

Original Research Article

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Association Study of Morphological and Physiological Traits with Yield in Groundnut Genotypes under Terminal Drought Condition

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ABSTRACT

Keywords

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Groundnut ($2n=4x=40$) is an important oilseed crop. India has high both in area and production of groundnut, but low in productivity. The low productivity due to many constraints among them important one is drought, in that terminal drought is a most damaging one. Development of drought tolerant varieties is only a cost-effective method to mitigate the drought effect on agriculture. But, the studies under terminal drought conditions in association with yield and some surrogate/physiological traits were limited. Hence, keeping these in view, present correlation study was conducted by considering 12 morphological and five surrogate traits in 144 groundnut genotypes. The dry pod yield had a positive significant correlation with the number of mature pods, kernel yield at both phenotypic (0.493, 0.655) and genotypic (0.854, 0.922) level under end season drought. Harvest Index (%) had a strong significant positive correlation with dry pod yield in terminal drought condition at both genotypic (0.537) and phenotypic level (0.513), the rest of surrogate traits like relative water content, canopy temperature, specific leaf area, and SPAD chlorophyll meter reading had the non significant association with dry pod yield under end season drought expect at RWC and SCMR at 80 days after sowing.

Introduction

The commercially cultivated Groundnut or peanut (*Arachis hypogaea* L.) is an allotetraploid ($2n = 4x = 40$). The region of eastern foothills of Andes (Southern Bolivia and Northern Argentina) was the most probable centre of origin of groundnut. Peanut is widely utilized as an oil seed or food crop in more than 144 countries (includes tropical and warm temperate regions) of the world. The commercial production largely confined

between 40°N and 40°S latitudes. India has high both in area and production of groundnut, but low in productivity. This is due to cultivation of the crop on marginal and sub-marginal lands (mainly under rainfed condition), biotic and abiotic stress and many socio-economic factors (Reddy *et al.*, 1993). Among the numerous abiotic stresses the drought is major limitation for production. The rainfall is the most significant climatic factor affecting groundnut production in the arid and semi-arid region where the crop is

raised mostly under rainfed conditions. There are three types of drought like early, mid and end season drought based on stage of drought during the crop production. The economic concern more loss from terminal drought condition. The adverse effect of end-season drought can be overcome by developing short duration varieties and breeding for drought tolerance varieties. The selection of tolerance varieties based on yield alone might be mislead the breeder because yield is complex trait which depends on many independent traits along with environment factor. Direct selection for yield under drought is effective but it is resource consuming and lacks of repeatability across different environments. Hence, to overcome these difficulties by using easily measurable surrogate or physiological trait like relative water content (RWC %), specific leaf area (SLA), canopy temperature, SPAD chlorophyll meter reading (SCMR) etc., to decided use as selection criteria along with yield and yield components. Obviously, knowledge about character association with yield will surely aid selection for higher yield varieties. With a view to determine the extent and nature of relationship prevailing among yield contributing characters, an attempt has been made to study the character association in the 144 genotypes of groundnut both at phenotypic and genotypic levels under terminal drought condition.

Materials and Methods

The present investigation was initiated during *kharif* 2015 at Main Agriculture Research Station (MARS), University of Agriculture Sciences, Raichur, Karnataka, India. The field experiment conducted during *kharif* (August to December- 2015), on alfisol soil type. The weather data during experiment are presented in Table 1. The experimental material for the present study comprised of 144 groundnut genotypes (Table 2) which were collected from different institutes from across India.

