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Research Note

Character association studies of drought tolerant attributes in groundnut (*Arachis hypogaea* L.)

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Abstract
An investigation was carried out to study character association among physiological and drought tolerant attributes with 30 groundnut genotypes at College farm, Agricultural College, Mahanandi, Kurnool district, Andhra Pradesh. It indicated that the characters pod yield per plant, shelling out turn, harvest index, number of mature pods per plant, number of sound mature kernel, plant height, specific leaf area, crop growth rate at 75 DAS to harvest and relative growth rate at 75 DAS to harvest were significantly and positively inter-related among themselves and also with the kernel yield per plant. Hence, the improvement of any of these attributes would simultaneously improve the kernel yield per plant. Pod yield per plant exerted high positive direct effect on kernel yield per plant followed by shelling out turn. Plant height, number of mature pods per plant, number of sound mature kernels, harvest index and CGR at 75 DAS to harvest exerted their indirect effect through source contributions for several other characters. It is, therefore, inferred that these characters are to be given importance while formulating selection criteria in breeding programmes to isolate lines with genetic potential for high kernel yield.

Keywords
Groundnut, drought tolerance, correlation, path analysis.

India stands first in cultivated area of groundnut (5.81 m ha) but second place in production (7.4 m t) in the world (Agristat, 2012-2013). The productivity of groundnut in India, however, is low (1274 kg ha^{-1}) compared to that of USA (5000 kg ha^{-1}), China (3530 kg ha^{-1}) and Argentina (2840 kg ha^{-1}). In India, groundnut is mostly grown in six states *viz.,* Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Rajasthan which accounts for 80 per cent of total area and production of groundnut. In Andhra Pradesh, groundnut is the principal oilseed crop, grown in an area of 13.44 lakh ha with a total production of 11.14 lakh t and productivity of 829 kg ha^{-1} (Directorate of Economics and Statistics, 2012-13).

Breeding and selection of drought tolerant genotypes offers the best long term solution to minimize the risks and impact of limited water availability. Use of physiological traits that confer water use efficiency in groundnut will help in improvement of groundnut productivity under rainfed conditions. Several physio-morphological characters have been reported as associated traits for increasing pod yield under pre-flowering drought stress. Nageswara Rao *et al.* (1985) and Nautiyal *et al.* (1999) found that crop growth rate (CGR) was associated with increased yield under pre- flowering drought stress. Awal and Ikeda (2002) reported that relative growth rate was increased after re-watering. Crop growth rate is the key parameter for evaluation of genotypes in terms of dry matter production and yield differences. In groundnut variation for water use efficiency is primarily due to variation in photosynthetic capacity that is reflected by carboxylation efficiency. Nageswara Rao *et al.* (2001) emphasized the importance of surrogate traits like specific leaf area (SLA) and SPAD chlorophyll Meter Reading (SCMR, a measure of chlorophyll content) for screening large breeding populations for WUE. Therefore, availability of reliable and rapid tools to screen drought related traits and also knowledge of character association among various morphological and physiological traits will hasten the progress of genetic improvement for drought tolerance in groundnut.

The present investigation was carried out during *kharif,* 2011 at dryland farm of Agricultural College, Mahanandi situated at an altitude of 233.48 m above mean sea level, latitude $15^0.51^1$ and longitude $78^0.61^1$. The soil is sandy loam with medium fertility. The experimental material consisting of 30 genotypes of groundnut was obtained from Groundnut breeding section, Regional Agricultural Research Station (RARS), Tirupati, Andhra Pradesh. These genotypes were developed at different centers associated with All India Coordinated groundnut improvement programmes. The experiment was laid out in a Randomized Block Design with three replications. The crop was sown during second fortnight of July, 2011. In each replication genotypes were grown in two rows of 4.2 m length with spacing of 30 cm between the rows and 10 cm between the plants within rows. Observations were recorded on randomly chosen five plants in each genotype in each replication for all the nineteen characters . Yield related traits namely, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of mature pods per plant, number of immature pods per plant, number of sound mature kernels, dry haulm weight per plant (g), weight of pods per plant (g), kernel weight per plant (g), shelling out turn (%), 100-seed weight (g); physiological traits namely, SPAD Chlorophyll Meter Reading (SCMR), harvest Index (%), specific leaf area ($cm^2\ g^{-1}$), crop growth rate (CGR), relative growth rate (RGR), and also oil content were recorded. The mean values of five plants in each replication were utilized for character association studies as per standard methods suggested by Johnson *et al* (1955), Wright (1921) and Dewey and Lu (1959).

