Identification of High Yielding Water use Efficient F$_6$ and F$_7$ Families Derived from the Cross of GKVK-16 × KCG-2 in Groundnut (*Arachis hypogaea* L.)

Padmashree R.*[1], *Shanthala J.*[1], *Honnappa M.*[2], *D. L. Savithramma*[1], *Sanjeevkumar R.*[1], *E. Gangappa*[1]
and A.G. Shankar[1]
[1]*Department of Genetics and Plant Breeding, UAS Bengaluru (Karnataka),560065, India.*
[2]*Department of Genetics and Plant Breeding, UAS Raichur (Karnataka), 584104, India.*

(Corresponding author: Padmashree R.*)

ABSTRACT: Yield is a complex trait, governed by many traits and there is ample evidence to show that selection directly for grain yield in plants is not easy. However, groundnut frequently experiences drought stresses for various durations and intensities. 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. Losses in yield that are due to water stress can be tackled partially by developing varieties that are better adapted to water scares conditions with yield advantage. With this background an experiment was conducted to understand the genetic potential, heritability, genetic advance and traits association of yield contributing characters for F$_6$ and F$_7$ families derived from the cross GKVK-16 × KCG-2 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* 2016. 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 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: GCV, PCV, Heritability, GAM, 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). Yield is a complex trait, governed by many 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 a pod that's developed under the soil, prediction of its performance supported aerial morphological characters is nearly difficult (Weiss, 2000). Gain under direct selection for pod yield in groundnut is low and slow as pod yield isn't 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 varieties that are better adapted to water scares conditions (Ravi *et al.,* 2011). Water use efficiency 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. 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 soil-plant analysis development and SPAD chlorophyll meter reading (SCMR). Pandey *et al.* (2020) identified 19 major main-effect QTLs with 10.0–33.9% phenotypic variation explained (PVE) for drought tolerance- and iron deficiency tolerance- related traits, major main-effect QTLs were detected for haulm weight (20.1% PVE), SCMR (soil plant analytical development (SPAD) chlorophyll meter reading, 22.4% PVE), and visual chlorosis rate (33.9% PVE) through Genome-wide QTL discovery analysis. Nageswara Rao *et al.* (2001); Sheshshayee *et al*. (2006) reported a direct correlation between SLA and carbon isotope discrimination, and a indirect correlation with WUE in groundnut, suggesting that SLA can be used as a surrogate trait to measure WUE in groundnut. SCMR has been used effectively to determine leaf nitrogen content non-destructively in several crops including groundnut (Nageswara Rao *et al*., 2001) and reported significant and high negative inter-relationship among SLA and SCMR. Upadhyaya *et al.* (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. 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. 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 study the genetic variability, an association of traits related to WUE with pod yield and its component traits, and to identify superior families 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* 2016 at the experimental field, K-Block, Department of Genetics and Plant Breeding, 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-16 × 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 rise F_7 generation. Statistical analysis of the mean data was analyzed in WINDOSTAT *version* 8.5 for augmented design and SPSS for descriptive statistics.

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 2016 with 5 m row length and 30 cm and 10 cm inter and intra row spacing respectively (Plate 1).

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.

Weather parameter details and recording of morphological data. Recommended fertilizer doges, cultural practices and all plant protection measures were followed to ensure a good crop stand of the F_6 and F_7 families and the monthly mean weather data for the experimental sites during the crop growth period were recorded as total rainfall (mm), the number of rainy days, the minimum and maximum temperature in ˚C, sunshine hours for 1hours and 2 hours (Table 2). 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: Sound mature kernel (SMK) *per cent:* was calculated by using the following formulae.

$$\text{Shelling percent} = \frac{\text{Kernel weight (g)}}{\text{Pod weight (g)}} \times 100$$

$$\text{SMK (\%)} = \frac{\text{Number of well developed kernels}}{\text{Total number of kernels}}$$

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.

