International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 2179-2185

Received: 25-09-2018
Accepted: 30-10-2018

Harkesh Saini
Department of Plant Breeding and Genetics, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner, Rajasthan, India

MM Sharma
Department of Plant Breeding and Genetics, Professor, Agriculture Research Station, S. K. Rajasthan Agricultural University, Bikaner, Rajasthan, India

Correspondence
Harkesh Saini
Department of Plant Breeding and Genetics, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner, Rajasthan, India

Genetic variability and character association study in a RIL population for yield and quality traits in groundnut (*Arachis hypogea* L.)

Harkesh Saini and MM Sharma

Abstract
An experiment was one hundred forty-nine groundnuts (*Recombinant inbred* Lines) RILs were tested. Highly significant variations were observed among the RILs for all the characters studied. The highest genetic coefficient of variation was observed for kernel yield per plant, harvest index, pod yield per plant, number of pods per plant, biological yield per plant and 100-kernel weight. The highest heritability was observed in 100-kernel weight (g) followed by pod yield per plant (g), shelling percentage, kernel yield per plant (g), biological yield per plant (g), harvest index and palmitic acid while high values of genetic advance as per cent of mean were obtained in all the characters except shelling percentage and palmitic acid. The kernel yield per plant showed the highly significant and positive association with number of kernels per pod, number of pods per plant, pod yield per plant (g), 100-kernel weight (g), shelling percentage, biological yield per plant (g), harvest index, stearic acid. The kernel yield per plant had high positive direct effect on pod yield per plant followed by harvest index, oleic acid, linoleic acid, number pods per plant, oil content, protein content, palmitic acid, number of branches per plant, days to 50% flowering, biological yield per plant and 100-kernel weight. Therefore, kernel yield per plant, number of kernels per pod, pod yield per plant (g), number pods per plant, 100-kernel weight (g), shelling percentage, biological yield per plant (g), stearic acid, harvest index, oleic acid and linoleic acid were identified to be the important characters which could be used in selection for yield.

Keywords: genetic variability, PCV, GCV, heritability, genetic advance as per cent of mean

Introduction
Cultivated groundnut is an important oilseed crop of the world covering an area of 25 million ha (30%) with a production of 34 million tonnes. In India, it is spread over an area of 7.6 million ha with a production of 7.8 million tonnes (22%). (Basu & singh, 2004) [5]. Commercially, Groundnut is the world's fourth most important source of edible oil and third most important source of vegetable protein. Groundnut seeds are rich source of edible oil and contain 42-50% oil, 25-32% protein on dry weight basis. Groundnut oil is considered as stable and nutritive as it contains right proportions of saturated and unsaturated fatty acids. Since fatty acids make up the major portion of the weight of an oil molecule, the physical and chemical properties of the oil tend to be determined by the properties of the fatty acids which predominate in their makeup. Oleic acid, a monounsaturated fatty acid and linoleic acid, a polyunsaturated fatty acid both account for 75-80 per cent of the total fatty acids in the groundnut oil. The higher ratio of oleic/linoleic acid in groundnut oil, which ranges from 0.75 to 5.50 imparts stability and improves its shelf life by delaying the development of rancidity (Mozingo *et al.*, 2004) [22] and thus improves its cooking quality. Oil and protein contents and oil quality with respect to its fatty acid composition are most important quality traits both for oil and confectionary purposes. Seed oxidative stability is closely associated with oil composition. Groundnut seed with high of oleic acid content and O/L ratio have improved stability against lipid peroxidation and also higher shelf life can be achieved as compared to low O/L ratio because oleic acid, the 18-carbon monounsaturated fatty acid and precursor to linoleic acid which is less reactive with oxygen (Azharudheen and Gowda, 2013) [3].
Evaluation of genotypes to assess the existing variability is considered as preliminary step in any crop improvement programme. It is also essential to have knowledge regarding the amount of genetic variability generated through hybridization for various economic characters, as information on nature and magnitude of variability for various characters is prerequisite for crop improvement.

The phenotypic expression of the plant character is mainly controlled by the genetic makeup and environment. So it is necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable parameters such as phenotypic and genotypic coefficient of variation, heritability and genetic advance.