The correlation co-efficients estimated among 19 yield and physiological traits indicated that for most of the characters the genotypic correlation co-efficient were observed to be higher than the phenotypic correlation coefficients, indicating that though there exists an intrinsic association between the characters studied, the environment and genotype x environment interaction played a major role in determining these associations between the characters (Tables 1 and 2).
Kernel yield per plant per plant displayed significant positive association with pod yield per plant (r_p=0.89**; r_g=0.87), harvest index (r_p=0.72**; r_g=0.75), shelling outturn (r_p=0.46**; r_g=0.53), number of mature pods per plant (r_p=0.36**; r_g=0.39), plant height (r_p=0.32**; r_g=0.38), number of sound mature kernel (r_p=0.30**; r_g=0.32), CGR at 75 DAS to harvest (r_p=0.28**; r_g=0.29) and RGR at 75 DAS to harvest (r_p=0.21*; r_g=0.18). The results indicate that with the improvement in these characters, improvement in kernel yield per plant can be achieved. However, kernel yield per plant had significant negative association with number of secondary branches per plant (r_p= -0.26*; r_g= -0.28).

Similar kind of positive association of kernel yield per plant with pod yield (Venkateswarlu *et al*.,2007 and Dhaliwal *et al.*,2010), kernel yield per plant with mature pods per plant (Venkateswarlu *et al*., 2007 and Dolma *et al.* 2010b) were reported earlier. Significant positive association was reported by Venkateswarlu *et al*. (2007a), Dolma *et al*. (2010b) for kernel yield per plant with harvest index. Marfo and Padi (2000) reported positive association of seed yield with CGR. Uddin *et al.* (1995) and Dolma *et al*. (2010b) reported positive association of seed yield with plant height. Jayalakshmi *et al.* (2000) reported significant and positive association of weight of kernel per plant with sound mature kernel percent and a significant and negative association of kernel yield with number of secondaries per plant.

Not only pod yield per plant, harvest index, shelling outturn, number of mature pods per plant, plant height, number sound mature kernel per plant, RGR at 75 DAS to harvest and CGR at 75 DAS to harvest exhibited positive significant association with kernel weight per plant, but to a great extent *inter-se* correlations among these characters were also found to be significant and positive. The inter-correlations estimated for the yield components indicate the possibility of simultaneous improvement of correlated traits by selection.

Number of mature pods per plant exhibited positive and significant association with sound mature kernel per plant (r_p=0.98**; r_g=0.99), CGR at 30 DAS to 75 DAS (r_p=0.41**; r_g=0.43), RGR at 30 DAS to 75DAS (r_p=0.38**; r_g=0.41), shelling out turn (r_p=0.31**; r_g= 0.35), CGR at 75 DAS to harvest (r_p=0.30**; r_g=0.32), pod yield per plant (r_p=0.25*; r_g=0.26) and SLA (r_p=0.21*; r_g=0.23). Whereas it showed significant and negative association with oil content (r_p= -0.53**; r_g= -0.59). Luz *et al*. (2011) and Venkariya *et al*. (2011) also observed positive association of mature pods per plant with pod yield per plant which is an indication of favourable partioning of source to sink. As positive significant association of mature pods per plant with weight of kernel per plant per plant was observed, which makes it the most important character to bank upon for realizing higher weight of kernel per plants. Number of immature pods per plant registered negative and significant association with dry haulm weight per plant (r_p= -0.45**; r_g= -0.72), RGR at 75 DAS to harvest (r_p=-0.29**; r_g=-0.36) and CGR at 75 DAS to harvest (r_p=-0.26*; r_g=-0.40). This clearly indicated that there is a need to develop genotypes which can put forth flowers, effective peg initiation and pod development almost in a narrow space of time, so that immature pod formation could be minimized.