SPAD Chlorophyll Meter Reading (SCMR). Amongst several leaf characters, leaf thickness and chlorophyll content determine the leaf transmittance characters. 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.

RESULTS AND DISCUSSION

Analysis of variance revealed a significant difference for all the characters among families in the cross GKVK-16 × KCG-2. Further, checks *vs* families exhibited greater significant difference for days to first flowering, plant height, primary branches per plant, pods per plant, SCMR, SLA, pod yield per plant, kernel yield per plant and SMK (%) except plant height in F_7 populations as shown in the Table 3. Thus, indicating the presence of a sufficient amount of genetic variability for all the studied traits. Hence the result indicates that choice of material for the study is suitable and further selections could be practiced for crop improvement in achieving desirable traits

Estimates of Genetic variability parameters. High GCV and PCV coupled with the narrow difference between GCV and PCV for kernel yield per plant, pods per plant and shelling *per cent* in F_6 and F_7 generations

of the cross GKVK-16 × KCG-2 (Table 4) which suggest that expression of pods per plant, kernel yield per plant, shelling *per cent* and SMK *per cent* are less influenced by the environment, therefore, these characters could be used for selection of superior families as selection criteria. Similar findings of higher estimates of GCV and PCV for kernel yield per plant and pod yield per plant were reported by Giri *et al.* (2009); 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. Thus individual plant selection can be practiced for these characters. Whereas 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. In literature 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) in groundnut. High broad-sense heritability accompanied with high genetic advance as *per cent* mean was recorded for pods per plant, pod yield per plant, SMK *per cent*, kernel yield per plant and shelling *per cent* in F_6 and F_7 generation of the cross GKVK-16×KCG-2 (Table 4). This indicates that the heritability is mostly due to additive gene effects and there is a lot of scope for improvement of these traits in the future breeding programme. Similar results were reported by Nath and Alam (2002); 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); Rao *et al.* (2012) for kernel yield per plant, Reddi *et al.* (1991); Venkataravana *et al.* (2000) for SMK *per cent*.

Phenotypic correlation coefficients. Phenotypic correlation coefficients for growth, traits related to water use efficiency, pod yield and yield and its component traits was estimated in F_6 and F_7 generation and results are presented in Table 5. DFF showed significant positively correlation with primary branches per plant, (r= 0.27, 0.45), SLA (r= 0.34, 0.40), pods per plant (r= 0.45, 0.56), pod yield per plant (r= 0.22, 0.38), kernel yield per plant (r= 0.43, 0.37). Whereas, DFF showed a negative correlation with shelling%. Plant height exhibited significant positive correlation with SCMR (r= 0.41, 0.48), pods per plant (r= 0.22, 0.34), pod yield per plant (r= 0.39, 0.41), kernel yield per plant (r= 0.40, 0.48), SMK% (r= 0.43, 0.21). Primary branches per plant showed a significant positive correlation for all traits except SLA and shelling%. SCMR exhibited significant positive correlation with, pods per plant (r= 0.46, 0.53), pod yield per plant (r= 0.69, 0.66), kernel yield per plant (r= 0.67, 0.51), shelling% (r= 0.33, 0.42) however it exhibited the presence of significant negative correlation with SLA (r= -0.70, -0.81). SLA showed a significant negative