Correlation estimates between yield and other characters are useful in selecting desired plant types in designing an effective breeding programme. Correlation coefficient measure the degree of association, genotypic or phenotypic relationship between two or more characters, which forms the basis for selection. Path coefficients analysis (Wright, 1921) [36] is an important tool for partitioning the correlation coefficient into direct and indirect effects of variables on dependent variable.

Materials and Methods

The experimental material consisted of *Recombinant inbred* Lines (RILs) of groundnut were procured from International Crops Research Institute for Semi-Arid Tropics Patancheru, Hyderabad, India, through All India Coordinated Research Project on Groundnut, ARS Bikaner. The present experimental material comprised of 150 RILs developed through single seed descent method using the parental lines CHICO and ICGV 12473.

The experiment was conducted during *Kharif* 2016 in Alpha Lattice Design (30 blocks x 10 lines). Each genotype was grown with a spacing of 30 cm between rows and 10 cm between plant to plant within the rows. The experiment material sown on June 30, 2016 and one line (No.49) germinated after 30 days and could not produce pods, therefore, could not be included in the study and the remaining 149 RILs were evaluated for traits related to yield and quality. The experiment was harvested on November 4, 2016.

The observations were recorded on the basis of five randomly selected plants from each replication for ten characters *viz.*, days to 50 % flowering, days to maturity, number of branches per plant, number of pods per plant, pod yield per plant, number of kernels per pod, kernel yield per plant (g), 100-kernel weight (g), shelling percentage, biological yield per plant, harvest index, protein content, oil content and fatty acids. The data were subjected to statistical analysis using Genstat Diccovery Edition 3 software.

Results and Discussion

High estimates of PCV and GCV were observed for characters kernel yield per plant, harvest index, pod yield per plant, number of pods per plant, biological yield per plant and 100-kernel weight (Table 1). Selection based on these characters would facilitate successful isolation of desirable groundnut RILs. Such high genetic variation was also being reported by Shinde *et al*. (2010) [32], Zaman *et al*. (2011) [38] for kernel yield, Shinde *et al*. (2010) [32] for pod yield and John *et al.* (2007) [13], Rao *et. al.* (2012) [30], Yadlapalli (2014) [37] for number of pods per plant, John *et al.* (2007) [13] for harvest index and kernel yield per plant.

In the present investigation kernel yield per plant observed high magnitude of variation (PCV, GCV) with heritability. Similar results have been reported by Ramana *et al.* (2015) [29].

The heritability estimates were high for the characters 100-kernel weight, harvest index, biological yield per plant, shelling percentage, pod yield per plant, kernel yield per plant and palmitic acid. Similar results have been reported by Zaman *et al*. (2011) [38], Yadlapalli (2014) [37], Balaraju and Kenchanagoudar (2016) [4] for 100-kernel weight, Krishnamurthy *et al.* (2015) [18], Balaraju and Kenchanagoudar (2016) [4] for shelling percentage, John *et al*. (2007) [13], Zaman *et al*. (2011) [38], Nandini and Savithramma (2012) [24], Rao *et al*. (2012) [30] for kernel yield and John *et al*. (2007) [13], Vasanthi *et al.* (2012) [34] and Balaraju and Kenchanagoudar (2016) [4] for harvest index.

Genetic advance as per cent of mean was highest for harvest index, kernel yield per plant, pod yield per plant, biological yield per plant, 100-kernel weight, number pods per plant and oleic acid. Similar results have been reported for the traits pod weight per plant (Darshora *et al*., 2002, John *et al.*, 2007, Shinde *et al.*, 2010, Nandini and Savithramma, 2012) [8, 13, 32, 24], 100-kernel weight (Venkataramana *et al*., 2001, Yadlapalli, 2014) [35, 37], pod yield and kernel yield (Sumathi and Ramanathan, 1995) [33], harvest index (John *et al*., 2011) [12], number of pods per plant (John *et al.*, 2007, Nandini and Savithramma, 2012) [13, 24] and Ramana *et al.* (2015) [29] for kernel yield per plant.

