Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P

Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 2262-2267
Received: 22-09-2019
Accepted: 23-10-2019

Chandrashekhara G
Department of Genetics and Plant Breediing, University of Agricultural and Horticultural Sciences Shivamogga, Karnataka, India

Hasanali Nadaf
Department of Genetics and Plant Breediing, University of Agricultural and Horticultural Sciences Shivamogga, Karnataka, India

Harish Babu
Department of Genetics and Plant Breediing, University of Agricultural and Horticultural Sciences Shivamogga, Karnataka, India

Santosh K Pattanshetty
Scientist, Genetic Resources ICRISAT, Patancheru, Hyderabad, Telangana, India

Corresponding Author:
Chandrashekhara G
Department of Genetics and Plant Breediing, University of Agricultural and Horticultural Sciences Shivamogga, Karnataka, India

Correlation and estimates of direct (diagonal) and indirect effects (of diagonal) of physiological, biochemical and root attributes on pod yield per plant at phenotypic level in groundnut genotypes under normal moisture condition and managed terminal drought conditions

Chandrashekhara G, Hasanali Nadaf, Harish Babu and Santosh K Pattanshetty

Abstract
The present genetic investigation was carried out to estimate the phenotypic correlations, direct and indirect effect of various physiological, biochemical and root attributes on pod yield per plant at phenotypic level in forty groundnut genotypes under normal moisture condition and managed drought conditions. The association studies revealed that, pod yield per plant showed significant positive correlation with oil content and root to shoot ratio. It can be concluded that, these traits should be given due importance while practicing selection for increasing yield. Results of path analysis for moisture stressed field condition reflected that, the physiological and yield related traits *viz*., relative water content, phenolic content of leaves, oil content of seeds, root to shoot ratio had direct positive effect on pod yield. This indicates that, if other characters are kept constant, an increase in matured pods per plant and total number of pods per plant will increase the yield significantly. Because of good correlation with pod yield, plant breeding approaches using these parameters are potentially useful as indirect selection traits and also might be effective and valuable improving for terminal drought resistance in peanut.

Keywords: Physiological, diagonal, biochemical

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the principal oilseed crops ranking fourth among the oil seed crops of the world (Cuc *et al.*, 2008 and Coulibaly, 2013) [3, 2]. It is an important food legume cash crop having adaptability to a variable soil and climatic conditions. Groundnut is cultivated worldwide in tropical, sub-tropical and warm temperature areas located between 40° N to 40° S latitude. India ranks first in acreage (6.4 m. ha.), which accounts for 28.44 per cent of the total world groundnut area (25.54 m. ha.) and contributes 24.69 per cent (7.21 m.t.) to the world production (40.47 m.t.). The average productivity of groundnut in India is 996 kg per ha, which is far below the world average pod yield of 1646 kg per ha (www.agricoop.com). In Karnataka, groundnut is an important oilseed crop grown in *kharif* and occupies 0.73 m. ha with a production and productivity of 0.66 m. t and 907 kg per ha, respectively, which is lower than the national average productivity of groundnut.

John *et al.* (2011) [6] worked out the character association and path analysis in F_2 population of groundnut and found that SCMR had significant positive association with pod yield per plant. These findings were fall in agree with results of Giri *et al.* (2009) [5], Songsri *et al.* (2008a) [12] and Tirumala *et al.* (2003) [12, 5]. Painawadee *et al.*, (2009) [8] reported negative correlation between SCMR and pod yield per plant.

Thakur *et al.* (2013a) [14] conducted a study on correlation and path coefficients for pod yield and its component traits in twenty-five groundnut genotypes and observed that root length had a high positive direct effect on pod yield per hectare.

