Genetic V~~v~~ariability and C~~c~~orrelation S~~s~~tudies in Advance~~F$_6$ and F$_7$~~ F~~f~~amilies of G~~g~~roundnut (*Arachis hypogaea* L) under Water Stress Conditions ~~derived from the cross GKVK-13 × KCG-2~~

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Abstract:

~~Sustaining plant productivity under water-limited condition is a major challenge to a breeder.~~ Genetic variability is a major component which helps in selecting better genotypes under different environmental conditions.~~,~~ Thus, ~~with~~ this study was ~~aim an experiment was~~ conducted to understand the genetic variability and its components and their ~~potential, heritability, genetic advance and~~ trait~~s~~ association~~s~~ of yield contributing characters in ~~for~~ F_6 and F_7 families derived from the cross GKVK-13 × KCG-2. The trial was conducted at the University of Agricultural Sciences, Bangalore in an augmented block design along with three checks *viz*., TMV-2, KCG-6 and KCG-2 during summer and Kharif (rainy seasons) 2017. Analysis of variance for all the characters studied in both F_6 and F_7 generations revealed highly significant differences among the families suggesting the presence of sufficient amount of variability among the genotypes used in the study. Furthermore, medium to high Phenotypic coefficient of variation and Genotypic coefficient of variation values coupled with high heritability and medium to high genetic advance as *per cent* mean observed in most of the traits indicated the presence of sufficient variability and involvement of additive gene action controlling most of the traits. In addition, phenotypic correlation coefficients depicted significant positive associations for most of the traits studied. The implications of the results are discussed. The study concludes that there was the presence of additive genes controlling most of the traits and early selection of these traits is possible for groundnut improvement in the breeding programme.~~Results from analysis of variance (ANOVA) revealed that highly significant differences were observed for all the characters studied. High genetic variability was observed for major yield contributing characters like the number of pods per plant (g), pod yield (g), kernel yield per plant (g), SMK% (sound mature kernel *per cent*), SCMR (SPAD chlorophyll meter reading) and SLA (specific leaf area) (cm^2/g). Narrow difference between~~

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GCV (genotypic coefficient of variation) and PCV (phenotypic coefficient of variation) was observed for pods per plant, pod yield, SCMR and SLA and high heritability coupled with moderate genetic advance *per cent* mean was recorded for pod yield, SCMR and SLA indicating the involvement of additive gene action in controlling these traits. Among 84 families studied 14 families have been selected based on high SCMR values, low SLA, more number of pods per plant, high shelling % and high pod yield over parents and checks were identified to be the important characters that could be used in selection for yield and the selected families will be tested further in multi rows for yield stabilization.

Keywords: Genotypic coefficient of variation, CV, Phenotypic coefficient of variation, CV, Heritability, Genetic AdvanceM, water use efficiency, Groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is a self-pollinated, cleistogamous annual herb belonging to the family Leguminaceae with a chromosome number of 2n=40. It is the most important oilseed crop of India and the world in terms of area and production. It is vernacularly known by different names as peanut, monkey nut, earthnut and pigmy nut. Cultivated groundnut is classified into two subspecies, subs. *fastigiate* and subsp. *hypogaea*. The subsp. *fastigiata* contains four botanical varieties, var. *vulgaris*, var. *fastigiata*, var. *peruviana*, and var. *aequatoriana*. The subsp. *hypogaea* contain two varieties, var. *hypogaea* and var. *hirsuta*. Each of those botanical types has the contrasting plant, pod and seed characteristics (Krapovickas and Gregory, 1994). There are many reasons which are attributed to low yield levels *viz.*, lack or non-availability of improved high yielding cultivars, cultivation under shallow soils of low fertility, uneven rainfall distribution, continuous cropping without rotation of crop, low plant population and incidence of foliar diseases and pests are cited as the major limiting factors in most of the groundnut growing regions. Yield is a complex trait, controlled governed by many genes traits and there is ample evidence to show that selection directly for grain yield in plants is not easy. Since the economic a part of groundnut may be is a pod that' is developed under the soil, prediction of its performance supported by aerial morphological characters is nearly difficult (Weiss, 2000). Gain under direct selection for pod yield in groundnut is low and slow as pod yield is n'ot only polygenically controlled but also influenced by its component characters (Alam *et al.*, 1985). The knowledge of existing variability and degree of association between pod yield and its contributing characters and their relative contribution to pod yield is important for developing high yielding genotypes. Heritability and genetic advance is a useful tool for breeders in determining the amount of genetic variation present in crops. Correlation analysis is useful to work out the magnitude of association among the characters and their relative contribution to pod yield. More than 70% of the groundnut growing area falls under arid and semi-arid regions, where groundnut frequently experiences drought stresses for various durations and intensities (Reddy *et al.*, 2003). Yield losses attributable to drought are highly variable depending on timing, intensity and duration in addition to other location-specific environmental stress factors like high irradiation and temperature (Kambiranda *et al.*, 2011). Losses in yield that are due to water stress can be tackled partially by developing drought tolerant varieties.varieties that are better adapted to water scares conditions (Ravi *et al.*, 2011).

