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Studies on Genetic Parameters for Growth Parameters, Traits Related to WUE, Yield and Yield Attributing Traits in F_3, F_4, F_5 and F_6 Segregating Generations of the Cross NRCG 12273 × ICG 12370 in Groundnut (*Arachis hypogaea* L.)

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A B S T R A C T

The present investigation was undertaken to study the variability, broad sense and narrow sense heritability, intergeneration correlation, correlation and regression in F_3, F_4, F_5 and F_6 generation during *kharif* 2012, *summer* 2013, *kharif* 2013 and *summer* 2014 respectively for growth parameters, traits related to WUE, yield and yield contributing characters. NRCG 12273 which has high SCMR, low SLA and high pod yield and ICG 12370 has low SCMR, high SLA and low pod yield were crossed to develop 153 F_3, 140 F_4, 128 F_5 and 112 F_6 superior segregants. Phenotypic co-efficient of variation (PCV) was higher than genotypic co-efficient of variation (GCV) for all the characters in all the four generations studied indicating the influence of environment on the characters. Higher GCV were found for pod yield per plant, kernel yield per plant, pods per plant, Specific Leaf Area, SCMR, plant height and days to first flowering in RILs of all the four generation indicating individual plant selection can be followed for these characters. High heritability coupled with high genetic advance was observed for pod yield per plant, kernel yield per plant, pods per plant, SCMR, SLA and plant height branches indicates involvement of additive gene action in controlling of these traits in superior segregants of all the four generations. Pods per plant, kernels per plant, kernel yield per plant, SCMR exhibited the positive correlation with positive effect on development of pod yield per plant in superior segregants of all the four generation suggesting pod yield per plant could be increased upon improving of these contributing characters. The study of intergeneration correlation among F_3, F_4, F_5 and F_6 generations noticed the presence of significant positive correlation between F_4 to F_5 and F_5 to F_6 for pods per plant, pod yield per plant, kernel yield per plant, kernels per plant, SCMR and SLA implies the these traits can be used as a selection criteria from F_4 generation onwards. High broad sense coupled with high narrow sense heritability was observed for pods per plant, pod yield per plant, kernel yield per plant, SCMR and SLA in F_6 RIL suggesting the alleles which are involved in expression of these traits are getting fix.

Keywords

Broad sense, Correlation, Genetic advance, Intergeneration correlation, Narrow sense heritability and regression.

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Introduction

Groundnut (*Arachis hypogaea*) is world important oilseed crop. Productivity is low in the arid and semi-arid regions mainly because of drought caused by low and erratic rainfall.

Identification of genotypes that have a greater ability to use limited available water is important to enhance productivity of the crop. Water Use Efficiency is one such important trait which is correlated with Specific Leaf Area (SLA), Soil Plant Analysis development (SPAD) Chlorophyll Meter Reading (SCMR), Carbon Isotopic Discrimination (Δ 13 C) and transpiration efficiency (δ 18 O) and these traits have been suggested as surrogate traits in selecting for WUE in groundnut. Δ 13 C and SLA are inversely related to WUE and yield. SCMR and δ 18 O are positively related to yield and WUE (Farquar *et al.,* 1989; Wright, 1994; Nageshwara Rao *et al.,* 2001).

Breeders very often use segregating populations derived from hybrids which is obtained crossing two parents they are highly diverse for trait of intrest. These segregating population used as source population to exercise selection for identifying homozygous lines with better performance to develop varieties. At the same time, the breeding lines from the advanced generations are also used as parental lines for developing commercially exploitable heterotic hybrids. But, most often the source of early generations *i.e.*, F_3, F_4, F_5 and F_6 segregating populations offer wider opportunities for achieving high success, because of wider genetic base.

Materials and Methods

With the objective of developing RILs for high pod yield with high water use efficiency the genotypes such as NRCG12273 and ICG 12370 were selected. Results from this table suggested that these genotypes are enough diverse for pod yield per plant, kernel yield per plant, pods per plant, kernels per plant, SCMR and SLA. Hybridization was made between these two genotypes to develop F_1 hybrid, selfing upon these hybrids was made get F_2 plants and all F_2 plants were forwarded to get F_3 progenies.

