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Original Research Article

Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)

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Abstract

Pod yield per plant exhibited positive significant association with number of pods per plant, total sugar, kernel yield, non reducing sugar, test weight, SCMR, harvest index, oil content and shelling per cent, whereas, LLS severity, reducing sugar, stomata frequency and size showed negative significant association. Total sugar, kernel yield, stomata length, LLS severity, test weight, SCMR, days to maturity and oil content exerted the positive direct effect on pod yield, whereas, non-reducing sugar, stomata frequency, shelling per cent and harvest index had maximum indirect direct effects on pod yield per plant. Thus, due emphasis should be placed on these characters while selecting genotypes for high yield with LLS tolerance in groundnut.

Keywords

Character association
Groundnut
Path analysis

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the important protein rich vegetable oilseed crops of the world. The groundnut kernels contain about 44-55% oil, 22-32% protein and 8-14% carbohydrates in addition to minerals and vitamins. Groundnut oil contains a higher proportion of unsaturated fatty acids including essential fatty acids like linolenic acid and linoleic acids (Desai et al., 1999). Thus, the crop has great future as oilseed as well as food crop. Understanding the relationship between yield and its components is of the paramount importance for making the best use of the relationships in selection. The data obtained from correlation coefficient can be augmented by path analysis. Path coefficient analysis splits the genotypic correlation coefficient into the measure of direct and indirect effects. Hence, the present study was carried out to obtain information on the magnitude of relationship of individual yield components on yield, interrelationships among themselves and to measure their relative importance.

Materials and methods

The experimental material comprised eighteen groundnut genotypes including three checks *viz.*, JL-24, LGN- 1 and LGN -123. The sowing was carried out by dibbling at the spacing of 30 cm and 10 cm between the rows and plant, respectively during *kharif*, 2014. Observations were recorded on eighteen characters *viz.*, pod yield per plant , number of pod per plant, kernel yield per plant , days to maturity, shelling , test weight , harvest index , oil per cent, LLS severity , stomata

frequency per mm^2 , stomata size [stomata length and breadth (µm)], SPAD chlorophyll meter reading, reducing sugar, non-reducing sugar and total sugar. The genotypic and phenotypic coefficients of correlation were calculated using the method given by Johnson et al. (1955). Path coefficient analysis was carried out by using phenotypic and genotypic correlation coefficients as per the method suggested by Dewey and Lu (1959).

Results and discussion

Characters association

In the present study, genotypic correlations were higher than phenotypic correlations for most of the characters. These indicate that the strong inherent association between the characters governed largely by genetic causes and reduced by environmental forces. The environment and genotype x environment interaction played a major role in determining these associations between the characters.

The results pertaining to correlation studies are presented in Table 1. The pod yield per plant exhibited highest, positive and significant association with number of pod per plant followed by total sugar, kernel yield, non-reducing sugar, test weight, SCMR, harvest index, oil content and shelling per cent. The similar kinds of associations earlier reported by Sharma and Dashora (2009) for number of pods per plant and kernel yield, Gouda Patil et al. (2006) for number of pods per plant and shelling per cent, Azad and Hamid (2000) and Rao et al. (2014) for number of pods per plant, kernel yield and test weight, Kadam et al. (2009) for number of pods per plant, harvest index, test weight and oil content, Kahate et al. (2014) for kernel yield, harvest index, non-reducing sugar and test weight and John and Raghava Reddy (2015) for number of pod per plant, kernel yield per plant, test weight and shelling per cent.

The pod yield also exhibited negative and significant association with stomata frequency, stomata size (length and breadth), LLS severity and reducing sugar. The similar kind of findings were reported by Gopal et al. (2006) for LLS severity, Giri et al. (2009) for LLS severity and reducing sugar, Kahate et al. (2014) for stomata size, stomata frequency, LLS disease severity and reducing sugar.

