Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 1966-1973
Received: 12-07-2017
Accepted: 13-08-2017

Sushree Sibanee Sardar
Senior Research Fellow, NRRI, Cuttack, Odisha, India

Kedareswar Pradhan
ADR-RRTTS, Semiliguda, Odisha, India

Bibhu Santosh Behera
PhD Research Fellow, OUAT, Bhubaneswar, Odisha, India

Correspondence
Sushree Sibanee Sardar
Senior Research Fellow, NRRI, Cuttack, Odisha, India

Variation, correlation and path-coefficient study in groundnut breeding lines of Odisha

Sushree Sibanee Sardar, Kedareswar Pradhan and Bibhu Santosh Behera

Abstract
Thirty two F6 progenies with along with 4 released varieties as parents were evaluated in R.B.D for yield and its component traits grown in *rabi* season showed a wide range of variation in all the 10 morphometric traits including yield. The genotypic source of variations were highly significant (at 1% level) for all the traits. The P.C.V. and G.C.V. estimates were high for haulm yield per plant and low for harvest index and shelling percent. The rest of the characters exhibited medium PCV and GCV. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated that they are controlled largely by non-additive gene action and selection would be less effective, so there is need to create variability either by hybridization or mutation followed by selection. High heritability and high genetic advance indicated that these traits are mainly governed by additive gene action. Hence, improvement of these traits would be more effective through the phenotypic selection. Moderate heritability and genetic advance (GAM) as percent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non additive gene actions for these traits and phenotypic selection would be effective to some extent. Kernel yield per plant had the highest direct positive effects on pod yield per plant followed by number of kernels per plant and 100 kernel weight. All other characters through these three characters made major indirect contribution towards pod yield. Plant height, number of branches per plant and number of pods per plant exhibited greater influence on pod yield per plant via kernel number per plant and kernel yield per plant. Haulm yield and harvest index influenced indirectly on pod yield through kernel weight and kernel number respectively. Present study thus indicated that kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.
But OGZ5 and OGZ6 recorded highest pod and kernel yield per plant with haulm yield although exhibited moderate chlorophyll and protein values is due to the balance in the physiological parameters contributing towards yield. Chlorophyll, protein and yield were not related in the same magnitude and direction in all the crosses. OGZ5 & OGZ6 may be identified as promising line for high protein content (25%) and (31%) with moderate chlorophyll and higher yield.
Out of 36 genotypes evaluated the genotypes like OGZ5, OGZ2, R 2001-3A, OGZ6 and OGX4 were sorted out to be promising in respect of high yield. The higher productivity in these promising lines is due to a combination of various morpho- physiological traits and which could be ascribed as the basis of potential productivity in groundnut. High yield of different promising entries could be attributed to taller plant height, moderate to high number of branches /plant and number of pods per plant and moderately high 100 kernel weight, may serve as the basis of yield vigour which could be utilized as important selection criteria for prediction and realization of high yield in groundnut.

Keywords: Variation, correlation, path-coefficient study, groundnut breeding lines

Introduction
Groundnut is an important oil, food, and feed legume crop grown in over 100 countries. It covered 24 million ha area worldwide with a total production of 41 million tons in 2012 (FAOSTAT, 2012) [9]. In India, groundnut is cultivated in an area of 4.9 m ha, with production and productivity levels of 5.8 m tons and 1179 kg/ha respectively during 2012. Groundnut is valued as a rich source of energy contributed by oil (48–50%) and protein (25–28%) in the kernels. They provide 564 kcal of energy from 100 g of kernels (*Jambunathan*, 1991). Breeding for high yield and superior quality parameters such as food (protein) is important targeted trait in advanced breeding programs which help in enhancing the economic returns to the farmers and other stakeholders along the value chain.
The pod yield is a function of crop growth rate, duration of reproductive growth, and the fraction of crop growth rate partitioned toward pod yield. Therefore, understanding the physiological basis of yield and manipulation of physiological trait such as harvest index is as important as yield contributing parameters i.e. Pod yield per plant, number of pods per plant,

shelling outturn, and 100-seed weight for improvement of production and productivity in groundnut. Haulm yield becomes an important consideration in addition to pod yield for the development of dual purpose varieties in groundnut.

Adequate amount of genetic variability and the genetic nature of the traits of interest are prerequisites for judicious selection of parents as well as choice of appropriate breeding methods for the development of improved varieties in groundnut. However, much of the variability is still underexploited in groundnut improvement. Therefore, it becomes a serious and challenging problem for the breeders to make rapid improvement for development of varieties with high yield, better resistance and superior quality in groundnut.

Selection for yield *per se* has been the basis for improving groundnut productivity in semi-arid environments **(**Nigram *et al*., 1991) but gain from such selection is slow due to large environmental effects. Further, inter-genotypic competition and a large experimental error associated with yield measurements often bias the outcome of selection for higher yield. Therefore, several workers in different crop plants have emphasized the importance of indirect selection for yield through component traits governed by genes with additive effect and strong correlation with yield. Therefore, it would be rewarding and the efficiency of single plant selection for yield would be improved via selection of other additional component traits rather than yield alone. Use of physiological models offer means of identifying traits linked with yield and the selection of such traits for improvement of yield may enhance the efficiency of breeding **(**Williams, 1992).