As a procedure of plant to row progeny method each harvested plant from F_2 were sown in single row to get F_3 segregating generation. 153 plants harvested from F_2 were sown in augmented design along with parents and checks (TMV 2 and KCG 2) during *kharif* 2012. All recommended agronomic practices and plant protection measures were followed during the crop growth period to ensure better growth and yield. The observations were recorded on all the plants of F_3 generation.

Similarly 140 F_4, 128 F_5 and 116 F_6 segregating generations were sown each line in single row as a method of plant to progeny row in augmented design along with parents and checks during *summer* 2013, *kharif* 2013 and *summer* 2014 respectively. All recommended agronomic practices and plant protection measures were followed during the crop growth period to ensure better growth and yield.

The observations were recorded on all plants in all the generations for days to first flowering, plant height, primary branches per plant, specific Leaf Area, SPAD Chlorophyll meter reading, pods per plant, kernels per plant, kernel yield per plant, pod yield per plant and shelling percentage were recorded. The genotypic and phenotypic co efficient of variations was computed as suggested by Robinson *et al.,* (1949). Heritability and genetic advance were worked out as per the method outlined by Hanson *et al.,* (1956).

Correlation co-efficient of each character between two generations was found out by calculating the phenotypic correlation coefficient exactly as described under taking the same character in both the generations. Narrow sense heritability estimates were made based on the regression of F_4 on F_3, F_5 on F_4 and F_6 on F_5 generation using the following formula (Cahaner and Hillet, 1980).

Results and Discussion

Analysis of Variance for growth, traits related to WUE and yield attributing traits F_3, F_4, F_5 and F_6 segregating generations

Analysis of variance (Table 1) in F_3, F_4, F_5 and F_6 segregating populations of the cross NRCG12373 × ICG12370 revealed significant differences among the lines in all the four generations for all the characters except shelling percentage in F_3, F_4 and F_6 generations, whereas both segregating progenies and checks also recorded presence of high variability for all the characters except primary branches per plant and shelling percentage in all the four generations, which indicating the presence of enormous genetic variability and the choice of the material for the investigation is appropriate. This was further supported by the fact that range has been also quite wider for all the characters pointing out extreme segregates are found in population for selection.

Genetic variability parameters

The range was quit high for all characters in selected superior progenies of F_3, F_4, F_5 and F_6 segregation generations studied suggested that characters may be improved by individual plant selection.

GCV and PCV estimate were relatively high (Table 2) for plant height, SCMR, total number of pods per plant, pod yield per plant, number of kernels per plant and kernel yield per plant in F_3, F_4, F_5 and F_6 generations. Similar findings of higher estimates of GCV & PCV for pods per plant, kernel yield per plant and pod yield per plant were observed by Sharma & Varshney (1995), Sumathi & Ramanathan (1995), Gowda *et al.,* (1996), Makhan lal *et al., (*2003), Golkia *et al.*, (2005), Ganeshan and Sudhakar (1995) Veeramani *et al., (*2005), John *et al.,* (2007) and Parameshwarappa *et al.,* (2007) in groundnut.

The deference between estimates of GCV and PCV was narrow for SCMR, specific leaf area, and number of pods per plant in four segregating generations indicating less environmental influence of expression of these traits. Hence, these traits can be used for further selection for higher yield and Water Use Efficiency using SLA and SCMR as a surrogate traits. Moderate difference between PCV and GCV estimates were observed for yield attributing characters like number of kernels per plant, kernel yield and pod yield per plant in F_3, F_4, F_5 and F_6 segregating populations. Hence, pods per plant, kernel yield per plant, SLA and SCMR could be used for further selection for higher yield with high WUE.