The experiment was laid out in simple lattice design with two replications. Using a line-source sprinkler irrigation system, genotypes were screened for terminal drought tolerance ((Hanks *et al.*, 1976). Soil moisture level maintained uniformly at field capacity (FC) from planting to 80 days after sowing (DAS). After 80 DAS (pod filling stage in groundnut) provide the irrigation through line source sprinkler method. The traits morphological traits like Days to 50% flowering, Plant height (cm), number of primary branch per plant, number Days to physiological maturity, number of mature pods per plant, number of Immature pods per plant, Shelling Percentage, Kernel yield, Sound Mature Kernel, Hundred Kernel Weight, Haulm yield per plant (g), Oil content, Dry pod yield per plant along with physiological traits like, relative water conduct, specific leaf area, SPAD chlorophyll meter reading, canopy temperature and harvest index were considered under the experiment. The first four physiological parameters recorded at 80, 90 and 100 days after sowing (DAS). The Both genotypic and phenotypic coefficients of correlation between all pairs of characters were determined by using variance and covariance components as suggested by Abraham *et al.*, (1990).

Results and Discussion

Association of dry pod yield with its other yield attributing traits

The association between yield and 12 quantitative traits at genotypic and phenotypic level presented in Table 3. The dry pod yield had the positive significant correlation with number of mature pods, kernel yield at both phenotypic (0.493, 0.655) and genotypic (0.854, 0.922) level under end season drought. Whereas the traits like plant height (0.221) and primary branches (0.201) had significant positive association only at genotypic level with dry pod yield. The sound mature kernel

(0.14, 0.149), hundred kernel weight (0.091, 0.104) and haulm yield (0.167, 0.079) had the non-significant positive correlation at both phenotypic and genotypic level with dry pod yield. The traits like days to 50% flowering (-0.209, -0.258) and oil content (-0.194, -0.236) had significant negative correlation with dry pod yield at both genotypic and phenotypic level. The days to physiological maturity and shelling percentage had non-significant negative correlation at phenotypic (-0.038, -0.141) and genotypic (-0.048, -0.135) level. Whereas number of immature pods had significant negative correlation with yield at phenotypic level (-0.182) but shown the non-significant at genotypic level (-0.217).

Association of physiological parameter with dry pod yield

The results of association between physiological parameters with dry pod yield at genotypic and phenotypic are presented in Table 4. Harvest Index (%) had strong significant positive correlation with dry pod yield in terminal drought condition at both genotypic (0.537) and phenotypic level (0.513). Relative water content (%) had positive correlation with dry pod yield and only at 80DAS shown the significant positive correlation at both genotypic (0.242) and phenotypic (0.2033) correlation but not shown significant at RWC 90 (0.0752, 0.09) and 100 DAS (0.0408, 0.048). The correlation at genotypic and phenotypic level between canopy temperature and dry pod yield fallowed the similar result at 80, 90 and 100 DAS. At 80 DAS (-0.021, -0.039) and 100 DAS (-0.042, -0.055) canopy temperature had non-significant negative correlation at genotypic and phenotypic with pod yield but at 90 DAS (0.1089, 0.124) it had non-significant positive correlation in terminal drought situations. The specific leaf area had non-significant positive correlation with dry pod yield at 80 DAS (0.1295, 0.157), 90 DAS

(0.1295, 0.156) and 100 DAS (0.1378, 0.166) in control and end season drought at both genotypic and phenotypic correction levels. SPAD Chlorophyll Meter Reading (SCMR) had negative correlation with pod yield at 80, 90 and 100 DAS in end season terminal drought condition at both genotypic and phenotypic level but only significant negative correlation seen in terminal drought condition at 90 DAS (-0.2076, -0.236) in both levels.

In the present investigation the estimates of genotypic correlation was higher than those of phenotypic correlation for most of the traits. These higher genotypic values whenever observed were contributed to the relative stability of the genotypes (Davis *et al.*, 1961). Thus trait with higher genetic correlation may throw light on validity of selection for those traits.