The positive and highly significant interrelationships were observed among yield contributing characters like number of pod per plant, kernel yield, shelling and test weight and morpho-biochemical traits like LLS severity, reducing sugar, stomata frequency and size. The results are in accordance with earlier reports of Mathews et al. (2000), Hemant Kumar (2004) and Lakshimidevamma et al. (2004) for kernel yield with test weight, Mahalakshmi et al. (2005) for kernel yield with test weight and shelling; Kaur et al. (1989) for LLS severity with stomatal frequency; Li Dun (1996) for LLS severity with reducing sugar. Kahate et al. (2014) for kernel yield with harvest index, non-reducing sugar and test weight.

The interrelationships were also negative and highly significant among yield contributing characters like number of pods per plant, kernel yield, test weight with morpho-biochemical traits like LLS severity, reducing sugar, stomata frequency and size. The similar result reported by Giri et al. (2009) and Kahate et al. (2014).

Path analysis

The path co-efficient studies (Table 2) indicated that total sugar, kernel yield, LLS severity, test weight, SCMR, days to maturity, stomata length and oil content exerted positive direct effect on pod yield. Hence, a direct selection criterion should be followed for these traits to improve the pod yield. Similar results were earlier reported by Venkatravana et al. (2000), Lakshmidevamma et al. (2004), Garjappa (2005), Giri et al. (2009) and Dandu et al. (2012) for kernel yield per plant, Moinuddin (1997) and Khan et al. (2000) for test weight, Zaman et al. (2011) for days to maturity, Azad and Hamid (2000) for kernel yield and test weight and Kadam et al. (2009) for oil content.

Negative direct effects on pod yield were also exhibited by some characters *viz.*, non-reducing sugar, stomatal frequency, shelling, harvest index and reducing sugar. Similar kinds of results have been reported earlier by Moinuddin (1997), Francies and Ramalingam (1997), Kahate et al. (2014) for stomata frequency and shelling and Lakshmidevamma et al. (2014) for shelling percent.

From the results of character association and path coefficient analysis, it was evident that high yielding and LLS resistant genotypes can be developed by simultaneous improvement in the characters *viz.*, increase in kernel yield , harvest index, test weight, non-reducing sugar, total sugar, whereas by decrease in reducing sugar, stomata frequency and stomata size.

Table 1. Genotypic (G) and phenotypic (P) coefficients among yield, yield contributing and morpho-biochemical characters in groundnut.