correlation for all traits except plant height and primary branches per plant. Further, it also showed the existence of a significant positive correlation with DFF (r= 0.34, 0.40). Pods per plant exhibited a significant positive correlation with all traits except SMK% where it has shown a significant negative correlation with SLA (r= -0.06, -0.14). Pod yield per plant exhibited a significant positive correlation with all traits except SLA and shelling *per cent* where it showed a significant negative correlation in both F_6 and F_7 generation with the value of SLA (r= -0.74, -0.68) and shelling% (r= -0.56, -0.45). Kernel yield per plant showed a significant positive correlation with all the traits except SLA (r= -0.61, -0.57). Shelling % showed significant positive correlation with SCMR (r= 0.33, 0.42). This shows that selection of families whose SCMR value were higher than checks, which indirectly lead to improvement of yield in groundnut as high SCMR indicates high photosynthetic efficient genotypes with high water use efficiency. Kernel yield per plant (r= 0.52, 0.62) SMK% (r= 0.23, 0.29), whereas it found significant negative correlation with SLA (r= -0.22, -0.33), pods per plant (r= -0.25, -0.46), pod yield per plant (r= -0.56, -0.45). SMK% exhibited significant positive correlation with plant height (r= 0.43, 0.21), primary branches per plant (r= 0.31, 0.51), pod yield (r= 0.41, 0.65), kernel yield per plant (r= 0.37, 0.52), John *et al.* (2019), SMK% (r= 0.23, 0.29) and significant negative correlation with SLA (r= -0.32, -0.28). These results are in accordance with the reports of Sridevi *et al.* (2022); Reddy *et al.*, (2017); Mukhtar *et al.* (2011); Shoba *et al.* (2012). Koolachart *et al.* (2013); Thakur *et al.* (2013). This indicates that selection of traits for low SLA leads to improvement in yield. From F_7 generation fourteen

superior families from cross GKVK-16×KCG-2 were selected for multi-location evaluation (Table 6, Plate 2).

Plate 1: Field view of F_7 generation of groundnut crop.

Plate 2: Selected superior families in F_7 generation.

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

Genotypes	SCMR	SLA (cm²/g)	Pods/ plant	Pod yield (g/pt)	SMK (%)
GKVK-16	42.45	153.04	30.55	28.00	75.00
KCG-6	45.39	142.00	30.14	29.28	65.12
KCG-2	44.25	136.20	22.00	20.29	81.00
TMV-2	35.38	152.15	18.00	15.00	60.75

Table 2: Monthly Mean Weather Data of Experimental Sites During Crop Growth Period for the Year 2016.

Month	Total Rainfall (mm)	Rainy days (No.)	Temp (^{0} C)		Sun shine Hours	RH (%)	
			Max	Min		I hr	II hr
JAN	2.4	0	27.5	14.7	7.6	90	47
FEB	0	0	31.2	16.2	9.0	85	38
MAR	4.2	1	34.0	19.9	8.2	86	37
APR	1.2	0	35.8	23.1	9.1	84	37
MAY	112.6	6	33.1	21.4	7.8	88	42
JUNE	140.4	13	28.4	19.9	4.7	92	55
JULY	271.4	11	27.6	19.3	4.1	94	58
AUG	28.0	2	28.1	19.5	5.7	92	54
SEP	51.4	5	27.8	19.0	3.5	92	54
OCT	31.0	3	29.6	18.0	7.9	85	48
NOV	0	0	29.6	16.2	8.5	82	43
DEC	64.4	3	27.2	14.7	6.9	88	46
TOTAL	707	44	30.0	18.5	6.9	88	47

Table 3: Analysis of variance for growth, traits related to water use efficiency, pod yield and its component characters in F₆ and F₇ generations of the cross GKVK-16 × KCG-2 in groundnut.

SV	Generations	Df	DFF	Plant height (cm)	Primary branches plant⁻¹	SCMR	SLA (cm²/g)	Pods Plant⁻¹	Pod yield plant⁻¹(g)	Kernel yield plant⁻¹(g)	Shelling (%)	SMK (%)
Blocks	F_6	5.00	14.58	45.34	0.23	17.84	130.23	40.46	184.16	139.98	150.62	115.53
	F_7	3.00	10.52	57.82**	0.38	15.68*	160.82	436.54*	214.21	133.34	129.31	156.71*
Checks	F_6	2.00	22.88	22.17	0.42	31.11	42.59	312.41	140.62	111.00	162.11	107.27
	F_7	2.00	14.08	31.82	0.50	11.89*	81.82	348.60	280.44	141.20	239.04	108.89
Families	F_6	35.00	32.30**	67.83**	7.33**	33.04**	855.44**	536.75**	644.54**	532.98**	759.39**	402.95**
	F_7	23.00	41.38**	49.05**	8.29**	25.38**	849.05**	608.82**	608.22**	635.65**	538.51*	645.96**
Checks *vs.* Families	F_6	70.00	72.67**	227.12**	14.65**	364.06**	1342.25**	1463.76**	1016.29**	1660.04**	664.93**	4141.66**
	F_7	46.00	69.01**	40.39	12.58**	411.99**	1244.36**	1338.13**	2555.88**	2424.28**	690.58**	4668.19**
Error	F_6	20.00	5.42	5.29	0.185	8.17	6.57	16.71	16.63	22.16	18.99	10.58
	F_7	12.00	3.86	5.49	0.22	2.27	5.49	17.11	12.04	10.03	27.48	19.56