Association of dry pod yield with its other yield attributing traits

The dry pod yield had the positive significant correlation with number of mature pods, kernel yield at both phenotypic and genotypic level under end season drought. Obviously mature pods and kernel yield having direct association with dry pod yield so it is one of the most suitable and widely used traits to identify the high yielding genotypes under terminal drought conditions. The results are in accordance with Kavani *et al.*, (2004) and Shoba *et al.*, (2012). The Jayalakshmi *et al.*, (2000), Daboria *et al.*, (2004) found the negative relation between oil content and seed yield. Due to end season drought oil content will reduced (Dwivedi *et al.*, 1996).

Whereas the traits like plant height and primary branches had significant positive association only at genotypic level with dry pod yield. It indicates that under terminal drought condition plant height had strong direct proportional with yield so selection

based on plant height will be rewarding under terminal drought condition drought condition. The primary branches helped in production of additional pod yield and can be used as selection criteria. The similar results were found by Venkataravan *et al.*, (2000), Lakshmidevamma *et al.*, (2004), Sirisha (2005) and Vasanti *et al.*, (2015).

The days to physiological maturity, sound mature kernel, hundred kernel weight and haulm yield had the non-significant positive correlation at both genotypic and phenotypic level with dry pod yield. Sound mature kernels (SMK %) indicates the percent of bold seeds. Hundred kernel weight (HKW) parameter help in determine the kernel size so SMK and HKW helps in develop the variety suitable for commercial cultivation. The drought susceptible varieties usually have the low SMK and HKW so these traits can also be used as criteria to select the tolerant genotypes. Some of the evidence for result is Reddi *et al.*, (1991), Venkataravan *et al.*, (2000), Roy *et al.*, (2003) and Kavani *et al* (2004). Under stress condition or water limited situation biological yield had negative correlation because most of absorbed water is utilized to maintain the vegetative growth under stress condition (Kavani *et al.*, 2004, Moinuddin, 1997).

The some traits like days to 50% flowering and shelling percentage had non-significant negative correlation with dry pod yield at both genotypic and phenotypic level. Similar result found by Vasanthi *et al.*, (1998) and Suneetha *et al.*, (2005) and contrary to above result reported by Lakshmidevamma *et al.*, (2004). whereas number of immature pods had significant negative correlation with yield at phenotypic level but shown the non-significant at genotypic level. The negative association of immature pod with yield indicates that always select the genotypes which produce the less immature pods for improvement of yield. Under terminal drought condition select the genotypes with less number of immature pod productions as a drought tolerant variety. The similar result found by Pallas *et al.*, (1979) and Yao *et al* (1982).

Association between physiological and yield related traits

Harvest index is proportion of pods to total biomass; it can vary depending upon timing and severity of water deficit relative to pod set (Ong *et al.*, 1986). During *kharif* HI had strong significant positive correlation with dry pod yield both conditions at both genotypic and phenotypic levels.

Table.1 Meteorological data during 2015-16 at MARS, Raichur

Year	Month	Max.T (°c)	Min.T (°c)	RF (mm)	Rainy Day	RH I (%)	RH II (%)	Evporimeter	Sunshain Hours/day	Wind Spd (k/h)
2015	July	36.3	24.6	42.0	3	77	38	8.5	4.6	18.1
	August	34.6	24.3	51.4	6	80	46	6.6	4.3	11.3
	September	39.1	23.4	316.6	11	88	58	4.8	4.2	1.2
	October	33.4	23.0	65.4	3	80	43	4.9	7.6	4.0
	November	31.9	21.1	2.0	0	79	42	4.9	6.5	6.7
	December	32.0	18.4	2.2	0	83	36	4.5	8.4	5.0

Where, Max. = maximum, Min. = Minimum, RF (mm) = Rain fall (mm), RH = Relative Humidity

Table.2 List of groundnut (*Arachis hypogaea* L.) genotypes used during kharif and rabi/summer for screening