Comment [M2]: Kindly expand your literature on Heritability, GCV, PCV, GAM, SLA and SCMR their values and implications. You will need this to help you in your discussions.

Water use efficiency (WUE) is defined as the amount of water utilized in transpiration to produce dry matter during a specific growth period. Water Use Efficiency (WUE) is one such trait which will contribute to productivity under drought stresss. There are numerous easily measurable traits having a high correlation with WUE that are identified as surrogate traits. Traits that have practical advantages for WUE are specific leaf area (SLA) and chlorophyll content usually measured using and SSoil-PPlant AAnalysis DDevelopment (SPAD) and SPAD chlorophyll meter reading (SCMR). Nageswara Rao *et al*. (2001) and Sheshashayee *et al*. (2006) reported a direct correlation between SLA and carbon isotope discrimination, and an indirect correlation with WUE in groundnut, suggesting that SLA can be used as a surrogate trait to measure WUE in groundnut. The SPAD chlorophyll meter (SCMR)SCMR has been used effectively to determine leaf nitrogen content non-destructively in several crops including groundnut (Nageswara Rao *et al*., 2001). They reported significant and high negative inter-relationship among SLA and SCMR. Zhang *et al*. (2022), identified the genotypes PI 502120 and AU-NPL 17 as water spender genotypes as they showed high yield, $\Delta^{13}C$, photosynthesis, and stomatal conductance under drought.

Upadhyaya (2002) used SCMR and SLA as surrogate traits for assessing WUE in groundnut mini core germplasm collection and reported a negative correlation between SCMR and SLA. ~~There are many reasons which are attributed to low yield levels *viz.*, lack or non-availability of improved high yielding cultivars, cultivation under shallow soils of low fertility, uneven rainfall distribution, continuous cropping without rotation of crop, low plant population and incidence of foliar diseases and pests are cited as the major limiting factors in most of the groundnut growing regions. Keeping all the above points in view, an effort has been made to~~ Thus, the objective of this study was to assess the genetic variability and correlations amongst traits in groundnuts under water stress conditions ~~, an association of traits related to WUE with pod yield and its component traits, and~~ to identify superior families for varietal development. ~~performing better under drought stress conditions in F_6 and F_7 generation families derived from the cross of GKVK-16 × KCG-2.~~

Materials and Methods

Plant material and experimental site

The present study was conducted during summer and *Kharif* 2017 at the experimental field, GKVK, University of Agricultural Sciences, Bangalore. The experimental material for the present study comprised of 36 F_6 and 24 F_7 families of the cross *viz.*, GKVK-13 × KCG-2 and checks KCG-6, KCG-2 and TMV-2. The populations were developed by crossing the parents which were contrasting for the traits, SLA, SCMR, pod yield per plant, kernel yield per plant and pods per plant. The selected families from the F_5 generation of the cross were forwarded to the F_6 generation and the same procedure was repeated to raise F_7 generation. ~~Statistical analysis of the mean data was analyzed in WINDOSTAT *version* 8.5 for augmented design and SPSS for descriptive statistics.~~

Comment [M3]: Kharif season is monsoon season or rainy season so how did you impose the water stress? please indicate whether natural or artificial? Kindly state the actual period the experiment was conducted for example March-June which may coincide with Zaid season or June to November which is mainlyKharif or rainy season. It is important also to include here weather/rainfall data during the period of the experiment. Describe the location well. If water stress was not imposed in any way then I will suggest you leave out the water stress aspect in your manuscript.