Wallace *et al.* (1993) suggested that indirect selection for yield will be most effective when applied to traits that already integrate most of the genetic and environmental effects that lead to yield. Bandyopadhyay *et al.* (1985**)** evaluated the genetic potential of F2 progeny from single and three-way crosses using and they found that a selection index based on physiological and yield components to be more effective than an index based on yield components alone. The effectiveness of early generation selection in peanut appears to be enhanced by limiting its use to traits of high heritability or to indirect selection for yield, based on selection for correlated traits. This is contrary to the results of Halward *et al*. (1990) who reported no relationship between yield of F3 and F4 and concluded that pod yields in early generations were ineffective in predicting the yield potential of crosses grown in bulk in later generations.

Realizing the importance of developing groundnut varieties with high yield, better resistance and superior quality and in the light of the above discussions, efforts were made to evaluate 32 breeding lines along with 4 parental lines during the course of present investigation for the assessment of

- Availability and extent of genetic variability in yield and yield attributing characters and other traits like chlorophyll and protein level.
- Nature and magnitude of character association in relation to yield and its components and various other traits.
- Identification of promising breeding lines for prediction of higher yield.
- Direct and indirect effects of different component traits on yield through path analysis.

Materials Methods

The present "Study on morphometric and molecular variation in groundnut breeding lines." was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. The thirty six genotypes were evaluated comprised of 4 parents and their 32 progenies. Plant materials, their source and characters mentioned in Table 1. Observations on ten quantitative characters like plant height (cm), number of branches per plant, haulm yield per plant (g), harvest index (%), number of pods per plant, shelling percentage, number of kernels per plant, 100 kernel weight (g), kernel yield per plant (g) and pod yield per plant (g) were recorded from the field trial. The data were analyzed to get information on genetic variation of yield and its components for selection of promising lines.. Correlations among traits, direct and indirect effects of component traits on yield were estimated for selecting characters contributing to yield. Besides these, chlorophyll (a+b) and seed protein were estimated to study their relationship with yield. Each entry was represented by three rows of 3m length with 3 replications. Observations were recorded for 5 plants by random sampling per genotype in each replication.

Table 1: Plant materials, their source and characters

Variety no	Genotype	Source	Character
1	AK 12-24	Local variety	Well adopted var.
2	TG-26	Local variety	Better grain filling capasity
3	OGX1	AK-12-24 × TG-26	-
4	OGX2	AK-12-24 × TG-26	-
5	OGX3	AK-12-24 × TG-26	-
6	OGX4	AK-12-24 × TG-26	-
7	OGX5	AK-12-24 × TG-26	-
8	R-2001-3	Local variety	Higher number of pod/plant
9	AK-159	Local variety	Large seed and leaf size
10	OGZ1	AK-159 × TG-26	-
11	OGZ2	AK-159 × TG-26	-
12	0GZ3	AK-149 × TG-26	-
13	0GZ4	AK-159 × TG-26	-
14	OGY1	R-2001-3 × TG26	-
15	OGY2	R-2001-3 × TG-26	-
16	OGY3	R-2001-3 × TG-26	-
17	OGY4	R-2001-3× TG-26	-
18	OGY5	R-2001-3 × TG-26	-
19	OGY6	R-2001-3 × TG-26	-
20	OGY7	R-2001-3 × TG-26	-
21	OGY8	R-2001-3 × TG-26	-
22	OGY9	R-2001-3 × TG-26	-
23	OGY10	R-2001-3 × TG-26	-
24	OGY11	R-2001-3 × TG-26	-
25	OGY12	R-2001-3 × TG-26	-
26	OGY13	R-2001-3 × TG-26	-
27	OGY14	R-2001-3 × TG-26	-
28	OGY15	R-2001-3 × TG-26	-
29	OGY16	R-2001-3 × TG-26	-
30	OGY17	R-2001-3 × TG-26	-
31	OGY18	R-2001-3 × TG-26	-
32	OGY19	R-2001-3 × TG-26	-
33	OGY20	R-2001-3 × TG-26	-
34	OGZ5	AK-159 × TG26	-
35	OGZ6	AK-159 × TG26	-
36	OGZ7	AK-159 ×TG26	-

Analysis of variance of 4 parents and their 32 progenies for each character was carried out in RBD with plot means for partitioning of total variance into components. The test weight of significance of difference among lines was done by F test.

Genetic varience & heritability: The phenotypic, genotypic and environmental variance components for different characters were estimated from estimated from the mean squres in ANOVA according to Al-Jibouri *et al.*(1958)**.**

Correlation coefficient: Utilising the various components of variance, co-variance, the genotypic, phenotypic correlation were computed according to Al-jibouri *et al.*(1958).