Source	Genotypes	No. of genotypes
ICRISAT, Patancheru, Hyderabad, Telangana. India	Spanish types : series of ICGVs- 99233, 97092, 93280, 04018, 02411, 97058, 15415, 02317, 3584, 1342, 97262, 04149, 05036, 02242, 03043, 99051, 07227, 01276, 07120, 13245, 13241, 1-13238, 89104, 01274, 97182, 39x49-81-1, 06188, 3102, 06431, 03397, 03042, 91114, 98184, 07166, 07148, 95070, 03064, 99052, 96466, 86015, 27x49-12, 02189, 3343, 4955, 00343, 06422, 98105, 4729, 93470, 07235, 07270, 07273, 07286, 07390, 07392, 07395, 07396, 07296, 07403, 07404, 07405, 07406, 07408, 00350, 02266, 07222, 99206, 07220, 95440, 96172, 96155, 99102, 05193, 07213, 06227, 07219, 00440, 00187, 06423, 06319, 98163, 99161, 00201, 99160, 06189, 00189, 95058, 99210, 05184 and 96153 and CHICO	91
	Virginia types: Series of ICGVs- 01265, 01464, 9507, 05057, 00246, 05141, 03136, 01361, 05198, 07337, 00247, 07247, 89178, 00162 and CS39	15
BARC, Trombay, Mumbai, India	Spanish types: DTG-15, TG-49, TDG-51, TAG-24, TG-36, TG-37 ^A , TG-47, TPG-41, TG-51, TG-72, TG-74, TG-75, TG-80 and TG-67	14
	Virginia type: Somanatha	1
TNAU, Coimbatore, India	Spanish type: TMV-2,	1
PAU, Ludhian, Punjab, India	Spanish types: 49-M-16	1
	Virginia type : M-28-2	1
ARS, Kadiri Hyderabad, India	Spanish types : K-6 and K- Harithendra	2
UAS Dharawad, Karnataka, India	Spanish types : GPBD-4, GPBD-5, Mutant-3, Dh-216 and G2-52	5
	Virginia types : DSG-41, TDG-39 and Dh-86	3
UAS Raichur, Karnataka, India	Spanish types: R-8808, R-2001-2, KRG-01, SEL-01 Kadiri-9, ICGV 00351, and R-2001-3	7
	Virginia types : S-230	1
UAS Bangalore, Karnataka, India	Spanish type : Chintamani-2	1
ZARS Tirupati, Andhra Pradesh, India	Spanish type : Dharani	1

Table.3 Correlation co-efficient between yield and yield related traits in 144 groundnut genotype, during kharif under terminal drought

	X₁	X₂	X₃	X₄	X₅	X₆	X₇	X₈	X₉	X₁₀	X₁₁	X₁₂	X₁₃
X₁	1	-0.355**	0.113	0.318**	-0.194*	0.181*	-0.056	-0.230**	-0.109	-0.0648	0.392**	0.478**	-0.209*
X₂	-0.380**	1	0.144	-0.103	0.156	-0.134	-0.023	0.094	-0.036	0.0262	-0.007	-0.341**	0.103
X₃	0.121	0.161	1	0.157	0.108	-0.149	-0.148	0.055	-0.084	-0.0061	0.273**	0.047	0.144
X₄	0.334**	-0.105	0.177*	1	-0.131	-0.083	-0.167	-0.117	0.074	0.2533**	0.237**	0.054	-0.038
X₅	-0.229**	0.233**	0.178*	-0.166	1	-0.057	0.023	0.489**	-0.135	-0.272**	-0.026	-0.336	0.493**
X₆	0.222**	-0.155	-0.173*	-0.083	-0.051	1	-0.131	-0.211*	-0.328**	-0.229**	0.285**	0.099	-0.182*
X₇	-0.092	-0.028	-0.326**	-0.262**	0.094	-0.245**	1	0.376**	0.149	0.0682	-0.237**	-0.029	-0.141
X₈	-0.290**	0.208*	0.075	-0.137	0.691**	-0.269**	0.248**	1	0.1835*	0.115	0.037	-0.213*	0.854**
X₉	-0.132	-0.036	-0.078	0.074	-0.185*	-0.361**	0.240**	0.200*	1	0.385**	-0.182	0.135	0.14
X₁₀	-0.093	0.032	-0.007	0.255**	-0.325**	-0.237**	0.12	0.138	0.404**	1	-0.129	0.087	0.091
X₁₁	0.424**	0.024	0.326**	0.246**	-0.037	0.321**	-0.360**	-0.047	-0.213*	-0.139	1	0.277**	0.167
X₁₂	0.459**	-0.362**	0.048	0.054	-0.401**	0.118	-0.045	-0.267**	0.139	0.075	0.287**	1	-0.194*
X₁₃	-0.258**	0.221**	0.201*	-0.048	0.655**	-0.217	-0.135	0.922**	0.149	0.104	0.079	-0.236**	1