Evaluation of F_6 generation

The F_6 plants of the cross, their respective parents and checks (KCG-2, KCG-6 and TMV-2) were raised in a plant to progeny row method in an augmented design during summer 2017 with 5 m row length and 30 cm and 10 cm inter and intra row spacing respectively.

Evaluation of F_7 generation

Individual F_6 progenies which had mean values higher than the families grand mean and mean more than the checks and the parents for the traits *viz.*, SPAD chlorophyll meter reading (SCMR), pod yield, kernel yield, shelling *per cent* and sound mature kernel (SMK) *per cent* and the low mean values for specific leaf area (SLA) were selected and sown in a plant to progeny row for F_7 evaluation of yield and water use efficiency-related traits as the salient features of parents and checks were given in (Table 1).

Morphological data

The data on ten morphological characters namely days to 50% flowering (days to first flowering), plant height (cm), primary branches per plant, pods per plant, pod yield per plant (g), kernel yield per plant (g), shelling percentage, sound mature kernel (SKM) *per cent*, specific leaf area (SLA) and SPAD chlorophyll meter reading (SCMR) were recorded. Shelling percentage: was calculated by using the following formulae. Kernel weight (g)/Pod weight (g) ×100, Sound mature kernel (SMK) *per cent:* was calculated by using the following formulae. Number of well-developed kernels/Total number of kernels ×100.

Water use efficient traits

Specific leaf area (SLA): The second or third fully expanded leaf of the main axis was collected in butter paper covers at 65 days after sowing. The leaf area was measured using a leaf area meter. Then the leaves were kept in an oven at 70 ˚C for 3 days. The dry weight of the leaf was accurately measured using a sensitive balance. SLA was computed using the formula given below and expressed as cm^2/g.

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Comment [M5]: You can convert kernel yield /plant to pod yield/ha

SPAD Chlorophyll Meter Reading (SCMR): Leaf nitrogen content normally influences the leaf chlorophyll content. A device has been developed by Minolta company, New Jersey USA (SPAD-502) which measures the light attenuation at 430 nm (the peak wavelength for chlorophyll a and chlorophyll b) and 750 nm (near-infrared) with no transmittance. The unit less value measured by the chlorophyll meter is termed SCMR (SPAD chlorophyll meter reading), which provides information on the relative amount of leaf chlorophyll. The SPAD meter (soil-plant analytical development) is a simple handheld instrument, which operates with a DC power of three Volts.

The second or third leaf from the apex was selected to record the SCMR. The selected leaf of groundnut was clamped avoiding the midrib region into the sensor head of the SPAD meter. A gentle stroke was given to record the SPAD reading and the average of such four strokes per leaflet was considered. Since groundnut is a tetra-foliate leaf, SCMR was recorded in all four leaflets and the average value was recorded. The SCMR was recorded under normal sunlight between 9.00 am to 4.00 pm.

Statistical analysis

The mean data was analyzed using WINDOSTAT *version* 8.5 for augmented design and Statistical Packages for Social Sciences (SPSS) version…… was used for descriptive statistics.

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Results and Discussion

Analysis of variance for traits related to water use efficiency, pod yield and its component characters in F_6 and F_7 generations of groundnut.

Analysis of variance was carried out for growth, traits related to water use efficiency, yield and its component characters in F_6 and F_7 generations of the cross *viz.*, GKVK-13 × KCG-2 of groundnut and is presented in Table 2 and Figure 1. Mean sum of squares of families exhibited highly significant difference for all the traits. Similar results were observed in the Further, mean sum of squares of checks *versus* families exhibited greater significant difference for all the characters like days to first flowering, plant height, branches per plant, SCMR, SLA, pod yield per plant, kernel yield per plant and sound mature kernel *per cent* except SMK *per cent* in the F_6 generation which was not significant.except plant height in SMK *per cent* in F_6 generation. Hence, the differences observed in the varieties could form a basis for selection for further breeding.choice of material for the study is suitable and further selections could be practiced.