Path coefficient: In present study pod yield is taken as 'effect' and 9 growth component characters related to yield as 'causal factors'. Path coefficients are obtained by solving simultaneous equations, which gives the basic relationship between correlations (Wright, 1921; Dewey and Lu, 1959).

Estimation of chlorophyll content by SPAD meter:
Soil plant analytical development (SPAD) chlorophyll meter reading(SCMR) was taken in 3 random sample leaf from tip of the main stem at 60 days after sowing. Ambient light should be avoided during taking observation.

Extraction of chlorophyll sample by chemical method:
Procedure & estimation: Pre-chilled 80% acetone are prepared before. 80% acetone was added during grinding of 0.5g sample to dissolve the pigment. Leaf were grind to a fine powder. Extraction was decanted to 2ml eppendorf tubes. Then those chlorophyll samples were centrifused in 5000 rpm for 5mins at 4 ^{0}C in the dark. Then the entire extract decanted into the 10ml measuring cylinder and volume made to 10ml in each sample.

OD value of each sample was read in sprectro-photometer. Samples are taken in curvette (1ml capacity) of sprectrophotometer. OD value recorded at 646nm and 663nm against the solvent 80% acetone as blank.. chl a and chl b content calculated according to procedure of Porra *et al.*(1989).

Protein content estimation: Protein can be estimated by method (Lowry *et al.* 1959)

Results and Discussion

Mean performance of the genotypes

Mean performance of 36 genotypes for all the ten morpho-metric traits is presented in Table 2. The genotype TG 26 was the tallest plant with 22.73 cm in plant height. OGZ7 was observed to be shortest in plant height of 12.13cm. The highest number of branches per plant (8.07) was observed in OGY14. OGY7 exhibited the lowest haulm yield per plant (5.0 g) with highest harvest index (70.29). The haulm yield per plant was highest (15.67 g) in OGZ6. The parent R 2001-3 exhibited highest number of pods per plant (23.87) and kernels per plant (33.13). Among the genotypes, parent AK 12-24 exhibited lowest shelling percent and the other parent TG 26 exhibited highest shelling percent (79.84). The hundred kernel weight of test entries ranged from 33.27 g (OGY1) to 67.65 g (OGZ5). Besides 100 kernel weight, OGZ5 exhibited highest value in both kernel yield (15.86 g) and pod yield (21.27g) per plant. A perusal of the relative magnitude of variation from the analysis of variance and range of variations in respect of all the characters under study, revealed the presence of ample genetic variability in the material, thus providing enormous scope for selection of genotypes and which could be used in the future breeding programmes for realization of high and stable yield in groundnut. Similar results were also reported by Jatti *et al*. (2008); Savalya *et al*., (2009); Singh *et al*., (2010) and Upadhyaya *et al*.,(2011).

The mean chlorophyll, protein and pod yield with SCMR are presented in table 2. OGX2 recorded the highest total chlorophyll and but not higher yield. OGY8 recorded lowest chlorophyll. OGZ7 exhibited highest protein % with highest SCMR. Some lines show higher range of SCMR reading (10.78-12.80) from which OGZ4 and OGZ6 shows moderate range of chlorophyll. High yielding line as OGZ6 shows high SCMR reading, with moderate chlorophyll value, with high protein content. OGZ5 recorded highest pod and kernel yield per plant with haulm yield although exhibited moderate chlorophyll value with higher protein content. The highest yield obtained in OGZ5 with moderate chlorophyll content is due to the balance in the physiological parameters contributing towards yield. Babitha *et al*. (2006) reported low, medium and high for SPAD chlorophyll meter reading (SCMR) in moisture stress and high tolerance stress. So OGZ5 and OGZ6 may be identified as promising line.

The protein content of 36 genotypes, presented in Table 2 indicated that entries like AK 12-24, OGZ4,OGY17,OGY18,OGZ5,OGZ6 and OGZ7 contain higher level of protein content ranging from 25.43%-32.72%. The variability in protein content in groundnut has been reported by Asibuo (2008) [2] and Cholin *et al*. (2010). It was interesting to note that majority of high yielding lines except OGZ5 and OGZ6 were lower in protein content and on the contrary, high protein lines are inferior in yield performance. There is a general observation that high yelding lines are inferior in protein content. However it is an important significant finding that two promising lines like OGZ5 AND OGZ6 combine high yield with high protein content, which could be identified as promising and prospective lines, on the contrary some of the genotypes like AK 12-24, OGZ4, OGY17, OGY18 AND OGZ7, despite lower yield have high protein content could be utilized as parental sources for transferring protein content in groundnut. Upadhyaya *et al*. (2012) reported eighteen accessions with higher nutritional traits such as protein content, oil content, with superior agronomic trait.

Variability, heritability and genetic advance

The 4 parents and their 32 progenies showed wide variation in all the 10 traits including yield. The genotypic source of variations were highly significant (at 1% level) for all the traits (table 3).