The character number of sound mature kernel displayed positive and significant association with CGR at 30 DAS to 75 DAS (r_p=0.36**; r_g=0.39), RGR at 30 DAS to 75 DAS (r_p=0.35**; r_g=0.38), CGR at 75 DAS to harvest (r_p=0.30**; r_g=0.31), shelling out turn (r_p=0.23*; r_g=0.26), weight of pods per plant (r_p=0.22*; r_g=0.23) and SLA (r_p=0.21*; r_g=0.22). On other hand, negative and significant association of sound mature kernel per plant was observed with oil content (r_p= -0.49**; r_g= -0.55). Pod yield per plant showed positive and significant association with harvest index (r_p=0.52**; r_g=0.51), CGR at 75 DAS to harvest (r_p=0.35**; r_g=0.37), RGR at 75 DAS to harvest (r_p=0.35**; r_g=0.35) and negative and significant association with SCMR (r_p=-0.26*; r_g=-0.38). Similar results were observed by Vaithiyalingam (2010) and Venkariya *et al*. (2011) for harvest index.

The association of shelling out turn was positive and significant with harvest index (r_p=0.55**; r_g=0.63) and 100-seed weight (r_p=0.25*; r_g=0.29) and negative and significant association with oil content (r_p=-0.22*; r_g=-0.23), RGR at 75 DAS to harvest (r_p=-0.21*; r_g=-0.23). Meta and Monpara (2010) observed significant positive correlation of shelling out turn with 100 kernel weight, sound mature kernel percent. John *et al*. (2005) observed significant positive association of shelling out turn with sound mature kernel percent. The positive association of shelling out turn with harvest index and 100-seed weight was observed by Reddy and Gupta (1992) whereas negative association of shelling out turn with harvest index was reported by Abraham *et al*. (1990). The differences in the sign of correlation between shelling out turn with harvest index reported by various workers might be attributed to the differences in the genetic architecture of biological material used in the respective studies.

The character 100-seed weight displayed positive association with SCMR. SLA showed non-significant and negative association with SCMR. The results are in consonance with the results of Reddy *et al.* (2004) who obtained inverse relationship obtained between SLA and SCMR substantiated the conclusion that SCMR was a potential physiological trait to be employed as a surrogate for transpiration efficiency. The character SLA displayed positive and significant association with RGR at 75 DAS to harvest (r_p=0.33**; r_g=0.39), CGR at 75 DAS to harvest (r_p=0.29**; r_g=0.35), where as it's association was negative and significant with SCMR (r_p=-0.31**; r_g=-0.53), CGR at 30 DAS to 75 DAS (r_p=-0.25*; r_g=-0.31) and RGR at 30 DAS to 75 DAS (r_p=-0.24*; r_g=-0.30). Nigam *et al*. (2004) reported negative association of SLA and CGR. SCMR and SLA have been suggested as surrogate traits for selecting genotypes in drought breeding programmes (Wright, 1994 and Nagehwara Rao *et al.* 2001). SLA was negatively correlated with WUE and SCMR has positive significant association with yield. Thus the negative and significant association observed between these traits in the present study confirmed the earlier findings.

The character SCMR exhibited negative and significant association with RGR at 75 DAS to harvest (r_p=-0.34**; r_g=-0.44) and CGR at 75 DAS to harvest (r_p=-0.32**; r_g=-0.40). Though SCMR is an indicator of photosynthetic activity of the leaf, increase in CGR and RGR at 75 DAS in groundnut might not necessarily be associated with increase in photosynthetic biomass. This might be the reason for negative association of SCMR with RGR at 75 DAS to harvest and CGR at 75 DAS after harvest. The character CGR at 30 DAS to 75 DAS displayed positive and significant association with RGR at 30 DAS to 75 DAS (r_p=0.88**; r_g=0.89) and negative and significant association with RGR at 75 DAS to harvest (r_p=-0.28**; r_g=-0.29). CGR at 75 DAS to harvest displayed positive and significant association with RGR at 75 DAS to harvest (r_p=0.94**; r_g=0.98). RGR at 30 DAS to 75 DAS displayed negative and significant association with RGR at 30 DAS to 75 DAS (r_p=-0.22*; r_g=-0.24).

When many characters are affecting a given character, splitting the total correlation into direct and indirect effects of cause as devised by Wright (1921) would give more meaningful interpretation to the causes of association between the dependent and independent variables. This kind of information will help in rationalizing the basis of selection more meaningfully in a breeding programme.