Estimates of genetic variability parameters traits related to water use efficiency, pod yield and its component characters in F_6 and F_7 generations of groundnut.

Information on genetic variability in the source population for different characters is prerequisite for breeding programme aimed at improving yield and other characters under consideration. The genotypic variance indicates the magnitude of variance arising due to differences in genotypic values. Whereas the phenotypic variance indicates the amount of variance which is due to the differences in phenotypic and genotypic values, environment and interaction of genotype and environment. The absolute values of genotypic and phenotypic variance cannot be used for comparing the degree of variability for different characters because these characters have different units. Hence the coefficient of variation which expresses variance as *per cent* of mean is used for the comparisons. A higher estimate of these characters indicates greater variability and *vice-versa*. In this context, narrow difference between the phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) implies lesser impact of environment on the expression of the characters.

The genetic variability parameters were analyzed and presented in the table 3. From our study the presence of wider range of variation was observed for plant height (25 to 35 cm with the mean of 30.22), SCMR (26.29 to 42.91 with the mean of 35.99), pods per plant (13 to 41.14 with the mean of 25.18), pod yield per plant (8.35 to 32.64 with the mean yield of 20.13) kernel yield per plant (3.82 to 19.51 with the mean of 11.45), SMK *per cent* (24.88 to 89.36 with the mean of 61.61) and shelling *per cent* (35.70 to 80.86 with the

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mean of 60.76) in F_6 generation, similarly wider range of variation was observed for plant height (11.50 to 46.45 cm with the mean of 30.17), SCMR (33.56 to 50.78 with the mean of 41.36), pods per plant (9 to 52 with the mean of 27.70), pod yield per plant (6.28 to 43.25 with the mean yield of 23.17) kernel yield per plant (3.60 to 27.20 with the mean of 13.74), SMK *per cent* (26.37 to 94.01 with the mean of 61.90) and shelling *per cent* (50.48 to 69.84 with the mean of 61.30) in F_7 generation, suggest that there is presence of wider range of phenotypes hence selection can be practiced.

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The high GCV and high PCV coupled with narrow difference between GCV and PCV for plant height, pods per plant, pod yield per plant, kernel yield per plant and SMK *per cent* in F_6 and F_7 generation. The medium to high estimates of GCV and PCV for the above mentioned traits suggests the presence of some degree higher magnitude of variation infor these traits. Thus individual plant selection can be practiced for these characters. Chauhan *et al*. (2022) reported high GCV, PCV for shelling %, kernel yield per plant and pod yield per plant in BC_1F_1, BC_1F_2 and BC_1F_3 populations. Similar results were reported by Meta and Monpara (2010), Makhan *et al*. (2003); Golakia *et al*. (2005); John *et al*. (2005); Rao *et al*. (2012); Vishnuvardhan *et al.* (2012); Sridevi *et al.* (2022) ,. in groundnut. Sridevi *et al*. (2022). The high estimates of GCV and PCV for the above-mentioned traits suggest the presence of a higher magnitude of variation for these traits. The moderate GCV and moderate PCV coupled with narrow difference between GCV and PCV was noticed for plant height, pods per plant, and SLA in F_6 and F_7 generations. Therefore, for selection of superior families these traits can also be used. These results are in confirmation with the reports of Vishnuvardhan *et al.* (2012) in groundnut. Lower GCV and PCV were recorded for days to first flowering and SCMR in F_6 and F_7 generation, SLA (F_6-) and shelling % (F_7). Tthis indicates the lower magnitude of variability for these traits in relation to their generations. days to first flowering and SCMR. Narrow difference between GCV and PCV observed generally indicateds that the environmental influence wasis less and the variability present was is mostly controlled by additive genes and thus early selection using these traits could be possible.genotypic. This indicates lower magnitude of variation for days to first flowering and SCMR. These results are in agreement with Same results were reported by (Makhan Lal *et al*, 2003); for days to first flowering and for SCMR (Nandini *et al.*, 2011; and John *et al.*, 2013);. Khote *et al.*, (2009);. These results are in confirmation with the results of Vishnuvardhan *et al.*, (2012) and Maurya *et al.* (2014). for days to first flowering in groundnut.