Table 2: Mean performance of the groundnut genotypes

Sl No	Character /Genotype	Plant height (cm)	No. of branches/ plant	Haulm yield/ Plant	Harvest index (%)	No. of pods/ plant	Shelling (%)	No. of kernels/ plant	100 kernel weight (g)	Kernel yield/ plant (g)	Pod yield/ plant (g)	Protein (%)	SCMR	Chlorophyll a+b (μg/g)
1	AK 12-24	15.57	4.07	6.33	69.39	12.73	52.75	21.27	35.41	7.53	14.53	30.58	9.00	286.83
2	TG 26	22.73	4.63	10.33	57.92	15.87	79.84	29.73	38.22	11.34	14.20	19.61	7.00	460.19
3	OG X1	16.83	3.50	9.33	45.51	9.43	62.70	13.67	35.85	4.88	7.80	13.68	7.96	391.71
4	OG X2	18.33	4.50	10.00	52.92	11.93	75.73	22.33	38.36	8.61	11.47	10.41	7.36	686.25
5	OG X3	19.10	4.00	10.00	52.05	13.67	73.65	23.47	35.00	8.15	11.10	17.85	8.84	352.59
6	OG X4	18.33	5.00	12.33	56.00	20.13	76.79	24.53	38.92	12.18	15.73	15.75	9.51	196.10
7	OG X5	12.53	4.20	7.00	57.06	9.93	78.34	17.00	43.20	7.30	9.30	10.21	7.83	154.10
8	R 2001-3	19.87	7.73	12.33	58.66	23.87	71.65	33.13	37.54	12.44	17.33	14.66	8.58	125.76
9	AK 159	16.23	5.23	9.00	60.18	16.80	75.64	29.67	35.26	10.33	13.67	13.04	6.58	391.56
10	OG Z1	16.73	6.80	14.33	48.03	13.20	61.28	17.93	43.27	7.79	12.67	9.01	7.53	208.71
11	OG Z2	20.00	6.40	11.33	62.43	14.13	74.09	20.93	65.36	13.69	18.47	18.41	10.78	221.29
12	OG Z3	14.13	5.00	11.00	52.74	17.87	72.70	19.53	43.63	8.48	11.73	23.32	12.32	166.36
13	OG Z4	12.80	4.93	10.33	50.26	11.40	75.42	18.07	43.29	7.81	10.40	26.25	12.50	288.55
14	OG Y1	16.73	7.60	9.33	58.38	18.33	73.11	29.47	33.27	9.89	13.53	13.32	9.81	192.79
15	OG Y2	17.13	7.00	7.33	63.69	18.27	73.58	22.87	40.56	9.25	12.73	14.09	9.30	203.84
16	OG Y3	21.33	6.73	8.00	62.30	16.13	72.71	23.40	38.49	8.90	12.27	8.43	10.91	216.77
17	OG Y4	16.73	7.60	7.80	63.36	16.47	71.85	24.53	39.23	9.65	13.40	15.59	8.01	198.75
18	OG Y5	14.07	6.73	5.80	67.64	16.80	72.21	23.47	37.10	8.72	12.13	12.55	7.30	242.71
19	OG Y6	17.20	6.67	6.67	62.71	15.53	73.21	22.40	36.65	8.10	11.07	19.79	7.50	174.51
20	OG Y7	12.33	6.80	5.00	70.29	15.47	74.89	23.07	38.26	8.82	11.80	20.51	8.55	292.90
21	OG Y8	14.53	6.57	7.67	56.31	16.87	76.24	20.27	37.66	7.58	9.93	16.95	7.60	88.33
22	OG Y9	18.13	6.20	7.67	61.90	14.33	75.73	19.27	46.81	9.15	12.00	21.13	7.30	201.60
23	OG Y10	16.47	7.00	8.33	62.43	19.33	72.72	24.07	40.96	9.93	13.80	12.45	7.10	135.81
24	OG Y11	13.47	6.33	6.67	64.92	15.53	77.61	23.00	40.22	9.21	11.93	18.45	7.40	87.73
25	OG Y12	16.47	7.40	8.33	62.33	18.13	75.02	27.20	37.20	10.22	13.60	19.95	8.50	113.05
26	OG Y13	15.13	7.13	6.33	68.09	13.87	71.63	27.80	35.00	9.72	13.53	13.88	8.60	297.86
27	OG Y14	16.73	8.07	9.13	58.32	15.27	71.17	24.60	35.56	8.82	12.47	16.99	8.10	217.69
28	OG Y15	17.53	7.20	9.13	60.31	17.33	73.51	27.93	36.45	10.33	13.87	24.41	9.20	220.59
29	OG Y16	17.60	6.87	8.13	63.22	14.80	76.70	26.40	40.13	10.63	13.87	23.17	7.10	214.00
30	OG Y17	16.07	7.07	6.33	70.09	13.93	76.63	28.73	39.03	11.25	14.73	30.64	9.15	240.06
31	OG Y18	18.33	7.67	9.00	61.60	16.87	76.53	29.00	36.82	10.78	14.13	27.95	8.18	143.60
32	OG Y19	19.07	7.47	9.00	62.37	20.00	76.04	32.27	35.18	11.24	14.80	17.80	9.01	159.95
33	OG Y20	18.60	7.33	11.53	48.11	15.17	60.57	15.53	40.59	6.42	10.47	20.26	8.64	109.37
34	OG Z5	22.20	7.73	17.67	54.94	18.73	75.06	23.47	67.65	15.86	21.27	25.43	8.65	281.05
35	OG Z6	21.93	6.27	15.67	52.18	18.27	71.67	24.20	50.37	12.25	17.07	31.39	11.50	282.79
36	OG Z7	12.13	5.13	6.00	67.41	14.60	75.98	23.33	39.52	9.18	12.07	32.72	12.80	130.97