Heritability and Genetic Advance as Per cent mean for growth, traits related to WUE and yield contributing characters in F_3, F_4, F_5 and F_6 segregating generations

The characters like plant height, SCMR, number of pods per plant, pod yield per plant, number of kernels per plant, and kernel yield per plant in all the generations had higher GCV and PCV. This shows that these characters are under the control of additive gene action. Hence, single plant selection could be followed to breed for high yielding and higher Water Use Efficient genotypes in groundnut. Higher GCV and PCV for pods per plant, kernels yield per plant were obtained by Alan Cruickshan *et al.*, (2005), Veeramani *et al.*, (2005), Golkia *et al., (*2005) and John *et al.,* (2007) in groundnut.

Moderate heritability coupled with high genetic advance as *per cent* of mean was observed for number of primary branches per plant and shelling percentage in F_4 segregating population, indicating the presence of narrow range of variability and prevalence of non-additive gene action. This suggested that limited scope for further improvement of this character. Similar result was reported by Reddy and Guptha (1992), Ganeshan and Sudhakar (1995), Mukhan *et al.,* (2003) and Praveen Kumar (2004) in groundnut.

Hence from the present investigation on F_3, F_4, F_5 and F_6 segregating populations, it revealed that heritability and genetic advance as *per cent* of mean was high for yield and its attributing traits like pods per plant, shelling percentage, kernel yield per plant. It indicates the presence of additive gene action. Hence, single plant selection could be effectively made as environment does not have any influence in the variation of traits.

Correlation of pod yield per plant with growth parameters, traits related to WUE and yield component characters

Phenotypic correlation coefficients studies (Table 3) revealed that pod yield per plant had strong positive correlation with pods per plant, kernels per plant, kernel yield per plant and SCMR in F_3, F_4, F_5 and F_6 segregating generations indicating that improvement pods per plant, kernel yield per plant, SCMR will leads to improvement in yield. These results are in agreement with the results of Sharma and Varsheny (1995), Moinuddin (1996) and also Singh(1999), Sabeta (2000), Nagda *et al., (*2001), Mahalakshmi *et al.,* (2005), Kalmeshwar *et al.,* (2006), John *et al., (2007)*, Mane *et al.,* (2008), Sudhir *et al.,*. (2008) in groundnut. Association of pod yield, kernel yield and pods per plant suggests that individual plant selection can be practiced for plants with higher number of pods which ultimately leads to improvement in both pod and kernel yield in the later generations.

Significant negative association of pod yield per plant with days to flowering and shelling percentage and SLA was observed in F_3, F_4, F_5 and F_6 segregating populations studied. Indicates that negative relationship of pod yield per plant with SLA, selection for high yielding and water use efficient segregates can be done in a single selection programme.

Association among growth parameters, traits related to WUE and yield attributing characters

SPAD chlorophyll meter reading showed significant positive association with yield characters like pod yield per plant, kernel yield per plant, kernels per plant and pods per plant. This shows that we can go for selection of genotypes with high SCMR, which indirectly leads to improvement of yield in groundnut. However, higher SCMR also leads to increasing of water retention capacity of the plant their by increase the WUE. The reports of Nageshwar Rao *et al.,* (2004), Talwar *et al., (*2004), Rekha (2005), Praveen kumar (2006), John *et al.,* (2007) and Krishna murthy *et al.,* (2007) conformed the same association in groundnut.

Specific leaf area exhibited significant negative association with SCMR, number of pods per plant, pod yield per plant, number of kernels per plant and kernel yield per plant in F_3, F_4, F_5 and F_6 segregating populations.

Thus selection for the individual plants with low SLA will result in higher yield coupled with high Water Use Efficient types in groundnut. Since, SLA is negatively associated with yield attributing traits and SPAD is positively associated with yield attributing traits resulting in improvement of both traits can be done in single selection programme. These results were in confirmation with the reports of Wright *et al.,* (1994), Arjunan *et al., (*1997), Reddy *et al.,* Jaiwar *et al.,* (2004), Swarna *et al.,* (2004), Songrit *et al.,* (2008) and Painwadee *et al.,*(2009b) in groundnut.