Significant at 5% = * and significant at 1% = **, Genotypic level = down ward left side of diagonal, Phenotypic level = upward ward right side of diagonal

Where, X₁=Days to 50% flowering, X₂= Plant height (cm), X₃= No. of primary branch per plant, X₄= Days to physiological maturity, X₅=No. of mature pods per plant, X₆= No. of Immature pods per plant X₇= Shelling Percentage, X₈= Kernel yield, X₉= Sound Mature Kernel, X₁₀= Hundred Kernel Weight, X₁₁= Haulm yield per plant (g), X₁₂= Oil content, X₁₃= Dry pod yield per plant (g).

Table.4 Correlation co-efficient between yield and physiological traits in 144 groundnut genotype, during kharif under terminal drought

	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z ₁₀	Z ₁₁	Z ₁₂	Z ₁₃	X ₁₃
Z ₁	1	-0.078	-0.142	-0.12	-0.005	0.042	-0.019	0.053	0.053	0.057	-0.36**	-0.385**	-0.33**	0.513**
Z ₂	-0.079	1	0.409**	0.285**	-0.004	0.127	0.036	0.138	0.138	0.138	0.139	0.132	0.088	0.2033*
Z ₃	-0.145	0.405**	1	0.407**	0.095	0.223**	0.195*	0.242**	0.241**	0.243**	0.082	0.109	0.134	0.0752
Z ₄	-0.123	0.283**	0.406**	1	0.132	0.193*	0.208*	0.128	0.128	0.129	-0.017	0.012	0.006	0.0408
Z ₅	-0.011	-0.037	0.08	0.13	1	0.233**	0.133	0.168	0.167	0.162	-0.005	0.102	0.112	-0.021
Z ₆	0.043	0.11	0.217*	0.192*	0.153*	1	0.848**	0.221**	0.22**	0.223**	-0.067	-0.074	-0.064	0.1089
Z ₇	-0.022	0.02	0.188*	0.207*	0.063	0.841**	1	0.117	0.117	0.115	-0.001	0.044	0.003	-0.042
Z ₈	0.058	0.128	0.236**	0.124	0.15	0.208*	0.103	1	1	0.999**	-0.193*	-0.151	-0.073	0.1295
Z ₉	0.058	0.128	0.236	0.125	0.15	0.209*	0.103	1	1	0.999**	-0.194*	-0.152	-0.074	0.1295
Z ₁₀	0.062	0.129	0.237**	0.126	0.146	0.212*	0.102	0.999**	0.999**	1	-0.201	-0.159	-0.076	0.1378
Z ₁₁	-0.378**	0.122	0.069	-0.027	-0.063	-0.111	-0.033	-0.220**	-0.220**	-0.226**	1	0.813**	0.679**	-0.1495
Z ₁₂	-0.401**	0.113	0.096	0.003	0.048	-0.124	0.012	-0.180*	-0.180*	-0.186*	0.806**	1	0.760**	-0.2076*
Z ₁₃	-0.351**	0.065	0.12	-0.004	0.053	-0.118	-0.035	-0.103	-0.103	-0.103	0.665**	0.749**	1	-0.1489
X ₁₃	0.537**	0.242**	0.09	0.048	-0.039	0.124	-0.055	0.157	0.156	0.166	-0.167	-0.236**	-0.167	1

significant at 5% = * and significant at 1% = ** Genotypic level = down ward left side of diagonal, Phenotypic level = upward ward right side of diagonal