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 4: Estimates of genetic variability parameters for growth, traits related to water use efficiency, pod yield and its component characters in F₆ and F₇ generation in the cross GKVK-16×KCG-2 of groundnut.

Traits	Crosses	Mean	Range Min.	Range Max.	Standardized Range	GCV (%)	PCV (%)	$h^2_{(bs)}$%	GAM%
DFF	F_6	30.91	29.00	36.00	0.23	03.56	05.74	62.09	08.53
	F_7	34.36	30.00	45.00	0.10	10.28	11.67	88.09	04.35
Plant height(cm)	F_6	32.85	20.12	45.45	0.77	10.73	14.19	75.62	22.10
	F_7	32.87	19.66	45.45	01.15	15.58	18.32	85.06	32.09
Primary branches plant⁻¹	F_6	05.11	03.64	06.20	0.50	08.08	10.56	76.57	07.95
	F_7	04.92	03.06	06.5	0.64	09.11	11.67	78.09	24.35
SCMR	F_6	38.95	32.63	48.03	0.40	06.17	08.79	70.27	05.48
	F_7	44.07	32.09	59.08	0.42	08.70	09.90	87.95	17.93
SLA (cm²/g)	F_6	154.56	129.00	186.50	0.37	14.71	16.39	89.75	30.30
	F_7	144.03	93.00	198.00	0.54	14.42	18.18	79.35	29.72
Pods plant⁻¹	F_6	31.42	20.00	41.60	0.69	13.65	17.81	76.65	17.12
	F_7	41.31	16.70	74.00	01.55	23.41	31.18	75.11	35.39
Pod yield plant⁻¹(g)	F_6	30.95	20.12	45.33	0.81	17.83	21.44	83.17	21.40
	F_7	42.88	13.59	88.45	01.59	19.29	26.47	72.88	34.28
Kernel yield plant⁻¹(g)	F_6	26.34	13.81	40.00	0.99	15.86	20.81	76.25	11.25
	F_7	22.51	02.14	54.62	01.72	26.94	36.82	73.19	47.94
Shelling (%)	F_6	60.27	48.39	92.4	0.73	11.65	12.48	93.42	13.45
	F_7	58.88	15.46	69.84	0.33	29.01	35.91	80.80	30.19
SMK (%)	F_6	64.24	39.58	90.22	0.79	16.56	20.69	80.06	17.08
	F_7	43.69	14.00	80.23	01.17	57.17	60.99	93.74	117.79

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 5: Phenotypic correlation coefficients for traits related to growth, water use efficiency, pod yield and its component traits in F₆ and F₇ generation of the cross GKVK-16×KCG-2 in groundnut.