Table.1 Analysis of variance for growth parameters, traits related to WUE, yield and its component characters in four segregating generations (F_3, F_4, F_5 and F_6) of the cross NRCG12473 × ICG12370 in groundnut

Source of variance		Df	Days to Flowering	Plant height (cm)	Primary branches/ plant	SLA (cm^2/g)	SCMR	Pods/plant (g)	Pod yield/ plant (g)	Kernels/ plant	Kernel yield/ plant (g)	Shelling Percentage
Block (eliminating Check + Va.)	F_3	3	15.80*	1.91	0.07	809.53	12.67	14.13	15.02	21.65	10.55	80.44*
	F_4	3	14.71*	4.58	0.14	392.96	12.77	4.55	47.38	92.9884	38.79*	91.68
	F_5	3	11.41	7.28**	0.04	776.77	51.71	2.95*	6.41	21.67	9.71	35.59
	F_6	3	8.75	2.79	0.14	309.12	5.36	33.42	22.66*	79.57**	1.07	172.36*
Progenies + Checks	F_3	154	42.43**	31.69**	0.67*	7403.56**	314.37**	99.73**	156.92*	319.44**	66.05*	115.47**
	F_4	142	38.25**	31.28**	0.64	4669.95*	369.64**	89.52**	178.21**	315.62*	61.95**	157.54
	F_5	126	36.22*	237.54**	0.59*	5013.64*	284.22**	37.06**	117.68*	162.04**	24.61	38.97
	F_6	106	33.33**	36.89**	0.57	8114.87**	279.17**	162.37*	167.85**	466.49**	100.97**	75.10
Checks	F_3	3	25.71*	12.82*	0.20	4216.06**	92.83**	75.45**	61.25	270.62*	81.61*	255.50**
	F_4	3	53.42**	12.23*	1.03	1219.90**	383.21*	85.87**	106.02	336.07*	85.28**	182.60
	F_5	3	17.94	16.37**	0.03	1822.63	27.03	68.31**	156.43*	567.11**	50.66*	33.10
	F_6	3	140.08**	18.36*	0.05	8227.92**	352.09**	21.85	36.82**	116.68	11.51**	274.47*
Progenies	F_3	151	42.66**	32.13**	0.28	7494.55**	319.39**	100.57**	159.10*	321.80**	66.09*	113.18**
	F_4	139	38.18**	31.78**	0.62	4594.93*	370.11**	90.05**	176.68**	315.69*	60.08**	157.72
	F_5	123	36.65*	24.01**	0.31	5031.23*	287.92**	36.83**	117.56*	156.38**	23.91	37.79
	F_6	103	30.09**	36.91**	0.27	8245.26**	280.11**	166.32*	171.31**	478.00**	101.31**	47.92
Checks *vs* Progenies	F_3	1	41.93**	3.17	60.78**	1339.01	20.39	22.25*	18.63	60.81	28.21*	181.26*
	F_4	1	17.43	0.18	11.65**	4738.86	278.35*	22.68**	535.45**	264.44	27.97**	81.95
	F_5	1	20.23	6.84**	36.84**	9231.83*	343.81*	1.94	54.93	48.72*	58.80*	195.88*
	F_6	1	153.27**	72.20**	32.61**	91490.2**	37.19	37.21	73.31**	180.97**	45.12**	2475.72**
Error	F_3	6	2.61	2.37	0.13	209.34	3.32	3.65	30.32	40.36	13.18	13.22
	F_4	6	3.00	1.84	0.57	100.90	41.08	0.98	22.71	50.38	7.63	95.97
	F_5	6	6.80	0.33	0.14	791.93	31.04	0.52	19.15	4.60	8.92	17.15
	F_6	6	4.08	1.84	0.17	78.36	13.86	40.89	2.64	6.16	0.81	29.12

*Significant @ P =0.05 ** Significant @ P = 0.01

Table.2 Genetic variability parameters for growth, traits related to WUE, yield and its component traits in four segregating generations (F_3, F_4, F_5 And F_6) of the cross NRCG12473 × ICG12370 in groundnut

