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STUDIES ON CORRELATION AND PATH ANALYSIS FOR TRAITS RELATED TO WATER USE EFFICIENCY AND POD YIELD AND ITS COMPONENTS IN GROUNDNUT (*ARACHIS HYPOGEA* L.)

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ABSTRACT
Character association and path analysis among fourteen characters were studied in F_2 segregating generations of three groundnut crosses *viz.*, KCG-6 × ICGV-91114, KCG-6 × TG-69 and TMV 2 × ICGV-00350. Analysis of correlation revealed that specific leaf area has significant negative correlation with SCMR(-0.59, -0.385, -0.70), total pods per plant (-0.59,-0.39, -0.70), matured pods per plant (-0.29, -0.25, -0.49), kernel yield (-0.36, -0.51, -0.06) and pod yield (-0.36, -0.18, -0.38). The pod yield was significantly positive correlated with SCMR(0.53, 0.50, 0.48), matured pods per plant (0.54, 0.67, 0.59), harvest index (0.38, 0.46, 0.69), kernel yield (0.83, 0.79, 0.89), oil yield (0.79, 0.76, 0.87) and sound mature kernel per cent (0.27, 0.37, 0.27). Path analysis indicated that, kernel yield per plant, matured pods per plant and sound mature kernel per cent showed highest direct effect on pod yield. This indicates that more emphasis can be given for following traits SCMR, matured pods per plant, kernel yield, sound mature kernel per cent and harvest index for the improvement of pod yield of groundnut.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), highly self-pollinated legume grown in tropical and sub-tropical regions of the world is good source of oil and protein. The seed contains about 40-50 per cent oil, 27 per cent protein and 18 per cent carbohydrates in addition to minerals and vitamins.

Drought is the most important yield limiting factor affecting groundnut productivity and its occurrence is highly dynamic over the years and locations. Limited water availability during crop growth, especially during flowering and peg penetration stages always hinders utilization genetic potential of improved cultivars. The yield loss due to drought has been estimated to be 56-85% (Nageshwara *et al.*, 1989; Shinde *et al.*, 2010). There fore, development of drought tolerant varieties is one of the key areas of breeding in groundnut. The SLA and SCMR are potential surrogate trait for WUE (Nageshwara Rao *et al.*, 2001). Groundnut is a predominately self-pollinated crop and heterosis in groundnut is unstable because of tetraploid. Assessment of inter-relationship of surrogate traits with pod yield and its components is essential for formulating selection strategy to combine drought tolerance conferring traits with higher seed yield. In order to achieve the goal of increased production by increasing the yield potential of crops, knowledge on direction and magnitude of association between various traits is essential for plant breeders (Kamleshwar *et al.*, 2013). Creation of variability by crossing between diverse parents and generating segregating population will give scope for assessing variability (shiva kumar *et al.*, 2014), studying association between characters (koart *et al.*,2010). In view of this, the present study was conducted to reveal the relationship between pod yield and drought tolerance traits by using F_2 generations of three crosses performed on groundnut. Thus, it helps us judge the best and important component characters during selection for achieving improvements in yield under water limited conditions.

MATERIALS AND METHODS

The material for the present study comprised of F_2 population derived from three crosses *viz.*, KCG-6 × ICGV- 91114, KCG-6 × TG-69 and TMV-2 × ICGV-00350 of each cross consist of 156 population of groundnut belonging to spanish habit groups. Source of the parent material obtained from All India Coordinated Research Project on Groundnut, Chintamani. The F_2 plants of three crosses and their parents were planted with a spacing of 30 x 20 cm during *kharif* 2014. F_2 population consisted of highly variable population, as they will be segregating for genes at each loci for which parents differ. The observations on plant height, number of primary branches, days to first flowering, specific leaf area (cm^2/g), SPAD Chlorophyll Meter Reading (mg/g), number of matured pods per plant, total number of pods per plant, pod yield per plant (g), kernel yield per plant (g), sound mature kernel (SMK) per cent, shelling per cent, harvest index (%), oil content (%), oil yield per plant (g) were recorded on all the F_2 plants along with ten randomly selected plants in the parental population grown along with F_2 generation in each cross for yield and drought related traits. The phenotypic correlation coefficients of all the characters were worked out through covariance analysis as per Al-Jibouri *et al.*(1958). The phenotypic path analysis were done as per the method suggested by Dewey and Lu (1957).