Information on the phenotypic and genotypic interrelationship of the pod yield with its components and physiological, biochemical and root characters and also among the component characters facilitates us to know the nature and degree of relationship among characters which would be useful to the breeder in developing an appropriate selection strategy. Still, direct contribution of every component towards yield and their indirect contributions through other components are unknown. In this context, the path analysis facilitate in partitioning the correlation coefficient into direct and indirect effects of the component characters on the yield which would helpful for accurate selection. If the correlation between yield and any of its component traits is due to the direct effect, it reveals a true relation between them and selection for that character will be effective in order to improve yield. But if the correlation is mainly due to indirect effect of another component character, the breeder has to select the latter character through which the indirect effect is used.

In this context, present genetic investigation was carried out to estimate the phenotypic correlations, direct and indirect effect of various physiological, biochemical and root attributes on pod yield per plant at phenotypic level in forty groundnut genotypes under normal moisture condition and managed drought conditions.

Material and Methods

The germplasm employed in the present study consisted of forty advanced breeding lines along with two checks which were subjected for assessment of key physiological, biochemical and root related traits under managed drought condition (moisture stress) and optimum moisture (non-stress) conditions in an experiment laid out in a randomized complete block design (RCBD) with two replications at College of Horticulture, Hiriyur, UAHS, Shivamogga. The crop was managed as per package of practices. The moisture stress was imposed by withholding irrigation for 20 days at ninety days after sowing for the drought stress trial and normal irrigation was provided to the genotypes in normal moisture condition trial. The following physiological, biochemical and root traits *viz.*, leaf relative water content, Membrane stability index (MSI), Phenolic content of leaves and seeds, Protein content of leaves and seeds (%), Per cent of wilted plants (after drought stress), SCMR reading (using SPAD chlorophyll meter; KONICA MINOLTA, SPAD 502 PLUS, Version: 1.20.0000), oil content (using NMR spectrometer) (%), Root length (base of the shoot to the tip of root) (CM) and Root to shoot ratio (ratio of root length to shoot length) were recorded for each genotype in each replication under both moisture stressed and non-stressed plots. The statistical analysis of the data on the individual characters was carried out on the mean values of five randomly tagged plants and analyzed by using GEN STAT 14.1 software package at ICRISAT, Patancheru, Hyderabad.

Correlations between drought, biochemical and yield parameters

Phenotypic correlation coefficients between all pairs of characters were determined by using variance and covariance components as suggested by Al-Jibouri *et al.*, (1958) [1]. Path coefficient analysis was done using the correlation coefficients to ascertain the direct and indirect effects of the yield components on yield as suggested by Wright (1921) [17] and illustrated by Dewey and Lu (1959) [4].

Results and Discussion

Association analysis

Results of phenotypic correlation analysis for physiological, biochemical and root related traits in 40 groundnut genotypes under both normal moisture and moisture stress environments are presented in table 1 and 2 respectively. It was evident from the results that, there exists a significant association among many of these traits.

In normal moisture field condition, pod yield per plant recorded a positive and highly significant association with oil content of seeds, root to shoot ratio and a negative significant association with membrane stability index. It had a negative non-significant association with RWC, SCMR, phenolic content of leaf, phenolic content of seeds, protein content of seed and protein content of leaf and positive non-significant correlation with root length.

However, in moisture stress field condition, pod yield per plant recorded a positive significant association with oil content of seeds and negative high significant association with phenolic content in leaf. But it had positive non-significant association with protein content of leaf, SCMR and root length. It also recorded negative non-significant association with RWC, membrane stability index, per cent of wilted plants, phenolic content in seeds, protein content of seed and root to shoot ratio. These results are in agreement with Songsri *et al.* (2009) [11]. Positive correlation between SCMR and seed yield has been reported in groundnut (Rao *et al.*, 2014) [10].

Among the component biochemical, physiological and root related characters, different types of correlations were observed and are discussed hereunder:

Relative water content in normal moisture condition had a positive significant association with membrane stability index and positive non-significant association with SCMR and protein content of leaf but negative non-significant relationship with phenolic content of seeds, protein content of seeds, phenolic content of leaves, root to shoot ratio, oil content of seeds and root length. However, under moisture stress condition, relative water content recorded a highly positive significant association with phenolic content of seeds. It had a negative non-significant association with membrane stability index, root to shoot ratio, oil content of seeds, phenolic content of leaves and root length. Positive non-significant correlation was observed for SCMR, per cent of wilted plants, protein content of seeds and protein content of leaves.