Characters		MEAN	RANGE		GCV (%)	PCV (%)	h^2_{bs} (%)	GAM
			MIN	MAX				
Days to first flowering	F_3	39.78	23.72	45.72	15.46	15.98	93.53	30.79
	F_4	39.66	22.28	49.31	14.49	15.14	91.66	28.58
	F_5	36.24	22.27	47.29	14.55	16.24	80.35	26.87
	F_6	37.86	25.82	43.39	12.92	13.97	85.42	24.59
Plant height (cm)	F_3	19.36	10.83	47.38	27.37	28.50	92.23	54.14
	F_4	21.68	12.36	39.87	25.90	26.73	93.85	51.67
	F_5	20.90	14.10	39.00	71.92	71.98	99.85	88.32
	F_6	22.24	14.60	37.67	25.54	26.26	94.59	51.17
Primary branches/plant	F_3	5.61	3.23	7.05	6.75	9.32	52.4	10.06
	F_4	3.27	2.23	4.46	35.18	41.12	66.18	28.78
	F_5	5.39	2.76	6.31	7.35	10.09	53.07	11.02
	F_6	4.99	3.71	6.24	7.25	10.22	70.93	8.56
SLA (cm^2/g)	F_3	230.96	78.95	368.45	35.90	36.44	97.05	72.85
	F_4	182.49	89.56	213.25	34.54	39.35	77.04	62.45
	F_5	193.64	95.36	365.26	32.46	35.56	83.3	61.02
	F_6	269.88	102.23	365.12	35.90	36.44	97.05	72.85
SCMR	F_3	34.74	10.20	78.65	49.72	49.99	98.90	78.32
	F_4	51.84	10.74	92.15	33.91	36.10	88.26	65.62
	F_5	45.29	13.95	80.78	34.16	36.30	88.52	66.2
	F_6	32.41	7.27	63.01	48.28	49.63	94.64	96.77
Pods /Plant	F_3	25.29	10.13	60.67	37.81	38.56	96.16	76.38
	F_4	28.01	12.82	68.06	32.65	32.84	98.84	66.87
	F_5	24.99	14.27	43.71	23.27	23.45	98.48	47.57
	F_6	24.17	8.27	66.89	44.43	51.71	73.83	78.65
Pod yield/plant (g)	F_3	29.09	8.38	89.26	37.90	42.37	80.03	69.84
	F_4	34.07	10.23	75.51	35.30	37.97	86.42	67.59
	F_5	35.39	17.50	72.27	27.06	29.75	82.73	50.69
	F_6	25.12	6.65	64.41	49.57	49.99	98.33	78.27
Kernels/plant	F_3	45.55	15.95	121.26	35.78	38.40	86.81	68.67
	F_4	51.34	20.52	119.48	30.75	33.71	83.18	57.76
	F_5	48.87	26.26	88.84	24.33	24.73	96.85	49.32
	F_6	40.27	9.09	98.65	51.73	52.09	98.60	52.32
Kernel yield/plant(g)	F_3	19.61	7.18	54.57	36.05	40.52	79.13	66.05
	F_4	22.00	9.17	53.76	31.91	34.29	86.58	61.16
	F_5	17.79	9.16	34.62	21.01	26.89	61.03	33.8
	F_6	18.58	4.23	51.09	51.74	51.97	95.13	106.13
Shelling percentage	F_3	68.43	45.88	89.92	14.20	15.17	87.71	27.4
	F_4	64.48	89.92	42.25	11.81	19.25	37.66	14.93
	F_5	50.46	40.14	60.93	8.69	11.95	52.86	13.01
	F_6	74.23	62.66	90.02	6.23	9.17	67.93	8.05

Table.3 Phenotypic correlation coefficients among growth parameters, traits related to WUE, yield and its component traits in four segregating generations (F_3, F_4, F_5 and F_6) of the cross NRCG12473 × ICG12370 in groundnut