RESULTS AND DISCUSSION

The results of the correlation coefficient among the fourteen traits studied in all three crosses are shown in Table 1. In all three crosses pod yield per plant was found to have high significant positive association with kernel yield per plant, oil yield, matured pods per plant, SCMR, total pods per plant, shelling per cent, sound mature kernel per cent and non-significant positive association with number of branches per plant. Further, it exhibited significant negative association with specific leaf area.These observations are in conformity with those of John *et al*. (2007), Vasanthi *et al*. (2015), Makhan *et al*. (2003), Mukhtar *et al*. (2011) and Pavan Kumar *et al*. (2014).

Days to first flowering showed non-significant positive association with pod yield in the crosses KCG-6 × ICGV-91114 (0.054) and KCG-6 × TG-69 (0.091), whereas this exhibited non-significant negative association with pod yield in the cross TMV-2 × ICGV-00350 (-0.037). Plant height had non-significant negative association with pod yield for the crosses KCG-6 × ICGV-91114 (-0.030), KCG-6 × TG-69 (-0.031), similar kind of association were reported by Thirumal Rao *et al*. (2014) and this trait showed non-significant positive association with pod yield for the cross TMV-2 × ICGV-00350 (0.012). This is accordance with the results of koart *et al*. (2010). Number of primary branches per plant was positively and non-significantly correlated with pod yield per plant in all three crosses. Oil content recorded non-significant positive association with pod yield in the crosses KCG-6 × TG-69 (0.015) and TMV-2 × ICGV-00350 (0.024), however it showed non-significant negative association in the cross KCG-6 × ICGV-91114 (-0.01).

Specific leaf area was showed significant and negative correlation with pod yield per plant, kernel yield per plant,

Table 1: Estimates of phenotypic correlation coefficients for pod yield and its attributing traits in three F_2 population

Characters	crosses	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	C1	1													
	C2	1													
	C3	1													
X2	C1	-0.214**	1												
	C2	-0.054	1												
	C3	0.079	1												
X3	C1	-0.037	0.128	1											
	C2	-0.116	0.087	1											
	C3	-0.029	-0.018	1											
X4	C1	-0.023	0.126	0.120	1										
	C2	0.024	-0.062	0.005	1										
	C3	0.110	-0.146	0.009	1										
X5	C1	0.045	-0.153	-0.040	-0.587**	1									
	C2	0.020	-0.056	0.014	-0.385**	1									
	C3	-0.167*	-0.047	0.019	-0.705**	1									
X6	C1	0.103	0.042	-0.015	-0.177*	0.105	1								
	C2	-0.060	-0.056	0.079	-0.207	0.005	1								
	C3	-0.074	-0.190*	0.080	-0.006	0.034	1								
X7	C1	0.100	-0.036	0.037	0.089	0.029	0.162*	1							
	C2	0.024	0.021	-0.035	-0.041	0.099	0.032	1							
	C3	-0.114	-0.138	0.004	0.095	-0.024	0.062	1							
X8	C1	0.035	-0.073	-0.025	-0.301**	0.491**	0.196*	0.274**	1						
	C2	0.074	-0.056	-0.084	-0.197*	0.521**	-0.113	0.205*	1						
	C3	-0.096	-0.003	0.045	-0.345**	0.384**	-0.050	0.186*	1						
X9	C1	0.044	-0.145	-0.038	-0.593**	0.995**	0.103	0.030	0.500**	1					
	C2	0.032	-0.058	0.003	-0.394**	0.996**	-0.001	0.100	0.413**	1					
	C3	-0.173*	-0.008	0.045	-0.732**	0.583**	0.018	-0.022	0.419**	1					
X10	C1	0.008	-0.062	-0.032	-0.335**	0.502**	0.165*	0.043	0.968**	0.510**	1				
	C2	0.064	-0.054	-0.075	-0.510**	0.586**	0.226*	-0.073	0.957**	0.498**	1				
	C3	-0.048	0.023	-0.001	-.0356**	0.381**	0.169	-0.034	0.972**	0.417**	1				
X11	C1	-0.060	-0.052	0.076	-0.176*	0.182*	0.106	0.105	0.635**	0.188*	0.637**	1			
	C2	-0.003	-0.065	-0.044	-0.157	0.197*	0.053	-0.134	0.597**	0.195*	0.639**	1			
	C3	-0.093	0.012	-0.030	-0.284**	0.340**	-0.061	0.190*	0.639**	0.349**	0.614**	1			
X12	C1	0.033	-0.127	-0.047	-0.288**	0.416**	0.008	-0.012	0.136	0.417**	0.741**	0.434**	1		
	C2	-0.039	0.021	-0.083	-0.245*	0.460**	-0.140	0.088	0.203*	0.465**	0.484**	0.722**	1		
	C3	-0.004	-0.130	-0.007	-0.488**	0.379**	-0.071	0.013	0.056	0.369**	0.738**	0.104	1		
X13	C1	0.009	-0.008	0.067	-0.254**	0.411**	0.018	0.120	0.276**	0.414**	0.265**	0.155	0.431**	1	
	C2	0.065	-0.078	-0.036	0-.340**	0.446**	-0.034	0.181*	0.289**	0.450**	0.358**	0.431**	0.381**	1	
	C3	-0.054	-0.135	0.092	-0.424**	0.682**	-0.023	0.016	0.207*	0.686**	0.202*	0.302*	0.673**	1	
X14	C1	0.054	-0.030	0.026	-0.361**	0.532**	0.378**	-0.010	0.794**	0.538**	0.830**	0.387**	0.548**	0.274**	1
	C2	0.091	-0.031	0.171	-0.180*	0.506**	0.463**	0.015	0.765**	0.497**	0.790**	0.165*	0.664**	0.366*	1
	C3	-0.037	0.012	0.0977	-0.380**	0.485**	0.696**	0.024	0.875**	0.506**	0.890**	0.708**	0.592**	0.270**	1

**Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

X_1 Days to first flowering; X_2- Plant height(cm); X_3- No. of branches per plant; X_4- SLA(cm^2/g);X_5- SCMR;X_6-Harvest index (%); X_7- Oil content (%); X_{12}- Mature pods per plant; X_8- Oil yield per plant (g); X_{13}- Sound mature kernel (%); X_9- Total pods per plant; X_{14} Pod yield per plant; X_{10}- Kernel yield per plant(g); X_{11}- Shelling per cent

C1 = KCG-6 × ICGV-91114; C2 = KCG-6 × TG-69; C3 = TMV-2 × ICGV-00350.

Table 2: Estimates of phenotypic path analysis indicating direct and indirect effect on pod yield in three F_2 population

characters	crosses	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	C1	0.0071	-0.0015	-0.0003	-0.0002	0.0003	0.0007	0.0007	0.0002	0.0003	0.0001	-0.0004	0.0002	0.0001
	C2	0.0060	-0.0003	-0.0007	0.0001	0.0001	-0.0004	0.0001	0.0004	0.0002	0.0004	0.0001	-0.0002	0.0004
	C3	0.0362	0.0029	-0.0011	0.0040	-0.0061	-0.0027	-0.0041	-0.0034	-0.0062	-0.0017	-0.0033	-0.0001	-0.0020
X2	C1	-0.0059	0.0276	0.0035	0.0035	-0.0042	-0.0988	-0.001	-0.0020	-0.0040	-0.0017	-0.0314	-0.0035	-0.1002
	C2	0.0006	-0.0112	-0.0010	0.0007	0.0006	0.0006	-0.0002	0.0006	0.0007	0.0006	0.0007	0.0001	-0.0099
	C3	0.0013	0.0170	-0.0003	-0.0025	-0.0008	-0.0032	-0.0023	-0.0001	-0.0001	0.0003	0.0000	-0.0022	-0.0023
X3	C1	0.0007	-0.0023	0.0181	-0.0022	0.0007	0.0003	-0.0007	0.0004	0.0007	0.0006	-0.0514	0.0009	-0.1012
	C2	0.0039	-0.0029	0.0332	-0.0002	-0.0005	-0.1026	0.0012	0.0028	-0.0001	0.0025	0.0014	0.0028	0.0012
	C3	0.0003	0.0002	0.0101	-0.0001	-0.0002	-0.0008	0.0001	0.0001	-0.0005	0.0000	0.0003	0.0001	-0.0009
X4	C1	0.0016	-0.0087	-0.0083	-0.0687	0.0404	0.0123	-0.0061	0.0207	0.0408	0.0230	-0.0621	0.0198	0.0175
	C2	-0.0004	0.0011	-0.0001	-0.0175	0.0067	-0.1001	0.0007	0.0034	0.0069	0.0037	0.0027	0.0025	0.0059
	C3	0.0070	-0.0092	0.0006	-0.1369	-0.0444	-0.0007	0.0060	-0.0217	-0.0462	-0.0224	-0.0179	-0.0187	-0.0267
X5	C1	0.0017	-0.0058	-0.0015	-0.0222	0.0378	0.0039	0.0011	0.0186	0.0376	0.0190	0.0069	0.0157	0.0155
	C2	0.0052	-0.0148	0.0037	-0.1011	0.2628	0.0004	0.0261	0.1370	0.2618	0.2329	0.0518	0.1210	0.1171
	C3	-0.0466	-0.0130	0.0053	-0.0959	0.2781	0.0099	-0.0068	0.1068	0.2735	0.1061	0.0945	0.1054	0.1897
X6	C1	-0.0006	-0.0003	0.0001	0.0011	-0.0006	0.1313	-0.0010	-0.0012	-0.0006	-0.0010	-0.0006	-0.0001	-0.0001
	C2	0.0020	0.0019	-0.0026	-0.0003	-0.0001	0.1971	-0.0009	0.0038	0.0001	0.0042	0.0017	0.0046	0.0011
	C3	-0.0002	-0.0005	0.0002	0.0001	0.0001	0.3225	0.0002	-0.0001	0.0001	-0.0002	-0.0002	-0.0002	-0.1001