In normal moisture situation, the membrane stability index recorded positive significant association with protein content of leaves, phenolic content of leaves and phenolic content of seeds. Negative high significant correlation was observed for root to shoot ratio and oil content of seeds. In addition, it also had a negative non-significant association with SCMR, root length and protein content of seeds. Whereas, in moisture stress situation, it had positive high significant association with protein content of seeds and root to shoot ratio. A negative non-significant association was noticed for SCMR and protein content of leaves. Further, it had a positive non-significant correlation with per cent of wilted plants, phenolic content of seeds, phenolic content of leaves, oil content of seeds and root length.

The SCMR, under normal moisture condition has shown positive significant relation with protein content of seeds besides having a negative significant relation with protein content of leaves. It had a positive non-significant relation with phenolic content of leaves, root to shoot ratio and root length. Further, it had a negative non-significant relation with oil content of seeds. However, under moisture stress situation, SCMR recorded a positive highly significant relation with protein content of seeds and phenolic content of leaves besides its negative significant relation with oil content of seeds. It recorded a positive non-significant relation with protein content of leaves, phenolic content of seeds, root to shoot ratio and root length. Further, it had negative non-significant relation for per cent of wilted plants.

In moisture stress condition, the per cent of wilted plants had a positive significant correlation with root to shoot ratio and root length in addition to its positive non-significant association with protein content of seeds and phenolic content of leaves. It had a negative non-significant association with protein content of leaves, phenolic content of seeds and oil content of seeds.

Under normal moisture condition, the protein content of leaves had a positive non-significant correlation with phenolic content of seeds as well as leaves. In addition, it also had a negative non-significant relation with protein content of seeds, oil content of seeds, root to shoot ratio and root length. However, under moisture stressed condition, the protein content in leaf tissue had a positive highly significant relation with protein content of seeds besides a positive non-significant association with phenolic content of leaves, root to shoot ratio and oil content of seeds. It had negative non-significant relation with phenolic content of seeds and root length.

Protein content of seeds had a positive non-significant relation with phenolic content of leaves and root to shoot ratio apart from having a negative non-significant relation with oil content of seeds, phenolic content of seeds and root length under normal moisture condition. Nevertheless, under moisture stress condition, the protein content of seeds recorded a positive highly significant relation with root length, phenolic content of leaves and root to shoot ratio. It had a negative significant relation with oil content of seeds and a positive non-significant relation with phenolic content of seeds.

In normal moisture condition, the phenolic content of seeds had a highly positive significant association with phenolic content of leaves, negative significant association with oil content of seeds and negative non-significant relation with root to shoot ratio and positive non-significant relation with root length. However in moisture stressed condition, this trait had a highly positive significant association with phenolic content of leaves and root length, and negative highly significant correlation with oil content of seeds in addition to exhibiting a positive non-significant relation with root to shoot ratio.

In normal moisture condition, the phenolic content of leaves had a negative non-significant association with oil content of seeds and root to shoot ratio besides having a positive non-significant correlation with root length. This trait had a highly negative significant association with oil content of seeds but it exhibited a positive significant relation with root length and positive non-significant association with root to shoot ratio under moisture stress condition.

In normal moisture condition, the oil content of seeds had a positive highly significant association with root to shoot ratio and positive non-significant correlation with root length. However, in moisture stress situation, this trait had negative non-significant association with root to shoot ratio besides having a highly negative significant relationship with root length.

For root to shoot ratio, highly positive correlation was observed with root length in both case of normal moisture and moisture stress conditions. Similar results were reported by Painawadee *et al.* (2009) [8] and Pirdasthi *et al.* (2009) [9].