Characters	Generations	Pods / plant	Kernels /plant	Kernel yield/ plant (g)	Shelling percentage	SLA (cm^2/g)	SCMR	Pod yield / plant (g)
Pods / plant	F_3	**1.00**	0.93**	0.92**	0.21*	-0.72**	0.78**	0.83**
	F_4	**1.00**	0.90**	0.92**	0.06	-0.25*	0.56**	0.81**
	F_5	**1.00**	0.87**	0.88**	0.11*	-0.65**	0.67**	0.75**
	F_6	**1.00**	0.91**	0.85**	-0.10*	0.76**	0.64**	0.90**
Kernels/ plant	F_3		**1.00**	0.96**	-0.06	-0.80**	0.87**	0.95**
	F_4		**1.00**	0.93**	-0.17*	-0.27*	0.69**	0.93**
	F_5		**1.00**	0.91**	-0.22*	-0.74**	0.79**	0.90**
	F_6		**1.00**	0.89**	-0.14*	0.89**	0.77**	0.95**
Kernel yield/ plant (g)	F_3			**1.00**	0.17*	-0.77**	0.84**	0.90**
	F_4			**1.00**	0.05	-0.26*	0.65**	0.88**
	F_5			**1.00**	-0.04	-0.78**	0.83**	0.94**
	F_6			**1.00**	0.25*	-0.82**	0.92**	0.88**
Shelling percentage	F_3				**1.00**	0.17*	-0.15*	-0.14*
	F_4				**1.00**	0.10*	-0.36*	-0.35*
	F_5				**1.00**	0.28*	-0.29*	-0.30**
	F_6				**1.00**	0.04	-0.01	-0.22*
SLA (cm_2/g)	F_3					**1.00**	-0.95**	-0.83**
	F_4					**1.00**	-0.33*	-0.29*
	F_5					**1.00**	-0.92**	-0.81**
	F_6					**1.00**	-0.91**	0.89**
SCMR	F_3						**1.00**	0.90**
	F_4						**1.00**	0.79**
	F_5						**1.00**	0.87**
	F_6						**1.00**	0.81**
Pod yield / plant (g)	F_3							**1.00**
	F_4							**1.00**
	F_5							**1.00**
	F_6							**1.00**

*Significant @ P =0.05 ** Significant @ P = 0.01

Table.4 Intergeneration correlation coefficients for growth parameters, related to WUE, yield and its component traits from F_3 to F_6 segregating generations of the cross NRCG12473 × ICG12370 in groundnut

characters	Generations	F_3	F_4	F_5	F_6
Days to flowering	F_3	**1.00**	0.46**	0.54**	0.36**
	F_4		**1.00**	0.33**	0.48**
	F_5			**1.00**	0.65**
	F_6				**1.00**
Plant height (cm)	F_3	**1.00**	0.31**	0.25*	0.33**
	F_4		**1.00**	0.59**	0.45**
	F_5			**1.00**	0.56**
	F_6				**1.00**
Primary branches/plant	F_3	**1.00**	0.12	0.69**	0.36**
	F_4		**1.00**	0.20*	0.42**
	F_5			**1.00**	0.41**
	F_6				**1.00**
Pods/ plant	F_3	**1.00**	0.40**	-0.03	0.09
	F_4		**1.00**	0.36**	0.25*
	F_5			**1.00**	0.35**
	F_6				**1.00**
Kernels /plant	F_3	**1.00**	0.36**	-0.10	0.04
	F_4		**1.00**	0.32**	0.20*
	F_5			**1.00**	0.47**
	F_6				**1.00**
Kernel yield / plant (g)	F_3	**1.00**	0.25*	-0.08	0.15*
	F_4		**1.00**	0.35**	0.32**
	F_5			**1.00**	0.52**
	F_6				**1.00**
Shelling percentage	F_3	**1.00**	0.16*	0.11	0.21*
	F_4		**1.00**	0.19*	0.05*
	F_5			**1.00**	0.32**
	F_6				**1.00**
SLA (cm^2/g)	F_3	**1.00**	0.24*	-0.06	0.14
	F_4		**1.00**	0.24*	0.22*
	F_5			**1.00**	0.36**
	F_6				**1.00**
SCMR	F_3	**1.00**	0.30*	-0.09	0.11
	F_4		**1.00**	0.29*	0.19*
	F_5			**1.00**	0.22*
	F_6				**1.00**
Pod yield / plant (g)	F_3	**1.00**	0.15	-0.06	0.07
	F_4		**1.00**	0.28*	0.25*
	F_5			**1.00**	0.55**
	F_6				**1.00**