The high genetic advance coupled with high heritability was observed for the characters biological yield per plant and 100-kernel weight. These characters suggested the importance of additive genetic variance and improvement of these characters could be made by simple phenotypic selection. These results were also in agreement with the findings of Rao *et. al.* (2012) [30] for 100-kernel weight Mollers and Schierholf (2002) [21] in doubled haploid segregating population of the oil seed rape and Kavera *et al*. (2008) [15, 16] in groundnut. The moderate to high heritability with low genetic advance was observed for the characters 50% flowering, oil content and protein content. Similar results have been reported by Cholin *et al.* (2011) [6] and Krishnamurthy *et al.* (2015) [18].

Table 1: Estimation of genetic parameters of variation for 17 characters of groundnut

Characters	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	GA % of Mean
Days to 50% flowering	33.85	30.71 - 37.49	3.59	4.45	65.15	2.02	5.97
Days to maturity	127.23	126.56 - 127.91	0.38	0.95	16.10	0.40	0.31
Number of branches per plant	7.43	6.36 - 9.05	11.92	20.5	33.81	1.06	14.28
Number of pods per plant (g)	20.16	11.98 - 32.51	28.07	35.76	61.65	9.16	45.41
Pod yield per plant (g)	21.51	8.14 - 39.46	37.12	42.01	78.06	14.53	67.56
Shelling percentage	63.22	46.95 - 81.00	10.73	12.12	78.37	12.37	19.56
Number of kernels per pod	1.63	1.28 - 1.88	9.82	12.01	66.89	0.27	16.50
Kernel yield per plant(g)	12.93	5.38 - 25.61	38.86	45.59	72.66	8.82	68.21
100-kernel weight (g)	52.16	29.73 - 91.41	27.56	28.32	94.68	28.81	55.24
Biological yield per plant(g)	78.54	28.50 - 165.51	31.89	34.30	86.46	47.97	61.08
Harvest index (%)	18.47	5.25 - 35.37	39.84	42.20	89.16	14.31	77.49
Protein content (%)	24.75	21.68 - 26.80	5.87	7.97	54.17	2.20	8.89
Oil content (%)	49.59	45.91 - 53.32	3.64	4.60	62.57	2.94	5.93

Palmitic acid (%)	11.90	9.72 - 13.38	6.31	7.49	71.04	1.30	10.95
Stearic acid (%)	2.79	2.19 - 3.89	12.88	17.91	51.74	0.53	19.10
Oleic acid (%)	34.33	23.95 - 44.46	13.10	15.88	68.00	7.64	22.24
Linoleic acid (%)	45.04	37.42 - 52.89	8.63	10.56	66.73	6.54	14.51

The genotypic and phenotypic correlations were calculated for all pairs of characters (Table 2). The genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficient means in general, all pairs of characters mean that environmental effect suppressed the association at phenotypic levels, indicating that both environmental and genotypic correlation in those cases act in same direction and finally maximize their expression at phenotypic level. Kernel yield/plant exhibited highly significant and positive correlation with all the characters except days to 50% flowering, protein content and oleic acid. Similar results have been reported by Mahalakshmi *et al*. (2005) [20] with pod yield per plant and shelling percentage and Zaman *et al*. (2011) [38] with number of nuts per plant. Golakia *et al*. (2005) [9] confirmed same association for pod yield.

Positive and significant association of pod yield per plant (g) with, number of pods per plant, 100-kernel weight (g), kernel yield per plant (g), biological yield per plant (g), harvest index, oil content and stearic acid at phenotypic level. Similar results have been reported by (John *et al.,* 2007, Nandini and Savithramma, 2012, Kiranmai *et al.* 2016) [13, 24, 17] with kernel yield, 100-kernel weigh (John and Reddy, 2015 and Padmaja *et al.*, 2015) [11, 26] with 100-kernel weigh (John *et al.,* 2007, Kiranmai *et al.*, 2016) [13, 17] with harvest index and (Nandini and Savithramma, 2012) [24] with number pods per plant.

Positive and significant association of oil content with number of pods per plant, pod yield per plant (g), harvest index, linoleic acid, stearic acid and kernel yield per plant (g) at phenotypic level. Similar results have been reported by Mollers and Schierholt 2002 [21], with oleic acid, linoleic acid and (Parmar *et al.*, 2002, Kahate *et al.* 2014) [27, 14] with pod yield. The negative and significant association was found with protein content, was recorded for phenotypic level. Similar results have been reported by Dwivedi *et al.* (1990) [7] and Noubissie *et al.* (2012) [25].