Traits	Generations	Plant height(cm)	Primary branches plant⁻¹	SCMR	SLA (cm²/g)	Pods Plant⁻¹	Pod yield plant⁻¹(g)	Kernel yield plant⁻¹(g)	Shelling (%)	SMK (%)
DFF	F_6	0.15	0.27*	0.10	0.34**	0.45**	0.22*	0.43**	-0.15	0.14
	F_7	0.14	0.45**	0.14	0.40**	0.56**	0.38**	0.37*	-0.12	0.19
Plant height(cm)	F_6	1.00	-0.47**	0.41**	-0.14	0.22*	0.39**	0.40**	-0.22*	0.43**
	F_7	1.00	-0.35*	0.48**	-0.19	0.34**	0.41**	0.48**	-0.18	0.21*
Primary branches plant⁻¹	F_6		1.00	0.26*	-0.15	0.23*	0.27*	0.62**	-0.11	0.31**
	F_7		1.00	0.36**	-0.18	0.36**	0.50**	0.53**	-0.19	0.51**
SCMR	F_6			1.00	-0.70**	0.46**	0.69**	0.67**	0.33**	0.10
	F_7			1.00	-0.81**	0.53**	0.66**	0.51**	0.42**	0.18
SLA (cm²/g)	F_6				1.00	-0.36**	-0.74**	-0.61**	-0.22*	-0.32**
	F_7				1.00	-0.41**	-0.68**	-0.57**	-0.33**	-0.28*
Pods plant⁻¹	F_6					1.00	0.34*	0.33*	-0.25*	-0.06
	F_7					1.00	0.27*	0.48**	-0.46**	-0.14
Pod yield plant⁻¹(g)	F_6						1.00	0.76**	-0.56**	0.41**
	F_7						1.00	0.84**	-0.45**	0.65**
Kernel yield plant⁻¹(g)	F_6							1.00	0.52**	0.37**
	F_7							1.00	0.62**	0.52**
Shelling (%)	F_6								1.00	0.23*
	F_7								1.00	0.29*
SMK (%)	F_6									1.00
	F_7									1.00

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

Table 6: Performance of selected superior families in F$_7$ generation for water use efficiency related traits, pod yield and its component traits in the cross GKVK-16 × KCG-2 of groundnut.

Sr. No	Name	SCMR	SLA (cm²/g)	Pods plant^{-1}	Pod yield plant^{-1} (g)	Kernel yield per plant (g)	Shelling %
1.	C1-213-2-1-1-2	47.72	104	54.00	48.36	32.05	65.86
2.	C1-74-4-3-3-2	46.96	110	61.00	56.61	42.85	58.02
3.	C1-213-6-2-7-2	55.36	116	72.00	62.28	52.90	84.93
4.	C1-213-6-2-2-4	59.80	93	52.00	48.50	35.20	76.12
5.	C1-213-2-8-4-16	46.08	136	69.00	61.79	45.34	74.38
6.	C1-40-1-5-1-8	47.50	114	69.00	63.60	40.00	59.52
7.	C1-74-4-3-3-1	44.38	118	64.00	57.81	39.66	55.91
8.	C1-213-6-2-7-1	45.14	116	57.00	47.48	42.12	88.76
9.	C1-47-9-10-1-1	52.58	119	62.00	56.24	48.16	85.63
10.	C1-40-1-5-1-7	48.20	121	59.00	49.56	34.98	70.58
11.	C1-137-4-7-5-9	51.50	116	74.00	57.39	34.62	60.12
12.	C1-137-4-7-5-3	49.38	124	56.00	45.52	37.54	52.14
13.	C1-46-1-10-1-9	52.06	132	67.00	58.91	36.93	62.72
14.	C1-137-4-7-5-1	48.60	145	60.00	57.66	36.36	60.00
	GKVK-16	42.57	155	30.00	20.10	15.20	50.23
	KCG-2	40.00	158	24.00	19.11	12.39	49.77
	TMV-2	32.00	160	20.00	15.33	8.00	42.36

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. Further, genetic variability estimates such as PCV and GCV coupled with high heritability and genetic advance as *per cent* mean for kernel yield per plant, pod yield per plant and sound mature kernel percentage, SLA indicating the presence of sufficient variability and involvement of additive gene action in both F$_6$ and F$_7$ generations for these traits. 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 association 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-16×KCG-2 were selected from F$_7$ generation for multi-location evaluation.

Conflicts of Interest. None.

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