Characters		KY	HI	DM	SH	LLS Severity	TW	SCMR	N.R. sugar	R. Sugar	Total sugar	Oil content	Stomata frequency		Stomata length		Stomata breath		PY
													Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	
No. of pod/plant (NP)	G P	0.9352** 0.8968**	-0.0461 0.2538	-0.1264 -0.0880	0.2921* 0.2670	-0.9468** -0.8624**	0.9745** 0.8999**	0.6583** 0.5402**	0.9821** 0.9076**	-0.9819** -0.7555**	0.9779** 0.9053**	0.3504** 0.2768*	-0.9812** -0.9447**	-0.9637** -0.9308**	-0.9571** -0.9150**	-0.9586** -0.9108**	-0.9107** -0.8733**	-0.9574** -0.9243**	0.9914** 0.9266**
Kernel yield per plant (KY)	G P	1.0000 1.0000	-0.275* 0.2417	-0.1938 -0.1186	0.5931** 0.5070**	-0.9982** -0.8040**	0.8685** 0.8400**	0.6636** 0.4652**	0.9359** 0.7849**	-0.9162** -0.7555**	0.9388** 0.7909**	0.4342** 0.2970*	-0.9494** -0.8574**	-0.9372** -0.8370**	-0.9795** -0.8617**	-0.9840** -0.8505**	-0.9679** -0.8515**	-0.9512** -0.8446**	0.9682** 0.9714**
Harvest index (HI)	G P		1.0000 1.0000	0.6775** 0.3749**	-0.633** -0.2332	0.1273 0.0397	0.0203 0.0681	-0.5677** -0.3095*	0.2492 0.2012	-0.1980 -0.165	0.2663 0.2126	0.1112 0.0120	0.0099 -0.1587	0.0044 -0.1417	-0.0273 -0.1798	-0.1053 -0.1804	-0.1744 -0.2493	-0.3309* -0.3351*	0.4421** 0.3161*
Days to maturity (DM)	G P			1.0000 1.0000	-0.2872* -0.2156	0.2332 0.2173	-0.2248 -0.2041	-0.3857** -0.3248*	-0.0879 -0.0806	0.0752 0.0723	-0.0920 -0.0831	0.0310 0.0070	0.2384 0.2080	0.2530 0.2231	0.1939 0.1678	0.1478 0.1251	0.1007 0.0486	0.0299 0.0268	-0.1337 -0.0718
Shelling(SH)	G P				1.0000 1.0000	-0.4481** -0.3897**	0.4133** 0.3646**	0.7761** 0.3501**	-0.8514** 0.1209	-0.1209 -0.1159	0.1317 0.1220	0.2996* 0.1847	-0.2795* -0.2618	-0.3024* -0.2699*	-0.3919** -0.3302*	-0.3926** -0.3536**	-0.4175** -0.3299*	-0.2352 -0.2235	0.3751** 0.2914*
LLS Severity	G P					1.0000 1.0000	-0.9482** -0.9463**	-0.7761** -0.7263**	-0.8514** -0.8492**	0.8333** 0.8321**	-0.8540** -0.8505**	-0.3600** -0.3121*	0.9523** 0.9256**	0.9498** 0.9295**	0.9305** 0.8942**	0.9045** 0.8928**	0.8345** 0.7922**	0.8338** 0.8133**	-0.9150** -0.7971**
Test weight (TW)	G P						1.0000 1.0000	0.6937** 0.6505**	0.9059** 0.9051**	-0.8938** -0.8919**	0.9062** 0.9048**	0.3499** 0.3096*	-0.9809** -0.9571**	-0.9595** -0.9455**	-0.9725** -0.9388**	-0.9836** -0.9731**	-0.9589** -0.9181**	-0.9335** -0.9156**	0.9447** 0.8382**
SCMR	G P							1.0000 1.0000	0.5180** 0.4844**	-0.5520** -0.5113**	0.5036** 0.4722**	0.2539 0.2078	-0.6487** -0.5692**	-0.6370** -0.5717**	-0.5761** -0.5071**	-0.6161** -0.5618**	-0.5337** -0.4565**	-0.4378** -0.3900**	0.6401** 0.4412**
N.R. sugar	G P								1.0000 1.0000	-0.9909** -0.9883**	0.9989** 0.9985**	0.3319* 0.2962*	-0.9377** -0.9175**	-0.9116** -0.8979**	-0.9105** -0.8820**	-0.9043** -0.8955**	-0.8878** -0.8506**	-0.9508** -0.9340**	0.9520** 0.8404**
R. Sugar	G P									1.0000 1.0000	-0.9833** -0.9786**	-0.3020* -0.2651*	0.9237** 0.9030**	0.8927** 0.8757**	0.8902** 0.8607**	0.8884** 0.8790**	0.8729** 0.8284**	0.9322** 0.9113**	-0.8623** -0.8110**
Total sugar	G P										1.0000 1.0000	0.3411* 0.3056*	-0.9385** -0.9175**	-0.9144** -0.9007**	-0.9137** -0.8845**	-0.9060** -0.8963**	-0.8892** -0.8537**	-0.9532** -0.9227**	0.9761** 0.8461**
Oil content	G P											1.0000 1.0000	-0.2550 -0.2027	-0.2258 -0.2182	-0.3063* -0.2500	-0.3254* -0.2797*	-0.3527** -0.3023*	-0.3585** -0.3140*	0.4168** 0.2846*
Stomata frequency (Adaxial)	G P												1.0000 1.0000	0.9978** 0.9804**	0.9824** 0.9569**	0.9634** 0.9503**	0.9095** 0.8807**	0.9347** 0.9227**	-0.9301** -0.8844**
Stomata frequency (Abaxial)	G P													1.0000 1.0000	0.9786** 0.9552**	0.9498** 0.9385**	0.8840** 0.8632**	0.9137** 0.9075**	-0.9850** -0.8556**
Stomata length (Adaxial)	G P														1.0000 1.0000	0.9872** 0.9583**	0.9456** 0.9017**	0.9433** 0.9270**	-0.8760** -0.8675**
Stomata length (Abaxial)	G P															1.0000 1.0000	0.9918** 0.9480**	0.9550** 0.9445**	-0.9381** -0.8675**
Stomata breath (Adaxial)	G P																1.0000 1.0000	0.9733** 0.9316**	-0.9753** -0.8531**
Stomata breath (Abaxial)	G P																	1.0000 1.0000	-0.9434** -0.8720**