The existence of very strong positive association of palmitic acid with linoleic acid was recorded at phenotypic level whereas the association of that with oleic acid was negative and significant at phenotypic levels. Similar results have been reported by Kavera *et al.* (2008) [15, 16] and Kavera (2008) [15, 16]. The positive and significant association of stearic acid with number of pods per plant, pod yield per plant (g), kernel yield per plant (g), harvest index, oil content and linoleic acid was observed at phenotypic levels. Similar results have been reported by Anderson *et al.* (1998) [1].

Highly significant negative correlations of oleic acid with linoleic acid and palmitic acid were recorded whereas significant positive association was recorded between oleic acid and total unsaturated fatty acids. Similar results have been reported by Anderson *et al*. (1998) [1], Azharudheen and Gouha (2013) [3], Mukri *et al.* (2014) [23] with linoleic acid and Kavera *et al.* (2008) [15, 16], Cholin *et al.* (2011) [6], Azharudheen and Gouha (2013) [3] with palmitic acid and linoleic acid.

Direct and positive effect on pod yield per plant was observed by different characters viz., kernel yield per plant (g), harvest index, oleic acid, linoleic acid, number pods per plant, oil content, protein content, palmitic acid, number branches per plant, days to 50% flowering, biological yield per plant and 100-kernel weight (g) (Table 3). Hence, a direct selection criterion should be followed for these traits to improve the pod yield. Similar results were earlier reported by Rathod *et al.* (2015) [31], Rao *et al.* (2012) [30], Nandini and Savithramma (2012) [24], Garjappa (2005), Kahate *et al.* (2014) [14] and Kiranmai *et al*. (2016) [17] for kernel yield per plant, Rathod *et al.* (2015) [31] and Patil *et al*. (2015) [28] for test weight and oil content, Patil *et al.* (2015) [28] for number of branches per plant and Azad and Hamid (2000) [2] for kernel yield and test weight.

Negative direct effects on pod yield were also exhibited by some characters *viz* shelling per cent and stearic acid and days to maturity. Similar findings were reported by Rathod *et al.* (2015) [31], Patil *et al.* (2015) [28], Nandini and Savithramma (2012) [24] and Kahate *et al.* (2014) [14] for shelling per cent.

Kernel yield per plant showed positive indirect effect through 100-kernel weight, number of kernels per pod, number of pods per plant, harvest index and days to maturity. Similar results were earlier reported by Kahate *et al.* (2014) [14] with 100-kernel weight and harvest index. Among the above traits, the trait, number of 100-kernel weight had the highest positive indirect effect. When both direct and indirect positive contributions were considered, number of kernels per pod and pod yield per plant were proved to be the outstanding traits which influenced kernel yield per plant in groundnut. Similar results were observed by Gomes and Lopes *(*2005) [10] and Kumar (2006) [19].

Conclusions

The present study clearly showed that karnel yield/ha, karnel yield/plant, branches per plant, immature and mature nuts/plant, 100 kernal weight and plant height were more variable characters among these genotypes. All yield contributing characters except plant height and shelling percentage showed the highly significant positive correlation with karnel yield per hectare. Number of mature nuts/plant had high positive direct effect on karnel yield/ha whereas number of immature nuts/plant, karnel size, plant height and primary branches/plant exhibited direct negative effect on karnel yield/ha. Therefore, maximum number of nuts, larger nut size, higher shelling percentage, early days to 50% flowering and days to maturity are the important characters which could be used in selection for higher yield of groundnut.