Path coefficients among kernel yield per plant and its components were presented in Tables 3 and 4. Among various traits which are significantly associated with kernel yield, pod yield per plant exhibited the high positive direct effect (0.86) on kernel yield per plant followed by shelling out turn (0.43). Number of mature pods per plant (0.10), CGR at 75 DAS to harvest (0.04), harvest index (0.03), number of secondary branches per plant (0.00) and plant height (0.00) showed negligible positive direct effect on kernel yield per plant per plant. On the contrary, number of sound mature kernel displayed the negligible negative direct effect (-0.07) on kernel yield per plant followed by RGR at 75 DAS to harvest (-0.05).

A perusal of path coefficients revealed that pod yield per plant and shelling out turn had high direct effect on kernel yield per plant indicating that the genetic correlation between pod yield per plant, shelling out turn and kernel yield per plant explains the true relationship between these characters. These results corroborate well with the reports of Dolma *et al*. (2010b) and Venkariya *et al.* (2011) for pod yield per plant and Dolma *et al*. (2010b) for shelling percentage.

Though plant height exhibited strong positive correlation with kernel yield per plant, it exhibited positive negligible direct effect (0.00) with kernel yield per plant at both phenotypic and genotypic level. The strong association might be due to the indirect effects through *pod* yield per plant (0.35) both at phenotypic and genotypic level. Number of mature pods per plant exerted strong positive association with kernel yield per plant. It exhibited negligible positive direct effect (0.10) with kernel yield per plant at phenotypic level and negligible negative direct effect (-0.02) with kernel yield per plant at genotypic level. The positive correlations might be due to positive indirect effect of number of mature pods per plant through pod yield per plant (0.22) and shelling out turn (0.13).

Strong and positive association was observed between number of sound mature kernels and kernel yield per plant but it exhibited negligible negative direct effect (-0.07) with kernel yield both at genotypic and phenotypic level. The strong and positive association was due to the indirect effect of number of sound mature kernels through pod yield per plant (0.19) and shelling out turn (0.10) which was positive and high both at genotypic and phenotypic levels. Though harvest index exhibited strong and positive correlation with kernel yield per plant, it exhibited negligible positive direct effect (0.03) with kernel yield per plant at phenotypic level and negligible negative direct effect (-0.14) with kernel yield per plant at genotypic level. But the indirect effect of harvest index through pod yield per plant (0.45) and shelling out turn (0.24) was positive and high.

Crop Growth Rate at 75 DAS to harvest exhibited strong and positive correlation with kernel yield. It exhibited negligible positive direct effect (0.04) at phenotypic level and negligible negative direct effect (-0.08) at genotypic level. The indirect effect of Crop Growth Rate at 75 DAS to harvest through pod yield per plant (0.30) was the reason for strong association both at genotypic and phenotypic level.

It is clear from the study that pod yield per plant and shelling out turn exhibited strong positive correlation and high positive direct effect with kernel yield per plant both at genotypic and phenotypic level. They emerged as the major components of kernel yield per plant to emphasize selection. These characters may also be included in formulating the selection criterion for improving kernel yield in groundnut.

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Table 1. Phenotypic correlation coefficients among nineteen characters in 30 genotypes of groundnut

Character	PB	SB	MP	IMMP	SMK	DHW	PYP	SO	100 SW	HI	SLA	SCMR	OC	CGR1	CGR2	RGR1	RGR2	KYP
PH	-0.02	0.07	-0.01	-0.39**	0.02	0.23**	0.41**	-0.11	-0.10	0.19	0.23*	-0.31**	0.20	-0.10	0.15	-0.15	0.25*	0.32**
PB	1.00	0.10	0.51**	-0.07	0.56**	0.08	0.18	0.12	0.46**	0.15	-0.05	0.18	-0.37**	0.20	-0.06	0.18	-0.10	0.21*
SB		1.00	-0.04	-0.18	-0.01	0.06	-0.22*	-0.14	0.20	-0.14	-0.09	0.06	-0.13	0.23*	-0.11	0.29**	-0.07	-0.26*
MP			1.00	-0.08	0.98**	0.13	0.25*	0.31**	-0.02	0.11	0.21*	-0.07	-0.53**	0.41**	0.30**	0.38**	0.18	0.36**
IMMP				1.00	-0.12	-0.45**	-0.20	0.18	0.02	0.18	-0.17	0.01	-0.07	-0.14	-0.26*	-0.11	-0.29**	0.08
SMK					1.00	0.16	0.22*	0.23*	0.03	0.02	0.21*	-0.01	-0.49**	0.36**	0.30**	0.35**	0.18	0.30**
DHW						1.00	0.18	-0.26*	-0.13	-0.38**	0.09	-0.07	0.06	0.17	0.58**	0.27*	0.60**	0.04
PYP							1.0	0.00	0.06	0.52**	0.13	-0.26*	0.04	0.03	0.35**	-0.08	0.35**	0.89**
SO								1.00	0.25*	0.55**	0.18	0.11	-0.22*	0.07	-0.07	-0.10	-0.21*	0.46**
100 SW									1.00	0.13	-0.27*	0.34**	0.02	0.11	-0.10	0.03	-0.20	0.17
HI										1.00	0.08	-0.05	-0.15	-0.03	-0.32**	-0.14	-0.34**	0.72**
SLA											1.00	-0.31**	-0.18	-0.25*	0.29**	-0.24*	0.33**	0.19
SCMR												1.00	-0.07	-0.09	-0.32**	0.01	-0.34**	-0.18
OC													1.00	-0.27*	0.16	-0.40**	0.22*	-0.06
CGR1														1.00	-0.11	0.88**	-0.28**	0.05
CGR2															1.00	-0.14	0.94**	0.28**
RGR1																1.00	-0.22*	-0.13
RGR2																	1.00	0.21*