X7	C1	-0.0041	0.0014	-0.0015	-0.0035	-0.0011	-0.0064	-0.0397	-0.0109	-0.0012	-0.0017	-0.0041	0.0005	-0.0048
	C2	0.0024	0.0020	-0.0035	-0.0042	0.0100	0.0028	0.1011	0.0208	0.0101	-0.0074	-0.0136	0.0089	0.0183
	C3	-0.0102	-0.0123	0.0003	0.0085	-0.0022	0.0055	0.0894	0.0166	-0.0020	-0.0031	0.0170	0.0012	0.0015
X8	C1	0.0076	-0.0161	-0.0054	-0.0655	0.1068	0.0427	0.0598	0.2179	0.1088	0.2431	0.1383	0.0296	0.0601
	C2	-0.0274	0.0210	0.0312	0.0735	-0.1945	0.0434	-0.0766	-0.3731	-0.1914	-0.3570	-0.1226	-0.0757	-0.1077
	C3	0.0343	0.0012	-0.0001	0.1240	-0.1383	0.0177	-0.0668	-0.3600	-0.1508	-0.2796	-0.2301	-0.0201	-0.0744
X9	C1	-0.0030	0.0097	0.1026	0.0398	-0.0668	-0.0069	-0.0020	-0.0335	-0.0671	-0.0342	-0.0126	-0.0280	-0.0278
	C2	-0.0084	0.0153	0.1009	0.1036	-0.2620	0.0009	-0.0263	-0.1349	-0.2630	-0.1309	-0.0513	-0.1224	-0.1183
	C3	0.0104	0.0005	0.0927	0.0442	-0.0594	-0.0012	0.0013	-0.0253	-0.0605	-0.0252	-0.0211	-0.0223	-0.0415
X10	C1	0.0086	-0.0634	-0.0325	-0.3402	0.5101	0.2668	0.0436	0.9838	0.5182	0.9839	0.5468	0.3331	0.2693
	C2	0.1024	-0.0868	-0.0202	-0.3351	0.8077	0.3041	-0.1166	1.5278	0.7948	1.1969	0.4202	0.4934	0.4112
	C3	-0.0499	0.0207	-0.0012	-0.3735	0.4005	0.2712	-0.0360	1.0202	0.4381	0.9799	0.6453	0.3556	0.2123
X11	C1	0.0387	0.0341	-0.0492	0.1143	-0.1184	-0.0682	-0.0681	-0.4129	-0.1224	-0.4142	-0.2506	-0.0677	-0.1009
	C2	0.0019	0.0473	0.0319	0.1150	-0.1442	0.0376	0.0983	-0.4363	-0.1427	-0.3673	-0.3314	-0.0889	-0.0958
	C3	-0.0212	0.0001	-0.0070	0.0347	0.0780	-0.0138	0.0436	0.1467	0.0802	0.1411	0.2296	0.0230	0.0462
X12	C1	0.0010	-0.0041	-0.0015	-0.0093	0.0134	0.1004	-0.0004	0.0044	0.0134	0.0045	0.1033	0.2321	0.0139
	C2	-0.0001	0.0001	-0.0002	-0.0004	0.0012	0.0804	0.0002	0.0005	0.0013	0.1005	0.2003	0.3027	0.0010
	C3	0.0001	0.0021	0.0001	0.0049	-0.0062	0.0911	-0.0002	-0.0009	-0.0061	-0.0009	-0.0016	0.1836	-0.0111
X13	C1	0.0003	-0.0003	0.0022	-0.0083	0.0134	0.0007	0.0039	0.009	0.0135	0.0086	0.0051	0.0141	0.2326
	C2	0.0027	-0.0032	-0.0015	-0.0140	0.0184	-0.0014	0.0075	0.0119	0.0185	0.1106	0.0054	0.0157	0.1412
	C3	0.0011	0.0027	-0.0019	0.0086	-0.0139	0.0005	-0.0003	-0.0042	-0.0139	-0.0041	-0.0041	-0.0137	0.0797
r	C1	0.0537	-0.0297	0.0263	-0.3614	0.5318	0.3788	-0.0099	0.7945	0.5380	0.8299	0.3872	0.5467	0.2740
r	C2	0.0908	-0.0305	0.1711	-0.1799	0.5062	0.4628	0.0146	0.7647	0.4972	0.7897	0.1654	0.6645	0.3657
r	C3	-0.0374	0.0124	0.0977	-0.3799	0.4852	0.6960	0.0241	0.8747	0.5056	0.8904	0.7082	0.5916	0.2704