Table 2: Phenotypic and Genotypic correlation coefficient for different characters of groundnut

Characters		Days to 50% flowering	Days to maturity	No. of branches / plant	No. of pods / plant (g)	Pod yield / plant(g)	Shelling %	No. of kernels / pod	Kernel yield / plant(g)	100 kernel weight(g)	Bio. yield / plant(g)	Harvest Index (%)	Protein content (%)	Oil content (%)	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)
Days to 50% flowering	P	1.000	0.015	0.159	-0.149	-0.147	0.016	-0.218*	-0.143	-0.102	0.218*	-0.264**	-0.076	-0.076	0.060	-0.113	-0.036	0.020
	G	1.000	0.022	0.175*	-0.146	-0.160	0.033	-0.199*	-0.148	-0.090	0.226**	-0.267**	-0.072	-0.096	0.081	-0.111	-0.066	0.036
Days to maturity	P		1.000	-0.044	0.013	0.069	-0.124	0.083	0.067	0.057	0.003	0.015	-0.254**	0.078	-0.065	-0.081	0.081	-0.062
	G		1.000	-0.064	-0.014	0.060	-0.137	0.065	0.048	0.043	-0.005	0.001	-0.192*	0.050	-0.068	-0.096	0.068	-0.055
No. of branches / plant	P			1.000	0.345**	0.086	-0.278**	-0.038	0.019	-0.195*	0.494**	-0.302**	-0.204*	0.061	0.023	0.024	-0.090	0.098
	G			1.000	0.295**	0.054	-0.229**	-0.082	-0.031	-0.200*	0.443**	-0.287**	-0.174*	0.068	0.049	0.043	-0.114	0.126
No. of pods / plant (g)	P				1.000	0.577**	-0.190*	0.195**	0.520**	-0.102	0.348**	0.229**	-0.106	0.259**	-0.048	0.325**	-0.013	0.047
	G				1.000	0.576**	-0.167*	0.178*	0.496**	-0.145	0.304**	0.269**	-0.060	0.198*	-0.015	0.345**	-0.058	0.102
Pod yield / plant (g)	P					1.000	-0.005	0.479**	0.817**	0.428**	0.259**	0.594**	-0.142	0.253**	0.028	0.287**	-0.047	0.087
	G					1.000	0.007	0.506**	0.856**	0.451**	0.259**	0.624**	-0.072	0.223**	0.035	0.286**	-0.054	0.102
Shelling %	P						1.000	0.114	0.203*	0.239**	-0.276**	0.404**	0.093	0.087	-0.048	0.096	0.082	-0.087
	G						1.000	0.130	0.243**	0.254**	-0.245**	0.403**	0.047	0.105	-0.055	0.100	0.091	-0.093
No. of kernels / pod	P							1.000	0.570**	0.551**	0.100	0.472**	0.026	-0.102	0.000	0.083	0.027	-0.021
	G							1.000	0.595**	0.558**	0.095	0.477**	0.059	-0.143	-0.013	0.072	0.042	-0.032
Kernel yield / plant(g)	P								1.000	0.586**	0.332**	0.633**	-0.093	0.179*	0.018	0.286**	-0.021	0.042
	G								1.000	0.601**	0.285**	0.685**	-0.018	0.138	0.020	0.298**	-0.031	0.058
100 kernel weight (g)	P									1.000	0.055	0.486**	0.028	-0.010	-0.028	0.101	0.068	-0.072
	G									1.000	0.066	0.485**	0.068	-0.015	-0.045	0.100	0.085	-0.085
Bio. yield / plant (g)	P										1.000	-0.314**	-0.020	-0.070	0.109	-0.046	-0.093	0.052
	G										1.000	-0.326**	0.062	-0.097	0.135	-0.020	-0.138	0.089
Harvest index (%)	P											1.000	-0.074	0.272**	-0.012	0.323**	-0.014	0.075
	G											1.000	-0.061	0.264**	-0.032	0.306**	0.016	0.054
Protein content (%)	P												1.000	-0.483**	0.022	0.076	-0.051	-0.015
	G												1.000	-0.432**	0.016	0.108	-0.044	-0.015
Oil content (%)	P													1.000	0.099	0.521**	-0.106	0.211*
	G													1.000	0.091	0.488**	-0.095	0.199*
Palmitic acid (%)	P														1.000	-0.055	-0.905**	0.833**
	G														1.000	-0.067	-0.907**	0.831**
Stearic acid (%)	P															1.000	-0.103	0.181*
	G															1.000	-0.082	0.158
Oleic acid (%)	P																1.000	-0.973**
	G																1.000	-0.971**
Linoleic acid (%)	P																	1.000
	G																	1.000

P- Phenotypic, G- Genotypic, * Level of significance at 5%, ** level of significance at 1%.