Heritability and genetic advance are important selection parameters. The ratio of GCV to the PCV or total variance (broad sense) or the ratio of additive genetic variance to the phenotypic variance (narrow sense) is known as heritability, which indicates the heritable portion of phenotypic variance and a good index of the transmission of characters from parents to offspring. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimate alone, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*., 1955).

Heritability value alone cannot provide information on the amount of genetic progress that would result from selection of best individuals. Johnson *et al*. (1955) reported that heritability estimates along with genetic gain would be more useful in predicting the effectiveness of selecting the best individuals. High heritability coupled with medium to high genetic advance over mean was recorded for all the traits except days to flower (F_6) and SCMR (F_6) (Table 3). The results indicated that these characters were under the influence of additive genetic control and selection will be effective in contributing to yield.the traits plant height, pods per plant, pod yield per plant, kernel yield per plant and SMK *per cent* in F_6 and F_7 generation. Similar results of High heritability coupled with high genetic advance over mean were reported by Nath *et al.* (2002) and Golakia *et al.* (2005) for plant height, pods per plant and pod yield per plant which indicates that these characters are under the influence of additive genetic control and selection will be effective and may rapidly contribute to yield. Rao *et al*. 2012 for pods per plant, Padmaja *et al.* 2013a for pod yield per plant, Zaman *et al.* 2011 and Rao *et al*. 2012 for kernel yield per plant, Reddi *et al*. 1991; Venkataravana *et al*. 2001 for SMK *per cent.* High heritability accompanied with low to moderate genetic advance as *per cent* of mean was noticed for traits like days to first flowering and, SCMR and SLA, in the F_6 and F_7 generation. This indicates the presence of non-additive gene action and narrow range of variation for these traits. s Suggestings that limited scope for further improvement of these characters. Similar results were reported by Makhan *et al.* (2003) in groundnut.

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Association studies traits related to water use efficiency, pod yield and its component characters in F_6 and F_7 generations of groundnut.

Correlation coefficient is an essential tool. Correlation studies between yield and its component traits would help plant breeders to enhance crop growth and yield of crop. In the present study phenotypic correlation between pod yield per plant with component characters and also with physiological traits were studied in both F_6 and F_7 generations.

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Phenotypic correlation coefficients for traits related to water use efficiency, pod yield and yield and its component traits are presented in Table 4. Phenotypic correlation coefficient revealed that pod yield per plant had significant positive correlation with SCMR (0.85, 0.55), pods per plant (0.77, 0.85), kernel yield per plan (0.83, 0.91), DFF (0.11, 0.17) and plant height (0.44, 0.31), however, Pod yield per plant had significant negative correlation with SLA (-0.38, -.45), SMK *per cent* (-0.58, -.49) and shelling per cent (-0.58, -0.49) in F_6 and F_7 generation. This indicated that improvement in SCMR, pods per plant, kernel yield per plant and plant height will lead to improvement in yield. These results are in accordance with the reports of Sridevi *et al*. (2022), Mukhtar *et al*. (2011), Shoba *et al.* (2012). Koolachart *et al.* (2013) and Thakur *et al.* (2013). This indicates that selection of traits for low SLA leads to improvement in yield.