Table 2. Path coefficients for yield contributing and morpho-biochemical characters in groundnut.

Characters	No. of pod/ plant	Kernel yield (g)	Harvest index (%)	Days to maturity	Shelling %	LLS Severity (%)	Test weight (g)	SCMR	N.R. sugar (mg/g)	R. Sugar (mg/g)	Total Sugar (mg/g)	Oil content (%)	SF/mm² Ad (%)	SF/mm² Ab (%)	Stomata length (µm)		Stomata Breadth (µm)		Correlation with pod yield
															Ad	Ab	Ad	Ab	
No. of pod/ plant	G-**0.1602** P **0.0423**	0.0850 0.0379	0.0535 0.0107	0.1466 -0.0037	-0.3389 0.0113	0.0984 -0.0365	0.1305 0.0380	-0.7637 0.0228	-0.1394 0.0384	0.1392 -0.0380	-0.1345 0.0383	-0.4066 0.0117	0.1384 -0.0399	0.1181 -0.0393	0.1104 -0.0387	0.1122 -0.0385	0.0566 -0.0369	0.1108 -0.0391	0.9914** 0.9266**
Kernel yield (g)	G0.5156 P 0.9786	**0.7207** **0.0912**	-0.4464 0.2637	-0.3141 -0.1294	0.9612 0.5533	-0.6177 -0.8774	0.6506 0.9166	0.0755 0.5076	0.5168 0.8565	-0.4849 -0.5076	0.5215 0.8630	0.7038 0.3241	-0.9487 -0.9357	-0.9190 -0.9133	-0.9874 -0.9403	-0.9948 -0.9281	-0.9686 -0.9292	-0.5416 -0.9216	0.9682** 0.9714**
Harvest index (%)	G0.0073 P -0.0005	0.0437 0.0004	**-0.1587** **-0.0018**	-0.1075 -0.0007	0.1005 0.0004	-0.0202 -0.0001	-0.0032 -0.0001	0.0901 0.0006	-0.0396 -0.0004	0.0314 0.0003	-0.0423 -0.0004	-0.0177 0.0000	-0.0016 0.0003	-0.0007 0.0003	0.0043 0.0003	0.0167 0.0003	0.0277 0.0005	0.0525 0.0006	0.4421** 0.3161*
Days to maturity	G-0.0481 P -0.0015	-0.0737 -0.0020	0.2576 0.0063	**0.3802** **0.0168**	-0.1092 -0.0036	0.0887 0.0036	-0.0855 -0.0034	-0.1467 -0.0054	-0.0334 -0.0014	0.0286 0.0012	-0.0350 -0.0014	0.0118 0.0001	0.0907 0.0035	0.0962 0.0037	0.0737 0.0028	0.0562 0.0021	0.0383 0.0008	0.0114 0.0004	-0.1337 -0.0718
Shelling (%)	G-0.0779 P -0.0728	-0.1581 -0.1382	0.1689 0.0636	0.0765 0.0588	**-0.2665** **-0.2726**	0.1194 0.1062	-0.1102 -0.0994	-0.1253 -0.0954	-0.0345 -0.0330	0.0322 0.0316	-0.0351 -0.0333	-0.0799 -0.0504	0.0745 0.0714	0.0806 0.0736	0.1045 0.0900	0.1046 0.0964	0.1113 0.0899	0.0627 0.0609	0.3751** 0.2914*