Table 3: Direct (diagonal) and indirect effects (non-diagonal) of different characters on pod yield per plant in groundnut

Characters	Days to 50% flowering	Days to maturity	No. of branches / plant	No. of pods / plant (g)	Shelling percentage	No. of kernels / pod	Kernel yield / plant(g)	100- kernel weight (g)	Bio. yield / plant(g)	Harvest index (%)	Protein content (%)	Oil content (%)	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Pod yield / plant(g)
Days to 50% flowering	0.024	0.000	0.006	-0.019	-0.007	-0.004	-0.101	-0.002	0.005	-0.052	-0.003	-0.011	0.003	0.008	-0.012	0.005	-0.160
Days to maturity	0.001	-0.008	-0.002	-0.002	0.030	0.001	0.033	0.001	0.000	0.000	-0.008	0.006	-0.003	0.007	0.013	-0.008	0.060
No. of branches /plant	0.004	0.001	0.036	0.039	0.050	-0.002	-0.021	-0.004	0.011	-0.056	-0.007	0.008	0.002	-0.003	-0.021	0.019	0.054
No. of pods / plant (g)	-0.004	0.000	0.011	0.131	0.037	0.004	0.340	-0.003	0.007	0.053	-0.002	0.023	-0.001	-0.025	-0.011	0.015	0.576**
Shelling percentage	0.001	0.001	-0.008	-0.022	-0.220	0.003	0.166	0.005	-0.006	0.079	0.002	0.012	-0.002	-0.007	0.017	-0.014	0.007
No. of kernels / pod	-0.005	-0.001	-0.003	0.023	-0.029	0.022	0.408	0.011	0.002	0.094	0.002	-0.017	-0.001	-0.005	0.008	-0.005	0.506**
Kernel yield / plant(g)	-0.004	0.000	-0.001	0.065	-0.053	0.013	0.685	0.012	0.007	0.134	-0.001	0.016	0.001	-0.021	-0.006	0.009	0.856**
100- kernel weight (g)	-0.002	0.000	-0.007	-0.019	-0.056	0.012	0.412	0.020	0.002	0.095	0.003	-0.002	-0.002	-0.007	0.016	-0.013	0.451**
Bio. yield / plant(g)	0.005	0.000	0.016	0.040	0.054	0.002	0.195	0.001	0.024	-0.064	0.003	-0.011	0.005	0.001	-0.026	0.013	0.259**
Harvest index (%)	-0.006	0.000	-0.010	0.035	-0.089	0.010	0.469	0.010	-0.008	0.196	-0.003	0.031	-0.001	-0.022	0.003	0.008	0.624**
Protein content (%)	-0.002	0.002	-0.006	-0.008	-0.010	0.001	-0.012	0.001	0.001	-0.012	0.041	-0.051	0.001	-0.008	-0.008	-0.002	-0.072
Oil content (%)	-0.002	0.000	0.002	0.026	-0.023	-0.003	0.094	0.000	-0.002	0.052	-0.018	0.117	0.004	-0.035	-0.018	0.029	0.223**
Palmitic acid (%)	0.002	0.001	0.002	-0.002	0.012	0.000	0.013	-0.001	0.003	-0.006	0.001	0.011	0.040	0.005	-0.168	0.123	0.035
Stearic acid (%)	-0.003	0.001	0.002	0.045	-0.022	0.002	0.205	0.002	0.000	0.060	0.004	0.057	-0.003	-0.071	-0.015	0.023	0.286**
Oleic acid (%)	-0.002	-0.001	-0.004	-0.008	-0.020	0.001	-0.021	0.002	-0.003	0.003	-0.002	-0.011	-0.036	0.006	0.185	-0.143	-0.054
Linoleic acid (%)	0.001	0.000	0.005	0.013	0.020	-0.001	0.040	-0.002	0.002	0.011	-0.001	0.023	0.033	-0.011	-0.180	0.147	0.102