Table.5 Correlation and regression of pod yield on growth parameters, traits related to WUE and yield component traits in four segregating generations of the NRCG12473 × ICG12370 in groundnut

Characters	F_3 generation		F_4 generation		F_5 generation		F_6 generation	
	r-value	b-value	r-value	b-value	r-value	b-value	r-value	b-value
Days to first flower	0.20*	0.11	0.12*	0.20	0.08	0.16	-0.23*	0.03
Plant height (cm)	0.08	0.19	-0.03	-0.04	0.02	0.02	-0.33*	-0.26
Primary branches/plant	-0.04	-0.11	0.09	2.32	-0.24*	-4.80	0.08	2.23
SLA (cm^2/g)	-0.83**	-0.13	-0.29*	-0.02	-0.81**	-0.12	0.89**	-0.02
SCMR	0.90**	0.68	0.79**	0.55	0.87**	0.56	-0.81**	0.72
Pods / plant	0.83**	1.07	0.81**	1.13	0.75**	1.33	0.90**	0.96
Kernels / plant	0.95**	0.67	0.93**	0.69	0.90**	0.78	0.95**	0.57
Kernel yield / plant (g)	0.90**	1.40	0.88**	1.52	0.94**	2.09	0.88**	1.27
Shelling percentage	-0.14*	-0.18	-0.35*	-0.41	-0.30**	-0.54	-0.22*	-0.06

* Significant @ P=0.05 ** Significant @ P= 0.01

Table.6 Comparison between broad sense and narrow sense heritability for growth parameters, traits related to WUE, yield and its component traits in segregating populations for four generations in the cross of NRCG12473 × ICG12370 in groundnut

Characters	F_3-F_4		F_4-F_5		F_5-F_6	
	Broad sense heritability	**Narrow sense heritability**	**Broad sense heritability**	**Narrow sense heritability**	**Broad sense heritability**	**Narrow sense heritability**
Days to first flower	91.66	32.97	80.35	25.15	85.42	46.97
Plant height (cm)	93.85	23.28	99.85	38.12	94.59	44.26
Primary branches/plant	66.18	9.34	53.07	16.90	66.25	34.86
Pods / plant	98.84	28.19	98.48	20.05	73.83	61.42
Kernels per plant	83.18	24.97	96.85	17.46	98.60	70.55
Kernel yield / plant (g)	86.58	17.08	61.03	18.09	98.13	63.91
Shelling percentage	47.66	14.26	52.86	8.14	37.25	26.56
SLA (cm^2/g)	77.04	13.29	83.3	19.82	95.25	36.23
SCMR	88.26	21.92	88.52	21.27	94.64	53.42
Pod yield/plant (g)	86.42	10.44	82.73	18.12	98.33	61.22

Table.7 Performance of superior segregants for growth, traits related to WUE, yield and yield component traits in F_6 segregating generation of the cross NRCG12473 × ICG12370 in groundnut