PH=Plant height; PB=Number of primary branches per plant; SB=Number of secondary branches per plant; MP=Number of mature pods per plant; IMMP=Number of immature pods per plant; SMK=Number of sound mature kernel; PYP=Pod yield per plant; KYP=Kernel yield per plant; SO=Shelling out turn; 100SW=100-seed weight; HI=Harvest index; SLA=Specific Leaf Area; SCMR=SPAD chlorophyll meter reading; O.C=Oil content; CGR1=Crop Growth Rate at 30 DAS to 75 DAS; CGR2=Crop Growth Rate at 75 DAS to harvest; RGR1=Relative Growth Rate at 30 DAS to 75 DAS; RGR 2= Relative Growth Rate at 75 DAS to harvest.

Table 2. Genotypic correlation coefficients among nineteen characters in 30 genotypes of groundnut

Character	PB	SB	MP	IMMP	SMK	DHW	PYP	SO	100 SW	HI	SLA	SCMR	OC	CGR1	CGR2	RGR1	RGR2	KYP
PH	0.00	0.07	0.01	-0.47	0.04	0.33	0.50	-0.10	-0.12	0.22	0.27	-0.45	0.24	-0.11	0.17	-0.15	0.28	0.38
PB	1.00	0.14	0.56	-0.08	0.62	0.04	0.11	0.13	0.54	0.13	0.01	0.29	-0.43	0.21	-0.10	0.21	-0.16	0.16
SB		1.00	-0.03	-0.22	0.00	0.07	-0.24	-0.15	0.21	-0.14	-0.10	0.10	-0.15	0.24	-0.10	0.30	-0.07	-0.28
MP			1.00	-0.10	0.99	0.14	0.26	0.35	-0.02	0.11	0.23	-0.14	-0.59	0.43	0.32	0.41	0.18	0.39
IMMP				1.00	-0.14	-0.72	-0.35	0.22	-0.01	0.19	-0.17	0.15	-0.08	-0.25	-0.40	-0.20	-0.36	-0.17
SMK					1.00	0.20	0.23	0.26	0.03	0.01	0.22	-0.07	-0.55	0.39	0.31	0.38	0.19	0.32
DHW						1.00	0.17	-0.29	-0.14	-0.49	0.15	0.00	0.11	0.18	0.63	0.29	0.67	0.00
PYP							1.00	0.04	0.05	0.51	0.16	-0.38	0.11	0.03	0.37	-0.11	0.35	0.87
SO								1.00	0.29	0.63	0.21	0.21	-0.23	0.09	-0.06	-0.11	-0.23	0.53
100 SW									1.00	0.13	-0.31	0.50	0.03	0.10	-0.10	0.03	-0.20	0.19
HI										1.00	0.09	-0.03	-0.15	-0.04	-0.37	-0.17	-0.41	0.75
SLA											1.00	-0.53	-0.20	-0.31	0.35	-0.30	0.39	0.24
SCMR												1.00	-0.13	-0.13	-0.40	0.03	-0.44	-0.21
OC													1.00	-0.30	0.18	-0.45	0.25	-0.02
CGR1														1.00	-0.12	0.89	-0.29	0.05
CGR2															1.00	-0.16	0.98	0.29
RGR1																1.00	-0.24	-0.16
RGR2																	1.00	0.18