Residual effect 0.183

References

1. Anderson PC, Hill K, Gorbet DW, Brodbeck BV. Fatty acid and amino acid profiles of selected peanut cultivars and breeding lines. J. Food Compo. Anal. 1998; 11:100-111.
2. Azad MAK, Hamid MA. Genetic variability, character association and path analysis in groundnut (*Arachis hypogaea* L.), Thailand J. Agric. Sci. 2000; 33(3-4):153-157.
3. Azharudheen TPM, Gowda MVC. Assessment of genetic variability and correlation of important nutritional quality traits in *Recombinant inbred* lines of groundnut (*Arachis Hypogaea* L.) Indian J. Agric. Res., 2013; 47(5):465-468.
4. Balaraju M, Kenchanagoudar PV. Genetic variability for yield and its component traits in interspecific derivatives of groundnut (*Arachis hypogaea* L.) J Farm Sci. 2016; 29(2):172-176.
5. Basu MS, Singh NB. Groundnut Research in India: An Overview. Pub. NRC on Groundnut edited by Dr M.S. Basu and Dr N.B. Singh Groundnut Research in India, 2004; 1-7.
6. Cholin S, Gowda MVC, Varshney RK. Identification of quantitative trait loci for protein content, oil content and oil quality for groundnut (*Arachis hypogaea* L.). Published in Field Crops Research. 2011; 122(1)28:49-59.
7. Dwivedi SL, Jambunathan R, Nigam SN, Raghunath K, Ravishankar K, Nagabhushanam GVS. Relationships of seed mass to oil and protein contents in peanut (*Arachis hypogaea* L.). Peanut Sci. 1990; 17:48-52.
8. Darshora A, Nagada AK, Dashora A. Genetic variability and character association in spanish bunch groundnuts. Res. on Crops. 2002; 3:416-440.
9. Golakia PR, Makne VG, Monpara BA. Heritable variation and association in virginia runner and spanish bunch group of groundnut. Nat. J Plant. Imprv. 2005; 7 (1):50-53.
10. Gomes RL, Lopes A. Correlation and path analysis in peanut. Crop Breed. Appl. Biotech., 2005; 5 (1):105-110.
11. John K, Reddy PR. Character association and path analysis studies for pod yield and its components in early segregating population of groundnut (*Arachis hypogaea* L.), Int. J. Curr. Res. Biosci. Plant Biol. 2015; 2(7):149-157.
12. John K, Raghava Reddy P, Hariprasad RP, Sudhakar P, Eswar RNP. Genetic variability for morphological, physiological, yield and yield traits in F_2 populations of groundnut (*Arachis hypogaea* L). Int. J. of App. Biology and Pharmaceutical Technology. 2011; 2(4):145-153.
13. John K, Vasanthi RP, Venkateswarlu O. Variability and correlation studies for pod yield and its attributes in F_2 generation of six Virginia x spanish crosses of groundnut (*Arachis hypogaea* L.) Legume Res. 2007; 30(4):292-296.
14. Kahate NS, Toprope VN, Gadakh SS. Correlation and path analysis for yield, morphology and biochemical traits in groundnut (*Arachis hypogea* L.). Bio infolet. 2014; 11(3B):868-870.
15. Kavera. Oil quality improvement in groundnut (*Arachis hypogaea* L.) through induced mutagenesis. Ph. D. Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India), 2008.
16. Kavera SB, Nadaf HL, Vijayakumar AG, Salimath PM. Fatty acid profile of groundnut (*Arachis hypogaea* L.) cultivars. Crop Improv. 2008; 35(1):61-65.
17. Kiranmai Sandhya M, Venkataravana P, Pushpa HD. Correlation and path analysis studies in groundnut under different environment. Agricultural Research Communication Centre Legume Research. 2016; 39(6):1048-1050.
18. Krishnamurthy D, Goudar PVK, Keerthi CM, Babu, PH. Groundnut under organic farming: Genetic variability and association studies for yield, quality and disease resistance in *Recombinant inbred* lines, Legume Research. 2015; 38(5):626-630.
19. Kumar P. Genetics of Water use efficiency, yield and its related traits in groundnut (*Arachis hypogaea* L.). M.Sc. Agri Thesis submitted to the Uni. Agric. Sci., Bangalore, 2006.
20. Mahalakshmi P, Manivannan N, Muralidharan V. Variability and correlation studies in groundnut (*Arachis hypogaea* L.) Legume Research. 2005; 28(3):194-197.
21. Mollers C, Schierholt A. Genetic variation of palmitate and oil content in a winter oil seed rape double haploid population segregating for oleate content. Crop Sci. 2002; 42:379-384.
22. Mozingo R, O'keefe S, Sanders T, Hendrix K. Improving shelf life of roasted and salted in-shell peanuts using high oleic acid chemistry. Peanut Sci. 2004; 31:40-45.
23. Mukri G, Nadaf HL, Gowda MVC, Bhat RS, Koti RV, Bharati C. Isolation of superior segregation for yield, nutritional and oil quality traits from RILs population of groundnut, Karnataka J. Agric. Sci. 2014; 27(2):111-115.
24. Nandini C, Savithramma DL. Character association and path analysis in F_8 *Recombinant inbred* line population of the cross NRCG 12568 x NRCG 12326 in groundnut (*Arachis hypogea* L.). Asian J. Bio Sci. 2012; 7(1):55-58.
25. Noubissie TJB, Njintang NY Dolinassou S. Heritability studies of protein and oil contents in groundnut (*Arachis hypogaea* L.) genotypes. International Journal of Innovations in Bio-Sciences. 2012; 2 (3):162-171.
26. Padmaja DKB, Eswari Nigam SN, Rao MVB. Character association and path analysis in *Recombinant inbred* line population of the Cross JL 24 X ICG 13919 in groundnut (*Arachis Hypogaea* L.). International Journal for Scientific Research & Development. 2015; 3(5):1346-1351.
27. Parmar DL, Kumar R, Bharodia PS. Genetics and inter-relationship of oil and protein content in crosses involving confectionary genotypes of groundnut (*Arachis hypogaea* L.). J. Oilseeds Res. 2002; 19:32-34.
28. Patil Sk, Shivanna S, Irappa BM, Shweta. Genetic variability and character association studies for yield and yield attributing components in groundnut (*Arachis hypogeae* L.). International Journal of Recent Scientific Research. 2015; 6(6):4568-4570.
29. Ramana E, Venkata Vasanthi, RP, Reddy KH, Reddy BVB, Reddy BR. Studies on genetic variability for yield, yield components and resistance to kalahasti malady in groundnut (*Arachis hypogaea* L.). IJABPT. 2015; 6:1.
30. Rao VT, Bhadru D, Murthy KGK, Bharathi D. Genetic variability and association among the various characters in *groundnut (Arachis hypogaea* L). IJABPT. 2012; 3(3):337-341.
31. Rathod SS, Toprope VN, Misal AM. Character association and path analysis in groundnut (*Arachis hypogaea* L.) Int. J. Curr. Res. Biosci. Plant Biol. 2015; 2(12):64-68.
32. Shinde PP, Khanpara MD, Vachhani JH, Jivani LL, Kachhadia VH. Genetic variability in Virginia bunch