Table 3: Analysis of varience of 10characters of Groundnut

Sl. No.	Character	Source	MSS	F	Prob>F
1	Plant height (cm)	Replication	77.036	7.509**	0.001
		Genotype	22.722	2.215*	0.002
2	No of branches/ plant	Replication	7.763	14.999**	0.000
		Genotype	4.877	9.424**	0.000
3	Haulm yield/ plant (g)	Replication	1.111	0.148	0.863
		Genotype	23.375	3.110**	0.000
4	Harvest index (%)	Replication	27.975	0.968	0.385
		Genotype	125.385	4.337**	0.000
5	No. of pods/ plant	Replication	23.373	2.129	0.127
		Genotype	26.009	2.369**	0.001
6	Shelling (%)	Replication	32.216	1.009	0.370
		Genotype	89.110	2.791**	0.000
7	No. of kernels/ plant	Replication	1.082	0.072	0.931
		Genotype	61.932	4.090**	0.000
8	100 kernel weight(g)	Replication	5.302	0.265	0.768
		Genotype	160.773	8.022**	0.000
9	Kernel yield/ plant (g)	Replication	0.230	0.053	0.949
		Genotype	13.062	2.987**	0.000
10	Pod yield/ plant (g)	Replication	2.037	0.265	0.768
		Genotype	20.187	2.625**	0.000

* Significant at 5 % level, **Significant at 1 % level

Table 4: Genetic parameters of the morphological characters in groundnut

Character	Mean	Range	PCV (%)	GCV (%)	h^2 (%)	GA (% of mean)
Plant height (cm)	17.03	12.13-22.73	22.291	11.967	28.82	13.23
No of branches/ plant	6.29	3.5-8.07	22.307	19.155	73.74	33.89
Haulm yield/ plant (g)	9.17	5.00-17.67	39.010	25.066	41.29	33.18
Harvest index (%)	59.61	45.51-70.29	13.109	9.513	52.66	14.22
No. of pods/ plant	15.86	9.43-23.87	25.210	14.112	31.33	16.27
Shelling (%)	72.92	52.75-79.84	9.793	5.987	37.38	7.54
No. of kernels/ plant	23.82	13.67-33.13	23.275	16.579	50.74	24.33
100 kernel weight(g)	40.45	33.27-67.65	20.231	16.934	70.07	29.20
Kernel yield/ plant (g)	9.62	4.88-15.86	28.016	17.685	39.85	23.00
Pod yield/ plant (g)	13.19	7.80-21.27	26.105	15.472	35.13	18.89

The genetic parameters of morphological characters in groundnut during rabi seasons are presented in table 4. Wide range of variation was recorded for all the characters. The P.C.V. and G.C.V. estimates were high for haulm yield per plant and low for harvest index and shelling percent. The rest of the characters exhibited medium PCV and GCV. Among F2 population of six single crosses and their parents, John *et al*. (2008) and Jatti *et al*. (2008) observed high estimates of GCV and PCV, for haulm yield per plant. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated the need to create variability either by hybridization or mutation followed by selection. Low G.C.V. estimates for shelling percent was also reported by Pradhan and Patra (2011) in a study taking 460 genotypes of groundnut germplasm in four different seasons for pod yield and yield component characters. High heritability estimates were observed for number of branches per plant and 100 kernel weight indicating less influence of environment on these characters. Jogloy *et al*. (2011) recorded low to moderate heritability estimates for 100-seed weight. Johnson *et al*. (1955) reported that heritability estimates along with genetic gain would be more useful than the former alone in predicting the effectiveness of selecting the best indivisual. Therefore it is essential to consider the predicted genetic advance along with heritability estimate as a tool in the selection programme for better efficiency. Along with high heritability, high genetic advance as percentage of mean has been noticed for number of branches per plant and hundred kernel weight. Therefore it was clear that these two traits were less influenced by the environmental changes due to the presence of additive gene action in their expressions. For number of branches per plant, John *et al*. (2008) reported low heritability and moderate genetic advance as per cent of mean where as Hiremath *et al*. (2011) observed high GCV accompanied by high heritability and high genetic advance as per cent of mean. Savaliya *et al*. (2009) and John *et al*.(2008) observed high heritability combined with high genetic advance (GAM) as percent of mean for 100-seed weight, in contrast to which Jogloy *et al*. (2011) recorded low to moderate heritability estimates for 100-seed weight. Heritability and genetic advance as percent of mean were moderate for harvest index and low for shelling percent. Similar result was also reported by Vishnuwardhan *et al*. (2013) for shelling percentage and harvest index.