Shelling percentage showed significant positive correlation with kernel yield per plant (0.68, 0.55) in F_6 and F_7 generation indicated the shelling *per cent* could be improved by selecting more number of pod per plant with bold kernels. Similar result was noticed by Nandini *et al*. (2012). SLA exhibited significant negative correlation with SCMR (-0.34, -0.55), pods per pant (-0.38, -0.45), pod yield per plant (-0.58, -0.61) and kernel yield per plant (-0.57, -0.49) in F_6 and F_7 generation, suggesting the improvement of yield and water use efficiency could be done by selecting families that show low SLA. Rekha (2005) and Reddy *et al.* (2003) also reported similar kind of outcomes. SCMR exhibited highly significant positive association with pods per plant (0.64, 0.77), pod yield per plant (0.57, 0.69), kernel yield per plant (0.75, 0.64) and SMK *per cent* (0.54, 0.65)., Ffurthermore, SCMR showed negative correlation with

SLA (-0.34, -0.55) in F_6 and F_7 generation. Therefore, selection of genotypes with high SCMR offers the scope for simultaneous improvement of yield and water use efficiency in groundnut as higher SCMR indicate high photosynthetic efficient genotypes. The results are in agreement with the reports of Songsri *et al.* (2009) and Rekha (2005). John *et al.*, 2005 for SCMR. This shows that selection of families whose with SCMR values were higher than the checks, which indirectly could lead to improvement of yield in groundnut as since high SCMR indicates high photosynthetic efficient genotypes with high water use efficiency. The reports of Nageshwar Rao *et al.* (2001), Talwar *et al.* (2004), Rekha (2005), John *et al.* (2005) and Krishnamurthy *et al.* (2007) also confirmed the same association in groundnut.

Conclusions

Analysis of variance for all the characters studied in both F_6 and F_7 generations revealed highly significant differences among the families suggesting the presence of sufficient amount of variability. Thus, the breeding programme can take advantage and utilize these varieties for further crop improvement. Furthermore, genetic variability estimates such as medium to high PCV and GCV values coupled with high heritability and medium to high genetic advance as *per cent* mean observed in most of the traits for kernel yield per plant, pod yield per plant and sound mature kernel percentage, SLA indicated ing the presence of sufficient variability and involvement of additive gene action in both F_6 and F_7 generations for these traits and early selection for breeding of these traits in groundnuts is possible. Days to first flowering SCMR exhibited lower PCV and GCV estimates and thus indicating less variation for this trait. Phenotypic correlation coefficient depicted significant positive associations for most of the traits and these traits could be considered in the selection for high yielding groundnut varieties. of SCMR, pods per plant and kernel yield per plant with pod yield per plant. SLA exhibited significant negative association with pod yield per plant and SCMR. Therefore, superior genotypes for high yield and water use efficiency were selected depending on the relationship between SLA, SCMR and pod yield. From the overall study fourteen superior families from cross GKVK-13×KCG-2 were selected from F_7 generation for multi-location evaluation.

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Table 1: Salient features of parents and checks used in the study.

Genotypes	SCMR	SLA (cm^2/g)	Pods/plant	Pod yield (g/plant)	SMK (%)
GKVK-13	42.44	140.17	27.32	25.00	87.00
*KCG-2	34.25	160.20	22.00	20.29	71.00
*KCG-6	45.39	142.00	30.14	29.28	65.12
*TMV-2	35.38	152.15	18.00	15.00	60.75

Table 2: Analysis of variance for growth, traits related to water use efficiency, pod yield and its component characters in F_6 and F_7 generation.

SV	Generations	df	DFF	Plant height (cm)	Primary Branches plant $^{-1}$	SCMR	SLA(cm^2/g)	Pods Plant^{-1}	Pod yield plant $^{-1}$(g)	Kernel yield plant $^{-1}$(g)	Shelling (%)	SMK (%)
Blocks	F_6	5.00	17.95	58.97**	0.64	13.47	134.06	21.51	16.86	15.51	34.35	128.73
	F_7	3.00	12.75	43.95*	0.23	28.42	131.41	78.19	15.48	14.76	32.84	258.34*
Checks	F_6	2.00	12.88	20.86	0.24	25.83	156.16	90.84*	17.25	27.07	36.33	372.23**
	F_7	2.00	12.23	25.49	1.007	34.42	126.58	25.88	18.95	36.87	18.34	109.08