Path coefficient analysis

In the present study, the results of path analysis for physiological, biochemical and root related traits in forty ground nut genotypes under moisture stress and normal moisture conditions are presented in Table 3 and 4 respectively.

The results of path coefficient analysis under moisture stress field condition reflected that, the yield related traits *viz.*, relative water content, phenolic content of leaves, oil content of seeds and root to shoot ratio had direct positive effect on pod yield. In contrary, under normal moisture condition reflected that SCMR, protein content of leaves, oil content of seeds, root length had direct positive effect on pod yield.

Under normal moisture condition, the relative water content has direct positive effect (0.0386) towards pod yield and the indirect effect on pod yield through other component traits was found to be negligible (< 0.1). However, under water stress condition, the relative water content has direct negative effect towards pod yield (-0.0062). Further, the negative indirect effects were negligible.

According to Lenka and Mishra (1973) [7], if the direct or indirect effects were < 0.1, they were considered to be negligible. Hence, the indirect effects which have < 0.1 for other component traits were not considered for discussion in this chapter in view of their negligible influence on pod yield.

The membrane stability index has direct negative effect both under normal moisture (0.1374) and moisture stress (0.0438) towards pod yield which is considered to be low (Lenka and Mishra, 1973) [7]. However, the indirect effect of different component traits through this trait was found to be negligible both under normal moisture and moisture stress.

Under normal moisture condition, SCMR has direct negative effect towards pod yield (0.1836) whereas in water stressed conditions, it has direct positive effect towards pod yield (0.2040). However, the indirect effects were negligible under both the situations.

Under moisture stress, the per cent wilted plant has direct negative effect towards pod yield (0.1847). The indirect effects on pod yield through other component traits were negligible.

Under normal moisture condition, the protein content in leaves has direct negative effect towards pod yield (0.0149) while it recorded a positive direct effect under moisture stress (0.0514). Nevertheless, the indirect effects were negligible.

Under both normal moisture and moisture stress, the protein content in seeds has direct negative effect towards pod yield (0.0257 and 0.1482, respectively). The indirect effects on pod yield through other component traits were negligible.

Under normal moisture condition, the phenol content in seeds has direct positive effect towards pod yield (0.1369) while it recorded a negative direct effect under moisture stress - 0.0384). Nevertheless, the indirect effects were negligible.

Under both normal moisture and moisture stress, the phenol content in leaves has direct negative effect towards pod yield (0.0911 and 0.3389, respectively). The indirect effects on pod yield through other component traits were negligible.

Under normal moisture condition, oil content of seeds has direct positive effect towards pod yield (0.2924). Further, positive and negative indirect effect was observed towards yield through root to shoot ratio (0.1600) and MSI (0.1254), respectively. However, under moisture deficit condition oil content of seeds has direct positive effect towards pod yield (0.2134). The indirect effects on pod yield through other component traits were negligible. Similar results were reported by Varman and Raveendran (1996) [16].

Under normal moisture condition, the root to shoot ratio has direct positive effect towards pod yield (0.1647) while it recorded a negative direct effect under moisture stress (0.1595). Nevertheless, the indirect effects were negligible.

Under normal moisture condition, the root length has direct negative effect towards pod yield (0.0675). The indirect effects on pod yield through other component traits were

negligible. However in water stress condition, root length has direct high positive effect towards pod yield (0.4939). The indirect positive effect on pod yield was observed through root to shoot ratio (0.2886) which is considered to be medium and through other component traits were negligible.
The low residual effect shows that the important yield components have been included in the present investigation for path analysis.

Conclusion

It can be concluded that, these traits should be given due importance while practicing selection for increasing yield. Results of path analysis for moisture stressed field condition reflected that, the physiological and yield related traits *viz.*, relative water content, phenolic content of leaves, oil content of seeds, root to shoot ratio had direct positive effect on pod yield. This indicates that, if other characters are kept constant, an increase in matured pods per plant and total number of pods per plant will increase the yield significantly. Because of good correlation with pod yield, plant breeding approaches using these parameters are potentially useful as indirect selection traits and also might be effective and valuable improving for terminal drought resistance in peanut.