Thus harvest index and shelling percent were controlled largely by non-additive gene action and selection would be less effective. Moderate heritability and genetic advance (GAM) as percent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non-additive gene actions for these traits and phenotypic selection would be effective to some extent. High heritability along with, high genetic advance as percentage of mean for number of branches per plant and hundred kernel weight indicated that these traits are mainly governed by additive gene action and responsive to selection. Hence improvement of these traits would be more effective through the phenotypic selection. Low genetic advance along with low heritability estimate for shelling percent and harvest index in released varieties during 1905 to 2002 were reported by Rathnakumar *et al*. (2010) revealed no significant improvement in these two traits. Rather the enhanced pod yield of 9.4 kg/ha per annum has resulted mainly from improvements in number of pods per plant, pod and seed weight.

Phenotypic and genotypic correlations among traits

Table 5: Phenotypic correlation coefficients (r_p) among the characters in groundnut

Character	1	2	3	4	5	6	7	8	9	10
1	1.000	0.122	0.485**	-0.281*	0.267	-0.159	0.146	0.268	0.316*	0.378*
2		1.000	0.170	0.180	0.488**	0.007	0.414**	0.081	0.372*	0.388**
3			1.000	0.684**	0.392**	-0.233	0.042	0.518**	0.474**	0.576**
4				1.000	0.065	0.294	0.418**	-0.112	0.234	0.170
5					1.000	0.104	0.552**	0.116	0.600**	0.607**
6						1.000	0.353*	0.084	0.357*	0.028
7							1.000	-0.192	0.645**	0.576**
8								1.000	0.564**	0.568**
9									1.000	0.939**
10										1.000

Table 6: Genotypic correlation coefficients (r_g) among the characters in groundnut

Character	1	2	3	4	5	6	7	8	9	10
1	1.000	0.250	0.847**	-0.293*	0.493**	0.247	0.499**	0.422**	0.882**	0.884**
2		1.000	-0.041	0.417**	0.687**	0.197	0.474**	0.089	0.451**	0.438**
3			1.000	-0.713	0.120	0.033	-0.152	0.644**	0.461**	0.481**
4				1.000	0.292*	0.131	0.507**	-0.212	0.231	0.263
5					1.000	0.416**	0.750**	-0.101	0.597**	0.526**
6						1.000	0.487**	0.120	0.547**	0.237
7							1.000	-0.356*	0.581**	0.490**
8								1.000	0.554**	0.583**
9									1.000	0.943**
10										1.000

1. Plant height (cm), 2. No of branches/ plant, 3. Haulm yield/ plant (g), 4. Harvest index (%),
5. No. of pods/plant, 6. Shelling (%), 7. No. of kernels/plant, 8. 100 kernel weight (g),
9. Kernel yield / plant (g), 10. Pod yield / plant (g)
* and **Significance at 5 % level and 1 % level of probability respectively at n-2 degrees of freedom

Out of the 45 correlation coefficients among the 10 traits 22 correlation coefficients were significant at phenotypic level (table 5), whereas 28 correlation coefficients were significant at genotypic level (table 6). In general, the values of genotypic correlation (r_g) were higher than their corresponding phenotypic correlation (r_p) indicating that there was high degree of association between two variables at genotypic level. Its phenotypic expression was deflated by the influence of environment, pointing out the possibilities of effective phenotypic selection. Pod yield per plant and kernel yield per plant exhibited highly significant positive correlations and both these traits also exhibited significant positive correlations with number of branches per plant, haulm yield per plant, number of pods and kernels per plant and hundred kernel weight at both phenotypic and genotypic level. The plant height was significantly associated with pod yield per plant. Haulm yield exhibited highly positive correlation with plant height.

Besides correlation with pod and kernel yield, haulm yield also exhibited significant positive correlation with hundred kernel weight and number of pods per plant. Thus it can be inferred that haulm yield is one important selection criteria for increasing pod and kernel yield per plant. Number of pods per plant and number of kernels per plant were positively associated and both were positively correlated with number of branches per plant. Number of kernels per plant exhibited positive correlation with harvest index and shelling percentage.