Families	F_6	35.00	30.14**	47.15**	10.15**	194.82**	248.65**	129.85**	104.57**	87.42**	77.95**	280.86**
	F_7	23.00	20.82**	171.53**	10.53**	221.56**	244.56**	116.39**	95.49**	100.11**	89.02**	256.33**
Checks *vs.* Families	F_6	70.00	59.25**	183.04**	33.96**	311.98**	370.93**	553.97**	138.76**	116.81**	125.54**	89.56
	F_7	46.00	25.68*	152.10**	20.15**	322.55**	300.12**	655.16**	122.05**	133.60**	129.84**	337.43*
Error	F_6	20.00	2.08	7.21	0.14	5.99	17.80	12.73	11.01	9.11	13.15	25.54
	F_7	12.00	2.66	6.48	0.04	6.64	13.25	14.33	13.81	6.57	15.16	28.35

Note: * Significant at 0.05 probability level, ** Significant at 0.01 probability level.

SV- Source of variation, df: Degrees of freedom, DFF: Days to first flowering

Table 3: Estimates of genetic variability parameters for growth, traits related to water use efficiency, pod yield and its component characters in F_6 and F_7 generation.

Traits	Crosses	Mean	Range		Standardized Range	GCV (%)	PCV (%)	$h^2_{(bs)}$%	GAM%
			Min.	Max.					
DFF	F_6	30.22	25.00	35.00	0.33	05.30	06.79	78.14	09.54
	F_7	32.13	30.00	35.00	0.16	03.43	03.87	88.64	27.86
Plant height (cm)	F_6	37.86	25.12	50.60	0.67	12.75	15.92	80.15	26.29
	F_7	30.17	11.50	46.45	01.18	21.39	24.37	87.81	44.09
Primary branches plant^{-1}	F_6	04.18	03.00	05.00	0.48	08.30	12.29	67.61	27.24
	F_7	05.03	04.05	06.13	0.41	12.85	14.60	88.06	26.49
SCMR	F_6	35.99	26.29	42.91	0.46	08.82	10.42	84.69	03.15
	F_7	41.36	33.56	50.78	0.41	08.23	10.08	81.73	12.81
SLA(cm^2/g)	F_6	156.22	131.00	204.80	0.47	07.14	9.67	73.90	14.76
	F_7	127.50	90.00	189.00	0.78	12.09	13.48	89.70	16.02

Comment [M14]: The coefficient of variation CV) value is missing from the anova. also explain SCMR, SLA, SMK under the foot notes

Comment [M15]: Table 3 Estimates of Genetic variability.....
If possible add columns for additive variance, Dominance Variance, Environmental variance, phenotypic and genotypic variance, genetic advance, so the calculations for heritability, GCV, PCV and GAM could be verified.

Comment [M16]: Please check the formula for calculating the broad sense well and if correct state the source in the materials and methods.

Pods plant^{-1}	F_6	25.18	13.00	41.14	01.12	17.84	19.94	89.51	20.33
	F_7	27.70	09.00	52.00	01.54	27.27	35.18	77.54	41.69
Pod yield plant^{-1}(g)	F_6	20.13	08.35	32.64	01.21	17.54	22.70	77.28	22.11
	F_7	23.17	06.28	43.25	01.61	34.23	39.46	86.75	54.25
Kernel yield plant^{-1}(g)	F_6	11.45	03.82	19.51	01.37	30.56	33.99	89.92	27.96
	F_7	13.74	03.60	27.20	01.81	37.04	43.16	85.84	31.87
Shelling (%)	F_6	60.76	35.70	80.86	0.74	10.74	14.41	74.57	19.36
	F_7	61.30	50.48	69.84	0.32	06.13	07.37	83.29	20.50
SMK (%)	F_6	61.61	24.88	89.36	01.05	20.76	23.61	87.93	42.77
	F_7	61.90	26.37	94.01	01.20	20.44	23.98	85.25	42.11

Note: GCV - Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation,
$h^2_{(bs)}$% - Heritability in broad sense, GAM %- Genetic advance as *per cent* of mean.

Table 4: Phenotypic correlation coefficients for growth, traits related to water use efficiency, pod yield and its component traits in F_6 and F_7 generation.