LLS Severity (%)	G-0.4256 P -0.0068	-0.5030 -0.0063	0.1917 0.0003	0.3511 0.0017	-0.6747 -0.0031	**0.5057** **0.0078**	-0.4277 -0.0074	-0.1687 -0.0057	-0.2819 -0.0067	0.2547 0.0065	-0.2860 -0.0067	-0.5421 -0.0024	0.4339 0.0072	0.4302 0.0073	0.4011 0.0070	0.3620 0.0070	0.2565 0.0062	0.2555 0.0064	-0.9150** -0.7971**
Test weight (g)	G0.4810 P 0.0638	0.5027 0.0595	0.0100 0.0048	-0.1109 -0.0145	0.2040 0.0258	-0.4680 -0.0670	**0.4936** **0.0709**	0.3424 0.0461	0.4471 0.0641	-0.4412 -0.0632	0.4473 0.0641	0.1727 0.0219	-0.4842 -0.0678	-0.4736 -0.0670	-0.4800 -0.0665	-0.4855 -0.0689	-0.4733 -0.0651	-0.4608 -0.0649	0.9447** 0.8382**
SCMR	G0.2226 P 0.0025	0.2244 0.0021	-0.1919 -0.0014	-0.1304 -0.0015	0.1590 0.0016	-0.2624 -0.0033	0.2346 0.0030	**0.3381** **0.0046**	0.1751 0.0022	-0.1866 -0.0024	0.1703 0.0022	0.0858 0.0010	-0.2193 -0.0026	-0.2154 -0.0026	-0.1948 -0.0023	-0.2083 -0.0026	-0.1805 -0.0021	-0.1480 -0.0018	0.6401** 0.4412**
N.R. sugar (mg/g)	G-0.9169 P -0.8407	0.8737 0.7271	-0.2327 -0.1864	0.0820 0.0746	-0.1207 -0.1120	0.7948 0.7867	-0.8457 -0.8385	-0.4836 -0.4487	**-0.9336** **-0.9263**	0.9251 0.9155	-0.9325 -0.9250	-0.3099 -0.2744	0.8754 0.8499	0.8511 0.8317	0.8500 0.8170	0.8442 0.8295	0.8288 0.7879	0.8876 0.8652	0.9520** 0.8404**
R. Sugar (mg/g0	G0.1531 P 0.2245	-0.1428 -0.1886	0.0309 0.0414	-0.0117 -0.0180	0.0188 0.0289	-0.1299 -0.2077	0.1393 0.2226	0.0860 0.1276	0.1545 0.2467	**-0.1559** **-0.2496**	0.1533 0.2443	0.0471 0.0662	-0.1440 -0.2254	-0.1391 -0.2186	-0.1388 -0.2148	-0.1385 -0.2194	-0.1361 -0.2068	-0.1453 -0.2275	-0.8623** -0.8110**
Total Sugar (mg/g)	G 0.2433 P 0.6217	0.1936 0.5431	0.3386 0.1460	-0.1169 -0.0570	0.1675 0.0838	-0.6859 -0.5840	0.1522 0.6213	0.6403 0.3242	0.8700 0.6857	-0.2502 -0.6720	**0.9715** **0.6867**	0.4337 0.2099	-0.8933 -0.6300	-0.9626 -0.6185	- 0.18617 -0.6074	-0.7519 -0.6154	-0.6306 -0.5862	-0.7120 -0.6433	0.9761** 0.8461**
Oil content (%)	G 0.0783 P 0.0025	0.0970 0.0027	0.0249 0.0001	0.0069 0.0001	0.0669 0.0017	-0.0804 -0.0029	0.0782 0.0028	0.0567 0.0019	0.0742 0.0027	-0.0675 -0.0024	0.0762 0.0028	**0.2234** **0.0091**	-0.0570 -0.0019	-0.0504 -0.0020	-0.0684 -0.0023	-0.0727 -0.0026	-0.0788 -0.0028	-0.0801 -0.0029	0.4168** 0.2846*