Table 1: Phenotypic correlation of physiological, biochemical and root attributes with pod yield per plant (g) under normal moisture condition

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.0000	0.2371*	0.1372	0.0580	-0.1231	-0.0164	-0.1218	-0.1333	-0.2083	-0.0118	-0.0805
X2		1.0000	-0.0149	0.2203*	-0.1042	0.3267**	0.2730*	-0.4288**	-0.3277**	-0.0922	-0.2793*
X3			1.0000	-0.2420*	0.2320	0.2031	0.1210	-0.1187	0.0143	0.1708	-0.2057
X4				1.0000	-0.1901	0.0389	0.2112	-0.2178	-0.1220	-0.0691	-0.0866
X5					1.0000	-0.0391	0.0378	-0.0632	0.0043	0.1098	-0.0751
X6						1.0000	0.2995**	-0.2741*	-0.0749	0.1789	-0.0773
X7							1.0000	-0.2076	-0.0802	0.1168	-0.2004
X8								1.0000	0.5473**	0.1419	0.4347**
X9									1.0000	0.4593**	0.3268**
X10										1.0000	0.0482
X11											1.0000

Where,
X1- Relative water content (%)
X2- Membrane stability index (%)
X3- SPAD Chlorophyll Meter Reading
X4- Protein content of leaves (%)
X5- Protein content of seeds (%)
X6- Phenolic content of seeds (µg/g)
X7- Phenolic content of leaves (µg/g)
X8- Oil content of seeds (%)
X9- Root to shoot ratio
X10- Root length (cm)
X11- Pod yield per plant (g)

Table 2: Phenotypic correlation of physiological, biochemical and root attributes with pod yield per plant (g) under moisture stress condition

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1.0000	-0.1354	0.0078	0.0035	0.0500	0.0885	0.3243**	-0.0148	-0.1495	-0.0073	-0.0339	-0.0648
X2		1.0000	-0.0559	0.1937	-0.0230	0.2896**	0.1484	0.0793	0.0755	0.2863*	0.1886	-0.1033
X3			1.0000	-0.0927	0.1016	0.4036**	0.2113	0.3166**	-0.2798*	0.0357	0.1470	0.0607
X4				1.0000	-0.1219	0.1089	-0.0592	0.0033	-0.1276	0.2293*	0.2820*	-0.1579
X5					1.0000	0.3161**	-0.0092	0.0318	0.1244	0.1887	-0.0103	0.0294
X6						1.0000	0.1579	0.2446*	-0.2670*	0.2951*	0.3815**	-0.0875
X7							1.0000	0.4687**	-0.3194**	0.0779	0.2624*	-0.1266
X8								1.0000	-0.4782**	0.1759	0.3498**	-0.2883**
X9									1.0000	-0.0459	-0.3874**	0.2138*
X10										1.0000	0.5843**	-0.0250
X11											1.0000	0.1021
X12												1.0000

X1– Relative water content (%)
X2 – Membrane stability index (%)
X3 – SPAD Chlorophyll Meter Reading
X4 – Per cent of wilted plants (%) wilted plants (%)
X5 - Protein content of leaves (%)
X6 - Protein content of seeds (%)
X7 -Phenolic content of seeds (µg/g)
X8 - Phenolic content of leaves (µg/g)
X9 -Oil content of seeds (%)
X10 -Root to shoot ratio
X11 - Root length (cm)
X12 - Pod yield per plant (g)

Table 3: Estimates of direct (diagonal) and indirect effects (of diagonal) of physiological, biochemical and root attributes on pod yield per plant at phenotypic level in groundnut genotypes under normal moisture condition