Hiremath *et al*. (2011), Giri & Hudge (2010) [10], Shoba *et al*. (2012) and Korat *et al*. (2010) reported significant positive association for pod yield per plant with kernel yield and 100 seed weight both at genotypic and phenotypic level. Gomes and Lopes (2005) also reported pod yield was positively associated with 100 seed mass, primary secondary branches per plant and harvest index. Vaithiyalingan *et al*. (2010). Pod yield exhibited significant positive association with pods per plant, dry matter production, kernel weight and harvest index that supports the present finding.

Path co-efficient analysis

Table 7: Direct and indirect effects of component traits on pod yield

Characters	Plant height (cm)	No. of branches/ plant	Haulm yield/ Plant	Harvest index (%)	No. of pods/ plant	Shelling (%)	No. of kernels/ plant	100 kernel weight (g)	Kernel yield/ plant (g)	Pod yield/ plant (g)
Plant height (cm)	-0.076	-0.028	-0.023	0.004	0.042	-0.109	0.269	0.223	0.583	0.884
No of branches/ plant	-0.019	-0.111	0.001	-0.005	0.059	-0.087	0.255	0.047	0.298	0.438
Haulm yield/ plant (g)	-0.065	0.005	-0.027	0.009	0.010	-0.015	-0.082	0.340	0.304	0.481
Harvest index (%)	0.022	-0.046	0.020	-0.013	0.025	-0.058	0.273	-0.112	0.152	0.263
No. of pods/ plant	-0.038	-0.076	-0.003	-0.004	0.086	-0.184	0.404	-0.054	0.395	0.526
Shelling (%)	-0.019	-0.022	-0.001	-0.002	0.036	-0.442	0.262	0.063	0.361	0.237
No. of kernels/ plant	-0.038	-0.053	0.004	-0.007	0.064	-0.215	0.539	-0.188	0.383	0.490
100 kernel weight(g)	-0.032	-0.010	-0.018	0.003	-0.009	-0.053	-0.192	0.528	0.366	0.583
Kernel yield/ plant (g)	-0.067	-0.050	-0.013	-0.003	0.051	-0.241	0.313	0.292	0.660	0.943

The correlation of pod yield per plant was further analysed by the method of path coefficient analysis based on genotypic correlation. Correlation of yield with other characters were partitioned into components of direct and indirect effects to know the nature and relative importance of the components in determining pod yield (table 7). The present path coefficient analysis showed low residual effect (0.0476) indicating that most of the major yield components were included in the study. (Wallace *et al*.1993) also reported indirect selection for yield will be most effective when applied to traits that already intrigrate most of the genetic and environmental effects. Kernel yield per plant had the highest direct positive effects on pod yield per plant followed by number of kernels per plant and 100 kernel weight. All other characters through these three characters made major indirect contribution towards pod yield. Plant height, number of branches per plant and number of pods per plant exhibited greater influence on pod yield per plant via kernel number per plant and kernel yield per plant. Haulm yield and harvest index influenced indirectly on pod yield through kernel weight and kernel number respectively. Present study thus indicated that for selection prime emphasis should be given on kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant. Dhaliwal *et al*. (2010) and Babariya & Dobariya (2012) also observed high positive direct contribution of kernel yield per plant to the pod yield. Thus, kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.

Identification of promising breeding lines and the basis of higher productivity in groundnut

Out of 36 genotypes evaluated for yield and yield contributing parameters the genotypes like OGZ5,OGZ2, R 2001-3A,OGZ6 and OGX4 were found promising in respect of pod yield per plant. A perusal of data from the mean performance in Table -6, it is observed that superior performance of all traits was not expressed in a promising genotypes and different genotypes were found to be superior for various characters. The higher productivity in the promising varieties is due to a combination of various morpho- physiological traits and which could be ascribed as the basis of potential productivity in groundnut. For instance, the higher yield in OGZ5 could be attributed to taller height, higher no. of branches, high shelling %, higher 100 kernel weight and higher kernel yield per plant and higher harvest index. High yield level of P3 was due to tall plant height and higher magnitude of no.of branches, number of pods, shelling percentage, number of kernels per plant and kernel yield. High yield level in OGZ6 was due to tall height, higher shelling % and higher kernel yield per plant. The higher yield level of OGX4 could be attributed to higher no. of pods per plant and higher shelling percentage.

From the foregoing observations on superior yield performance of selected genotypes and their association with various yield related traits it is revealed that superior performance of all the traits was not expressed in any promising genotype and different genotypes were found to be superior for various characters and so no definite trend of relationship is suggested, still it is clearly demonsrared that high yield of different promising entries could be attributed to taller plant height,moderate to high number of branches /plant and number of pods per plant and moderately high 100 kernel weight, may srve as the basis of yield vigour which could be utilized as important selection criteria for prediction and realization of high yield in groundnut.

The result of present study indicated that the pattern of high yield in relation to different component traits differ greatly from genotype to genotype and any generalization regarding yield potentially of a genotype for all the traits is quite difficult. Gomes and Lopes (2005), Korat *et al* (2010), Dhaliwal *et al* (2010), Shoba *et al* (2012) and Babarya and Dabariya (2012) reported similar findings, indicating that higher yield level was due to higher number of branches/plant, higher number of pods per plant, 100 kernel weight, kernel yield per plant and shelling % and which are most important and key traits for stability of pod yield and these traits could be successfully employed for realization of higher productivity and ensures the possibility of predicting the performance of genotypes for higher
Productivity in groundnut.