SF/mm² Ad (%)	G 0.4948 P 0.0411	-0.4787 -0.0373	-0.0050 0.0069	-0.1202 -0.0090	0.1409 0.0114	-0.4802 -0.0402	0.4946 0.0416	0.3271 0.0247	0.4728 0.0399	-0.4658 -0.0393	0.4732 0.0399	0.1286 0.0088	**-0.5042** **-0.0435**	-0.5031 -0.0426	-0.4954 -0.0416	-0.4858 -0.0413	-0.4586 -0.0383	-0.4713 -0.0401	-0.9301** -0.8844**
SF/mm²Ab (%)	G 0.6927 P -0.0250	-0.6462 -0.0225	-0.0077 -0.0038	-0.4444 0.0060	0.5312 -0.0073	-0.6682 0.0250	0.6853 -0.0254	0.1188 -0.0154	0.6012 -0.0241	-0.5679 0.0235	0.6060 -0.0242	0.3965 -0.0059	-0.7526 0.0264	**-0.7564** **0.0269**	-0.7189 0.0257	-0.6682 0.0252	-0.5526 0.0232	-0.6048 0.0244	-0.9850** -0.8586**
S L Ad (µm)	G -0.3748 P 0.0174	-0.3836 -0.0164	-0.0107 0.0034	0.0759 -0.0032	-0.1534 0.0063	0.3644 -0.0170	-0.3808 0.0178	-0.2256 0.0096	-0.3565 0.0168	0.3486 -0.0164	-0.35780 0.0168	-0.1200 0.0048	0.3847 -0.0182	0.3832 -0.0182	**0.3916** **-0.0190**	0.3866 -0.0182	0.3703 -0.0171	0.3694 -0.0176	-0.8760** -0.8675**
S L Ab (µm)	G -0.6620 P -0.0357	-0.6795 -0.0333	-0.0727 -0.0071	0.1020 0.0049	-0.2711 -0.0139	0.6246 0.0350	-0.6792 -0.0381	-0.4254 -0.0220	-0.6244 -0.0351	0.6135 0.0344	-0.6256 -0.0351	-0.2247 -0.0110	0.6653 0.0372	0.6558 0.0368	0.6817 0.0376	**0.6905** **0.0392**	0.6849 0.0372	0.6595 0.0370	-0.9381** -0.8486**
SB Ad (µm)	G 0.0778 P -0.0014	-0.0827 -0.0013	0.0149 -0.0004	-0.0086 0.0001	0.0357 -0.0005	-0.0713 0.0012	0.0819 -0.0014	0.0456 -0.0007	0.0758 -0.0013	-0.0745 0.0013	0.0759 -0.00013	0.0301 -0.0005	-0.0777 0.0014	-0.0755 0.0014	-0.0808 0.0014	-0.0847 0.0015	**-0.0854** **0.0016**	-0.0831 0.0015	-0.9753** -0.8531**
SB Ab (µm)	G -0.3098 P -0.8340	-0.3078 -0.0762	-0.1071 -0.0302	0.0097 0.0024	-0.0761 -0.0202	0.2698 0.0734	-0.3021 -0.0826	-0.1416 -0.0352	-0.3076 -0.0843	0.3016 0.0823	-0.3084 -0.0845	-0.1160 -0.0283	0.3024 0.0833	0.2956 0.0819	0.3052 0.0837	0.3090 0.0852	0.3149 0.0841	**0.3236** **0.0903**	-0.9434** -0.8720**

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