on dry pod yield. The traits like number of mature pods per plant (0.0029), sound mature kernels (0.0024) and haulm yield (0.0018) had the high and positive indirect effect on dry pod yield via kernel yield (Table 4) (Fig. 1). However, the direct effect of number of mature pods, SMK, shelling percentage and haulm yield had very low but indirect effect of these traits via kernel yield per plant were high due to its phenotypic correlation with pod yield. Similar results were reported by Venkataravan *et al*. (2000) [28], Vijayasekhar (2002) [29].

Conclusions

From the results, it can be concluded that phenotypic selection would be more effective for improvement of plant height (cm), number of primary branches per plant, number of mature and immature pods per plant, kernel yield per plant, hundred kernel weight (g), haulm yield per plant and dry pod yield per plant because above characters had high GCV, PCV, heritability and GAM. Both at phenotypic and genotypic level kernel yield per plant, mature pods per plant, sound mature kernel and haulm yield per plant had significant positive correlation with dry pod yield. The kernel yield per plant had high direct and indirect effect on dry pod yield in groundnut.

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