Traits	Generations	Plant height (cm)	Primary branches plant^{-1}	SCMR	SLA (cm^2/g)	Pods Plant^{-1}	Pod yield plant^{-1}(g)	Kernel yield plant^{-1}(g)	Shelling (%)	SMK (%)
DFF	F_6	0.25*	0.36**	0.32*	0.24*	-0.33*	0.11	0.45**	-0.22*	0.24*
	F_7	0.30**	0.50**	0.29*	0.15	-0.46**	0.17	0.29*	-0.27*	0.31**
Plant height(cm)	F_6	1.00	-0.25*	0.34*	-0.29*	0.36**	0.44**	0.37**	0.36**	0.11
	F_7	1.00	-0.17*	0.22*	-0.12	0.22*	0.31**	0.33**	0.22*	0.25*
Primary branches plant^{-1}	F_6		1.00	0.19*	-0.05	-0.19*	0.30**	0.24*	-0.15	0.22**
	F_7		1.00	0.32**	-0.08	-0.12*	0.25*	0.33**	-0.18	0.28**
SCMR	F_6			1.00	-0.34*	0.64**	0.57**	0.75**	0.27*	0.53*
	F_7			1.00	-0.55**	0.77**	0.69*	0.64**	0.22*	0.65**
SLA(cm^2/g)	F_6				1.00	-0.38*	-0.58**	-0.57**	-0.23*	-0.20*
	F_7				1.00	-0.45**	-0.61	-0.49**	-0.35**	-0.32**
Pods plant^{-1}	F_6					1.00	0.77**	0.53**	0.52**	-0.33**
	F_7					1.00	0.85**	0.74**	0.40*	-0.41**
Pod yield plant^{-1}(g)	F_6						1.00	0.83*	-0.58*	0.85**
	F_7						1.00	0.91**	-0.49*	0.55*
Kernel yield	F_6							1.00	0.68**	0.73**

plant^{-1}(g)	F_7							1.00	0.55**	0.61*
Shelling (%)	F_6								1.00	0.40**
	F_7								1.00	0.56**
SMK (%)	F_6									1.00
	F_7									1.00

Note: *Significant at 0.05 probability level. ** Significant at 0.01 probability level

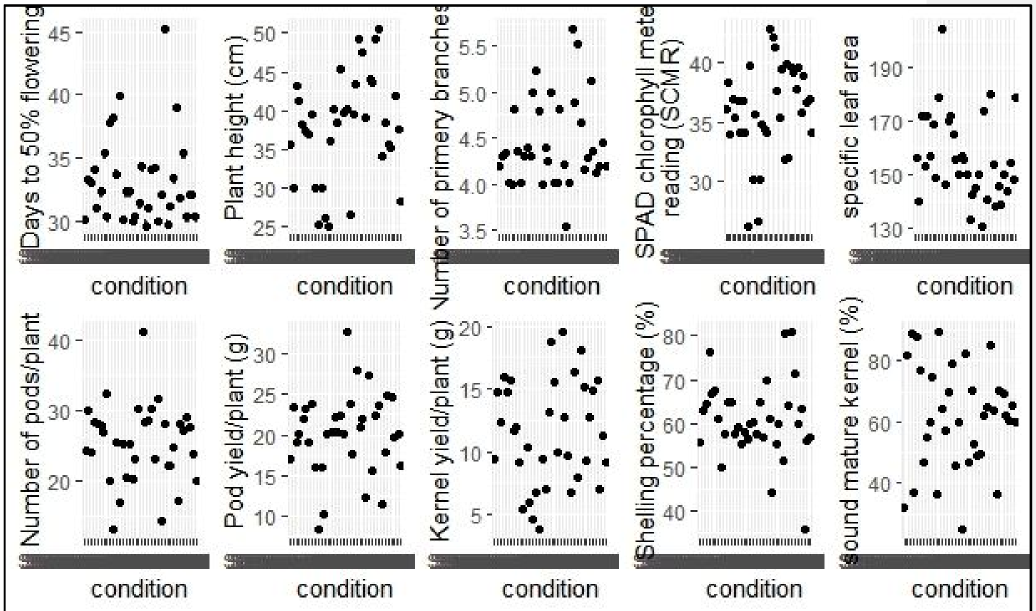

Figure 1: Box plots depicting variation in studied traits of groundnut