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	0.0386	0.0092	0.0053	0.0022	-0.0048	-0.0006	-0.0047	-0.0051	-0.0080	-0.0005
X2	-0.0326	-0.1374	0.0020	-0.0303	0.0143	-0.0449	-0.0375	0.0589	0.0450	0.0127
X3	-0.0252	0.0027	-0.1836	0.0444	-0.0426	-0.0373	-0.0222	0.0218	-0.0026	-0.0314
X4	-0.0009	-0.0033	0.0036	-0.0149	0.0028	-0.0006	-0.0031	0.0032	0.0018	0.0010
X5	0.0032	0.0027	-0.0060	0.0049	-0.0257	0.0010	-0.0010	0.0016	-0.0001	0.0028
X6	-0.0022	0.0447	0.0278	0.0053	-0.0053	0.1369	0.0410	-0.0375	-0.0103	0.0245
X7	0.0111	-0.0249	-0.0110	-0.0192	-0.0034	-0.0273	-0.0911	0.0189	0.0073	-0.0106
X8	-0.0390	-0.1254	-0.0347	-0.0637	-0.0185	-0.0802	-0.0607	0.2924	0.1600	0.0415
X9	-0.0343	-0.0540	0.0024	-0.0201	0.0007	-0.0123	-0.0132	0.0901	0.1647	0.0756
X10	0.0008	0.0062	-0.0115	0.0047	0.0074	-0.0121	-0.0079	-0.0096	-0.0310	-0.0675
X11 (r value)	-0.0805	-0.2795	-0.2057	-0.0867	-0.0751	-0.0774	-0.2004	0.4347	0.3268	0.0481
Residual effect = 0.2614										

Where,
X1- Relative water content (%))
X2 - Membrane stability index (%)
X3 - SPAD Chlorophyll Meter Reading
X4 - Protein content of leaves (%) X10 -
X5 - Protein content of seeds (%) X11 -
X6 - Phenolic content of seeds (µg/g)
X7 - Phenolic content of leaves (µg/g
X8 - Oil content of seeds (%)
X9 - Root to shoot ratio
Root length (cm)
Pod yield per plant (g)

Table 4: Estimates of direct (diagonal) and indirect effects (of diagonal) of physiological, biochemical and root attributes on pod yield per plant at phenotypic level in groundnut genotypes under moisture stress condition

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	-0.0062	0.0008	0.0000	0.0000	-0.0003	-0.0006	-0.0020	0.0001	0.0009	0.0000	0.0002
X2	0.0059	-0.0438	0.0024	-0.0085	0.0010	-0.0127	-0.0065	-0.0035	-0.0033	-0.0125	-0.0083
X3	0.0016	-0.0114	0.2040	-0.0189	0.0207	0.0823	0.0431	0.0646	-0.0571	0.0073	0.0300
X4	-0.0007	-0.0358	0.0171	-0.1847	0.0225	-0.0201	0.0109	-0.0006	0.0236	-0.0424	-0.0521
X5	0.0026	-0.0012	0.0052	-0.0063	0.0514	0.0163	-0.0005	0.0016	0.0064	0.0097	-0.0005
X6	-0.0131	-0.0429	-0.0598	-0.0161	-0.0469	-0.1482	-0.0234	-0.0362	0.0396	-0.0437	-0.0565
X7	-0.0125	-0.0057	-0.0081	0.0023	0.0004	-0.0061	-0.0384	-0.0180	0.0123	-0.0030	-0.0101
X8	0.0050	-0.0269	-0.1073	-0.0011	-0.0108	-0.0829	-0.1589	-0.3389	0.1621	-0.0596	-0.1186
X9	-0.0319	0.0161	-0.0597	-0.0272	0.0265	-0.0570	-0.0682	-0.1020	0.2134	-0.0098	-0.0827
X10	0.0012	-0.0457	-0.0057	-0.0366	-0.0301	-0.0471	-0.0124	-0.0281	0.0073	-0.1595	-0.0932
X11	-0.0167	0.0931	0.0726	0.1393	-0.0051	0.1884	0.1296	0.1728	-0.1914	0.2886	0.4939
X12 (r value)	-0.0648	-0.1034	0.0607	-0.1578	0.0293	-0.0877	-0.1267	-0.2882	0.2138	-0.0249	0.1021
Residual effect = 0.3581											