Conclusion

The P.C.V. and G.C.V. estimates were high for haulm yield per plant. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated the need to create variability either by hybridization or mutation followed by selection. Along with high heritability, high genetic advance as percentage of mean has been noticed for number of branches per plant and hundred kernel weight. These traits are mainly governed by additive gene action and thus less influenced by the environmental changes. Hence improvement of these traits would be more effective through the phenotypic selection. Thus harvest index and shelling percent were controlled largely by non-additive gene action and selection would be less effective. Moderate heritability and genetic advance (GAM) as percent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non additive gene actions for these traits and phenotypic selection would be effective to some extent.

Kernel yield per plant had the highest direct positive effects on pod yield per plant followed by number of kernels per plant and 100 kernel weight. All other characters through these three characters made major indirect contribution towards pod yield. Plant height,number of branches per plant and number of pods per plant exhibited greater influence on pod yield per plant via kernel nuber per plant and kernel yield per plant. Haulm yield and harvest index influenced indirectly on pod yield through kernel weight and kernel number respectively. Present study thus indicated that for selection prime emphasis should be given on kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.

Highest yield obtained in OGZ5 with moderate chlorophyll content is due to the balance in the physiological parameters contributing towards yield. However it is an important significant finding that two promising lines like OGZ5 AND OGZ6 combine high yield with high protein content, which could be identified as promising and prospective lines, on the contrary some of the genotypes like AK 12-24, OGZ4, OGY17, OGY18 AND OGZ7, despite lower yield have high protein content could be utilized as parental sources for transferring protein content in groundnut.

Out of 36 genotypes evaluated for yield and yield contributing parameters the genotypes like OG Z5, OGZ2, R 2001-3A,OGZ6 and OGX4 were found promising in respect of pod yield per plant. Superior performance of all traits was not expressed in a promising genotypes and different genotypes were found to be superior for various characters. The higher productivity in the promising varieties is due to a combination of various morpho- physiological traits and which could be ascribed as the basis of potential productivity in groundnut.
The result of present study indicated that the pattern of high yield in relation to different component traits differ greatly from genotype to genotype and any generalization regarding yield potentially of a genotype for all the traits is quite difficult., However the higher yield level was due to higher number of branches/plant, higher number of pods per plant, 100 kernel weight, kernel yield per plant and shelling % and which are most important and key traits for stability of pod yield and these traits could be successfully employed for realization of higher productivity and ensures the possibility of predicting the performance of genotypes for higher productivity in groundnut.

Bibliography

1. Arora G, Kandhola SS, Sharma P. Genetic Analysis of Pod Yield and Confectionery Traits in Crosses Involving Bold Seeded Varieties of Groundnut (Arachis Hypogaea L.). Crop Improvement. 2010; 37(1).
2. Asibuo J. Evaluation of Nutritional Quality of Groundnut *(Aarachis Hypogaea* L.) From Ghana. African Journal of Food, Agriculture, Nutrition and Development. 2008; 8(2).
3. Bianchi Hall CM, Keys RD, Stalker HT, Murphy JP. Diversity of Seed Storage Protein Patterns in Wild Peanut (Arachis, Fabaceae) Species, Plant Systematics and Evolution. 1993; 186(1-2):1-15
4. Birthal PS, Rao PP, Nigam SN, Bantilan CS, Bhagavatulu S. Groundnut and Soybean Economies in Asia: Facts, Trends and Outlook. International Crops Research Institute for the Semi-Arid Tropics Patancheru, 2010.
5. Chandran K, Pandya SM. Biochemical Characterization of Arachis Species of the Section Arachis, Indian Journal of Plant Genetic Resources, 1999; 12(2).
6. Chandran K, Rajgopal K, Radhakrishnan T. Electrophoretic Study on Seed Storage Proteins of Groundnut (*Arachis hypogaea* L.) Cultivars of India, Indian Journal of Plant Genetic Resources. 2002; 15(2).
7. Dolma T, Sekhar MR, Reddy KR. Genetic divergence studies in groundnut (*Arachis hypogaea* L.). J. Oilseeds Res. 2010; 27(2):158-160.
8. Dwivedi SL, Pande S, Rao JN, Nigam SN. Components of resistance to late leaf spot and rust among interspecific derivatives and their significance a foliar disease resistance breeding in groundnut (*Arachis hypogaea* L.). Euphytica. 2002; 125: 81–88.
9. Faostat, 2012
10. Giri RR, Hudge BV. Character Association and Path Analysis of Yield Component Traits and Late Leaf Spot Disease Traits in Groundnut (*Arachis hypogaea* L.), Agricultural Science Digest. 2010; 30(2).