PH=Plant height; PB=Number of primary branches per plant; SB=Number of secondary branches per plant;
MP=Number of mature pods per plant; IMMP=Number of immature pods per plant; SMK=Number of sound mature kernel;
PYP=Pod yield per plant; KYP=Kernel yield per plant ; SO=Shelling out turn; 100SW=100-seed weight; HI=Harvest index;
SLA=Specific Leaf Area; SCMR=SPAD chlorophyll meter reading; O.C=Oil content; CGR1=Crop Growth Rate at 30 DAS to 75 DAS;
CGR2=Crop Growth Rate at 75 DAS to harvest; RGR1=Relative Growth Rate at 30 DAS to 75 DAS;
RGR 2= Relative Growth Rate at 75 DAS to harvest.

Table 3. Phenotypic path coefficients for kernel yield and other characters associated characters among 30 genotypes of groundnut

Character	PH	PB	SB	MP	IMMP	SMK	DHW	PYP	SO	100 SW	HI	SLA	SCMR	OC	CGR1	CGR2	RGR1	RGR2
PH	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PB	0.00	**-0.01**	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00
SB	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP	0.00	0.05	0.00	**0.10**	-0.01	0.10	0.01	0.03	0.03	0.00	0.01	0.02	-0.01	-0.05	0.04	0.03	0.04	0.02
IMMP	-0.01	0.00	0.00	0.00	**0.01**	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
SMK	0.00	-0.04	0.00	-0.07	0.01	**-0.07**	-0.01	-0.02	-0.02	0.00	0.00	-0.01	0.00	0.03	-0.03	-0.02	-0.03	-0.01
DHW	0.01	0.00	0.00	0.00	-0.01	0.00	**0.03**	0.01	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.02
PYP	0.35	0.15	-0.19	0.22	-0.18	0.19	0.16	**0.86**	0.00	0.05	0.45	0.11	-0.23	0.03	0.03	0.30	-0.00	0.30
SO	-0.04	0.05	-0.06	0.13	0.08	0.10	-0.11	0.00	**0.43**	0.11	0.24	0.08	0.05	-0.09	0.03	-0.03	-0.04	-0.09
100 SW	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-0.00
HI	0.01	0.00	0.00	0.00	0.01	0.00	-0.01	0.02	0.02	0.00	**0.03**	0.00	0.00	-0.01	0.00	-0.01	-0.01	-0.01
SLA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00
SCMR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	-0.00
OC	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	0.00	0.00	-0.01	0.00
CGR1	0.00	-0.01	-0.01	-0.01	0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	**-0.04**	0.00	-0.03	0.01
CGR2	0.01	0.00	0.00	0.01	-0.01	0.01	0.02	0.01	0.00	0.00	-0.01	0.01	-0.01	0.01	0.00	**0.04**	-0.01	0.04
RGR1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	**0.01**	-0.00
RGR2	-0.01	0.00	0.00	-0.01	0.01	-0.01	-0.03	-0.02	0.01	0.01	0.02	-0.02	0.02	-0.01	0.01	-0.05	0.01	**-0.05**
correlation with kernel yield	**0.32****	**0.21**	**0.26***	**0.36****	**-0.08**	**0.30****	**0.04**	**0.89****	**0.46****	**0.170**	**0.72****	**0.19**	**0.17**	**-0.06**	**0.05**	**0.28****	**-0.13**	**0.21***

Residual effect: 0.0434

PH=Plant height; PB=Number of primary branches per plant; SB=Number of secondary branches per plant; MP=Number of mature pods per plant; IMMP=Number of immature pods per plant; SMK=Number of sound mature kernel; PYP=Pod yield per plant; KYP=Kernel yield per plant ; SO=Shelling out turn; 100SW=100-seed weight; HI=Harvest index; SLA=Specific Leaf Area; SCMR=SPAD chlorophyll meter reading; O.C=Oil content; CGR1=Crop Growth Rate at 30 DAS to 75 DAS; CGR2=Crop Growth Rate at 75 DAS to harvest; RGR1=Relative Growth Rate at 30 DAS to 75 DAS; RGR 2= Relative Growth Rate at 75 DAS to harvest