References

1. Al-Jibouri HA, Miller PA, Robinson HF, Genotypic and environmental variation in upland cotton of inter specific origin. Agron. J. 1958; 50:633-636.
2. Coulibaly AM. Genetic analysis of earliness and drought tolerance in groundnut (*Arachis hypogaea* L.) in Niger. Ph. D. Thesis, University of Ghana, Legon, 2013.
3. Cuc ML, Mace ES, Crouch JH, Quang VD, Long DT, Varshney RK *et al*. Isolation and characterization of novel microsatellite markers and their application for diversity assessment in cultivated groundnut (*Arachis hypogaea* L.). Pl. Biolog, 2008; 8:55-59.
4. Dewey DR, Lu KH. A correlation and path coefficient analysis of components crested wheat grass seed reduction. Agron. J. 1959; 51:515-518.
5. Giri RR, Toprope VN, Jagtap PK. Genetic variability, character association and path analysis for yield, its component traits and late leaf spot, *Phaeoisariopsis personata* (Berk and curt), in groundnut. Inter. J Pl. Sci. 2009; 4(2):551-555.
6. John K, Reddy PR, Reddy PH, Sudhakar P, Reddy NPE. Character association and path coefficient analysis among physiological (water use efficiency) traits and yield in F2 population of groundnut (*Arachis hypogaea* L.). Pl. Archives., 2011; 11(2):1123-1128.
7. Lenka D, Mishra B. Path analysis of yield in rice varieties. Ind. J Agri. Sci. 1973; 43:376-379.
8. Painawadee M, Jogloy S, Kesmala T, Akkasaeng, Patanothai A. Identification of trait related to drought in (*Arachis hypogaea* L). Asian J Pl. Sci., 2009; 8(2):120-128.
9. Pirdasthi H, Sarvestani ZT, Bahmanyar MA. Comparison of physiological responses among four contrast rice cultivars under drought stress conditions. Pwaset. 2009; 37(6):52-53.
10. Rao VT, Venkanna V, Bhadru D, Bharathi D. Studies on variability, character association and path analysis on groundnut (*Arachis hypogaea* L.). Inter. J Pure Appl. Biosci. 2014; 2(2):194-197.
11. Songsri P, Jogloy S, Holbrook CC, Kesmala T, Vorasoot, N, Akkasaeng C *et al*. Association of root, specific leaf area and SPAD chlorophyll meter reading to water use efficiency of peanut under different available soil water. Agric. Water Manag. 2009; 96:790-798.

12. Songsri P, Jogloy S, Kesmala T, Vorasoot N, Akkasaeng, C, Patanothai A *et al*. Heritability of drought resistance traits and correlation of drought resistance and agronomic traits in peanut. Crop Sci. 2008a; 48:2245-2253.
13. Sudhakar P, Latha P, Babitha M, Prasanthi L, Reddy, PV. Physiological traits contributing to grain yields under drought in blackgarm and greengram. Indian Journal of Plant Physiology. 2006b; 11(4):391-396.
14. Thakur SB, Ghimire SK, Chaudhary NK, Shrestha SM, Mishra B. Determination of relationship and path co-efficient between pod yield and yield component traits of groundnut cultivars. Nepal J Sci. Technol. 2013a; 14(2):1-8.
15. Thirumala R, Venkanna V, Bhadru D, Bharathi D. Studies on variability, character association and path analysis on groundnut (*Arachis hypogaea* L.), Inter. J Pure Appl. Biosci. 2014; 2(2):194-197.
16. Varman PV, Raveendran TS. Genetic variability and causal relationship in groundnut. Madras Agric. J 1996; 83(1):784-786.
17. Wright S. Correlation and causation. J Agric. Res. 1921; 20:557-587.