Residual effect of C1 = 0.2274 Residual effect of C2 = 0.2096 Residual effect of C3 = 0.3783 r = correlation coefficient of pod yield per plant

X1-Days to first flowering; X2-Plant height(cm);X3-Number of branches per plant;X4-SLA(cm2/g); X5-SCMR;X6-Harvest index (%);X7-Oil content (%);X8-Oil yield per plant(g); X9 -Total pods per plant; X10-Kernel yield per plant(g); X11-Shelling *per cent;* X12-Matured pods per plant; X13-Sound mature kernel (%)

C1 = KCG-6 × ICGV-91114; C2 = KCG-6 × TG-69; C3 = TMV-2 × ICGV-00350

matured pods per plant, total pods per plant, oil yield and sound mature kernel per cent for all the crosses. These results were in confirmation with the reports of Reddy *et al.* (2003), Suvarna *et al.* (2004), Meta and Monpara (2010) and Thakur (2013). Further, this also showed significant negative association with SCMR, similar result reported by Shyam Narayan Nigam and Rupakula Aruna (2008). Higher SLA indicates larger surface area and lesser leaf thickness, hence smaller photosynthesis capacity as result photosynthates for pod formation are diverted for biological maintaince results in decrease in pod yield.

It is observed that SCMR was positively and significantly correlated with oil yield per plant, kernel yield per plant, matured pods per plant, total pods per plant, sound mature kernel per cent and pod yield per plant. This report suggests that SCMR can be used as indirect selection criteria for high pod yield. The reports of Nageshwar Rao *et al.* (2001), Vasanthi *et al.* (2004) and Talwar *et al.* (2004) obtained similar trend of results in groundnut. It is significantly negative correlated with specific leaf area in all the three F_2 populations; this result is in conformity with reports of Chuni Lal *et al.* (2005). RuBisCo level has a direct association with leaf nitrogen (amount of nitrogen per unit leaf mass per unit area) and photosynthetic efficiency (Nageshwar Rao *et al.*, 2001). Hence, SCMR values indicate the RuBisCo concentration in leaves. Higher SCMR readings mean more RuBisCo level. Hence, high photosynthesis efficiency results in higher pod yield.

In all three crosses higher direct effect on pod yield and indirect effect *via* total pods per plant, shelling per cent, oil yield, matured pods per plant, SCMR, harvest index and sound mature kernel per cent was contributed by kernel yield per plant. SCMR has positive direct effect on pod yield in all the three crosses in contrast to SLA (Table 2). Similar findings were reported by Dandu Ravi Kumar *et al.* (2012) and Thirumalarao *et al.* (2014). Hence, plants with low SLA and high SCMR coupled with high kernel weight, matured pods per plant, sound matured kernel, shelling per cent will show high water use efficiency with high pod yield.

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