Where, Z₁= Harvest Index%, Z₂= RWC 80(DAS), Z₃= RWC 90 (DAS), Z₄= RWC 100 (DAS), Z₅=Canopy Temp.80 (DAS), Z₆=Canopy Temp. 90 (DAS), Z₇= Canopy Temp. 100 (DAS), Z₈= SLA 80 (DAS), Z₉= SLA 90 (DAS), Z₁₀= SLA 100 (DAS), Z₁₁= SCMR 80 (DAS), Z₁₂= SCMR 90 (DAS), Z₁₃= SCMR 100 (DAS), X₁₃= Dry pod yield.

So genotypes which record the high value of HI (%) under terminal drought conditions can use as stress tolerance parameter (Rathnakumar and Vadez, 2011). The similar study found by Sharma and Vershney (1995), Jayalakshmi *et al.*, (1999) and Jongrungklang *et al.*, (2008). Relative Water Content (RWC%) had positive correlation with dry pod yield at phenotypic level and genotypic level. Only RWC at 80DAS had shown the significant positive correlation not at RWC 90 and 100 DAS. The same result arrived in genotypic level correlation. Relative water content helps to know the retention capacity of water under normal and drought condition. It is one of the water use efficiency and drought tolerant physiological parameter. The groundnut genotypes with high RWC under terminal drought had high higher pod yield (Koolachart *et al.*, 2013). The healthy plant maintains the low canopy temperature compare to terminal drought imposed plant due to more transpiration and cooling effect. At 80 DAS and 100 DAS canopy temperature had non-significant negative with pod yield in contrary non-significant positive correlation at 90 DAS. The result indicates that select the genotype with low canopy temperature under terminal drought as tolerant genotype. Hence it is an important indirect and handy parameter to screen against terminal drought tolerant. The Specific Leaf Area (SLA) had non-significant positive correlation with dry pod yield at 80, 90 and 100 DAS at both genotypic and phenotypic correction levels. Similarly it is reported by Jayalakshmi *et al.*, (1999). Usually under drought stress plant reduces leaf area which helps in reduce the area for transpiration and increase the thickness of leaves which helps in retention of more water. The SLA had negative correlation with SCMR and positive correlation with RWC. The similar results found by Vasanthi *et al.*, (1998), Nageshwar Rao *et al.*, (2001), Nautiyal *et al.*, (2002), Upadhaya (2005), Nigam *et al* (2008),

Jungruklang *et al.*, (2008), Koolachart *et al* (2013) and Basu and Nautiyal (2008). The SPAD Chlorophyll Meter Reading had negative correlation with pod yield at 80, 90, 100 DAS in end season stress condition at both genotypic and phenotypic level but only significant negative correlation seen in terminal drought condition at 90 DAS in both levels. The SCMR value had negative correlation with SLA under stress condition. The similar results were found by Moreshet *et al.*, (1990), Vasanthi *et al.*, (1998), Nageshwar Rao *et al.*, (2001), Nautiyal *et al.*, (2002), Upadhaya (2005), Nigam *et al.*, (2008), Jungruklang *et al.*, (2008), Koolachart *et al* (2013) and Basu and Nautiyal (2008).

Association studies assist in selection of superior line though effortless and indirect way. The association of various morphological and physiological traits helps in selection of terminal drought tolerant genotypes. Some of parameters like kernel weight, number of mature pods, plant height, number of primary branches, number of immature pods, harvest index and SPAD chlorophyll meter reading are promising traits in during the selection of terminal drought genotypes.

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