groundnut (*Arachis hypogaea* L.). *Plant Archives.* 2010; 10(2):703-706.
33. Sumathi R, Ramanathan T. Genetic variability in interspecific crosses of groundnut (*Arachis hypogaea*) L. Karnataka J. Agric. Sci. 1995; 8:50-55.
34. Vasanthi RP, Vishnuvardhan KM, Reddy KHP, Reddy BVB. Genetic variability studies for yield attributes and resistance to foliar diseases in groundnut (*Arachis hypogaea* L.). International J. Appl. Biol. and Pharmaceutical Technol. 2012; 3(1):390-394.
35. Venkataramana P, Shireff A, Raman NJ. Assessment of groundnut germplasm and isolation of elite genotypes for improvement. J. Soil. Crops. 2001; 11:156-160.
36. Wright S. Correlation and causation. J. Agric. Res. 1921; 20:557-587.
37. Yadlapalli S. Genetic variability and character association studies in groundnut (*Arachis hypogaea* L.) International Journal of Plant, Animal and Environmental Sciences. 2014; 4(4):298-300.
38. Zaman MA, Tuhina-Khatun M, Ullah MZ, Moniruzzamn M, Alam KH. Genetic variability and path analysis of groundnut (*Arachis hypogaea* L.) A Scientific Journal of Krishi Foundation. 2011; 9(1&2):29-36.