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Table 4. Genotypic path coefficients for kernel yield and other characters associated characters among 30 genotypes of groundnut

Character	PH	PB	SB	MP	IMMP	SMK	DHW	PYP	SO	100 SW	HI	SLA	SCMR	OC	CGR1	CGR2	RGR1	RGR2
PH	**0.03**	0.00	0.00	0.00	-0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	-0.01	0.01	0.00	0.00	0.00	0.01
PB	0.00	**0.05**	0.01	0.03	0.00	0.03	0.00	0.01	0.01	0.03	0.01	0.00	0.02	-0.02	0.01	-0.01	0.01	-0.01
SB	0.00	0.00	**0.01**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP	0.00	-0.01	0.00	**-0.02**	0.00	-0.02	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.01	-0.01	-0.01	-0.01	0.00
IMMP	-0.01	0.00	0.00	0.00	**0.02**	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01
SMK	0.00	-0.03	0.00	-0.05	0.01	**-0.05**	-0.01	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.03	-0.02	-0.02	-0.02	-0.01
DHW	-0.02	0.00	-0.01	-0.01	0.05	-0.01	**-0.07**	-0.01	0.02	0.01	0.03	-0.01	0.00	-0.01	-0.01	-0.04	-0.02	-0.05
PYP	0.48	0.11	-0.23	0.25	-0.34	0.22	0.16	**0.96**	0.04	0.04	0.48	0.15	-0.36	0.10	0.03	0.36	-0.11	0.34
SO	-0.06	0.08	-0.09	0.21	0.13	0.16	-0.18	0.03	**0.60**	0.18	0.38	0.13	0.13	-0.14	0.05	-0.03	-0.06	-0.14
100 SW	0.01	-0.03	-0.01	0.00	0.00	0.00	0.01	0.00	-0.02	**-0.06**	-0.01	0.02	-0.03	0.00	-0.01	0.01	0.00	0.01
HI	-0.03	-0.02	0.02	-0.01	-0.03	0.00	0.07	-0.07	-0.09	-0.02	**-0.14**	-0.01	0.00	0.02	0.01	0.05	0.02	0.06
SLA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00
SCMR	-0.02	0.01	0.00	0.00	0.01	0.00	0.00	-0.01	0.01	0.02	0.00	-0.02	**0.03**	0.00	0.00	-0.01	0.00	-0.02
OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
CGR1	0.00	-0.01	-0.01	-0.01	0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	**-0.03**	0.00	-0.03	0.01
CGR2	-0.01	0.01	0.01	-0.03	0.03	-0.03	-0.05	-0.03	0.00	0.01	0.03	-0.03	0.03	**-0.01**	0.01	**-0.08**	0.01	-0.08
RGR1	-0.01	0.02	0.02	0.03	-0.01	0.03	0.02	-0.01	-0.01	0.00	-0.01	-0.02	0.00	-0.03	0.07	-0.01	**0.07**	-0.02
RGR2	0.0257	-0.015	-0.006	0.0172	-	0.0175	0.0626	0.0328	-	-0.019	-	0.0364	-0.0414	0.0231	-0.0275	0.0915	-0.0221	**0.0936**
correlation with kernel yield	**0.38**	**0.16**	**-0.28**	**0.39**	**-0.17**	**0.32**	**0.00**	**0.87**	**0.53**	**0.19**	**0.75**	**0.24**	**-0.21**	**-0.02**	**0.05**	**0.29**	**-0.16**	**0.18**

Residual effect: 0.0450

PH=Plant height; PB=Number of primary branches per plant; SB=Number of secondary branches per plant; MP=Number of mature pods per plant; IMMP=Number of immature pods per plant; SMK=Number of sound mature kernel; PYP=Pod yield per plant; KYP=Kernel yield per plant ; SO=Shelling out turn; 100SW=100-seed weight; HI=Harvest index; SLA=Specific Leaf Area; SCMR=SPAD chlorophyll meter reading; O.C=Oil content; CGR1=Crop Growth Rate at 30 DAS to 75 DAS; CGR2=Crop Growth Rate at 75 DAS to harvest; RGR1=Relative Growth Rate at 30 DAS to 75 DAS; RGR 2= Relative Growth Rate at 75 DAS to harvest