Line No.	Days to first flowering	Plant height (cm)	Primary branches/plant	SCMR	SLA (cm^2/g)	pods /plant	Kernels /plant	Pod yield/plant (g)	Kernel yield/plant (g)	Shelling percentage
1B2A1	32.36	21.27	5.09	45.25	165.25	55	99	54.30	46.28	85.23
1B2A2	33.08	24.00	4.23	40.21	175.25	42	68	39.99	31.94	79.86
1B2B1	32.20	17.07	4.33	55.26	125.32	65	115	60.61	45.23	74.62
6A1A1	31.65	21.65	4.41	47.12	145.23	55	96	50.21	40.12	79.90
10C2A2	39.53	29.80	4.73	40.12	165.25	48	66	44.75	32.25	72.06
13A1A1	40.71	16.33	4.86	58.20	125.23	62	95	67.72	55.24	81.58
14A1A1	32.12	25.35	5.06	39.25	185.25	47	84	37.75	26.44	70.03
14A1A2	31.21	16.89	5.11	45.25	155.26	52	78	48.98	40.95	83.61
16B1A1	31.00	17.77	5.08	58.20	165.25	63	96	55.21	35.44	64.19
19A2A1	30.92	15.92	5.17	47.25	185.25	45	67	45.53	32.10	70.50
21A1A1	32.50	36.28	4.67	50.18	135.23	55	83	55.13	45.79	83.06
28B1A1	38.33	15.25	5.17	57.25	142.25	55	83	55.49	45.79	82.51
30A1A1	40.60	16.67	5.13	53.25	133.20	66	105	58.21	45.74	78.57
38A1A1	40.42	27.17	5.25	44.78	165.55	62	110	62.17	44.32	71.29
54A2B1	36.31	34.77	5.00	41.21	144.25	49	94	53.04	34.62	65.27
86B1A1	42.85	27.62	4.31	40.25	175.25	55	103	65.73	44.06	67.02
122A2A1	25.82	16.53	5.18	48.25	145.20	42	84	60.03	52.32	87.16
139A1A2	36.79	17.79	4.43	58.26	175.25	71	120	68.69	50.80	82.26
145A1A1	36.11	26.00	5.17	55.41	136.20	62	96	53.57	43.25	52.27
155A2A1	42.63	17.13	5.50	39.25	178.25	45	67	45.53	32.10	70.50
156A2A1	37.79	14.93	5.36	42.15	145.20	55	83	55.13	45.79	83.06
156A2B1	31.64	27.36	5.07	35.25	199.25	55	83	55.49	45.79	82.51
NRCG12273	28.78	34.56	4.89	29.25	189.25	31	52	22.36	28.36	78.84
ICG12370	39.25	28.12	4.25	18.25	201.23	24	38	16.12	25.36	63.56
TMV-2	35.26	27.45	6.25	20.12	210.25	23	39	13.45	21.93	61.33
KCG-2	7.12	22.56	5.12	12.25	213.02	20	35	17.23	22.36	77.06

Number of pods per plant was found to be having highly significant and positive association with kernel yield per plant, number of kernels per plant, pod yield per plant SCMR at phenotypic levels. Suggest that individual plant selections can be practiced for a plant with higher number of pods which ultimately leads to improvement in both pod and kernel yield. Reports of Moinuddin (1997), Vindhiya Varman and Raveendran (1996), Singh & Singh (1999), Sabeta (2000), Nagda *et al., (*2001), Moinuddin (1997) and Sab *et al.*, (2000) also confirmed significant positive association between pods per plant and pod yield per plant in groundnut and they said that pod yield per plant can be improved by selecting plant which is having more number of pods.

Kernels per plant exhibited significant positive association with number of pods per plant, pod yield plant, number kernels per plant and SCMR and negative association with shelling percentage and SLA in F_3, F_4, F_5 and F_6 segregating population studied at phenotypic level.

This positive association between kernel yield and pod yield with other yield components traits indicating the possibility of simultaneous improvement of these traits by single selection programme. Kavani *et al.*, (2004), Canilal *et al.*, (2005), Golokia *et al., (*2005) and Sudhir kumar *et al.,* (2008) confirmed similar association for pod yield and kernel yield in groundnut.

Shelling percentage exhibited significant negative association with number of pods per plant, pod yield per plant, number of kernels per plant and kernel yield per plant at phenotypic level in all segregating populations studied which implies that as shelling percentage increases there will be reduction in yield. Similar results were reported by Alam (1985), Abraham (1990), Moinuddin *et al., (*1997) Vasanth *et al.*, (1998) and Kalmeshwar *et al.*, (2006).

Intergeneration correlation and regression studies

In this study the Significant and positive correlation (Table 4) was obtained between F_3 to F_4, F_3 toF_5 and F_3 to F_6 generations for days to flowering, plant height and primary branches per plant which indicating that prediction would be made from F_3 generation and theses trait are mostly governed by additive gene action and suitability of these traits for selection in individual plant basis in the advanced generations of segregating progenies. These findings were supported by Kulkarni *et al.*, (1976) and Reddy *et al.*, (1985). They also find the existence of significant correlation between F_3 to F_4 and F_3 to F_5 for plant height in okra.

There was no significant relationship among F_3 to F_6 generation for characters such as number of pods per plant, pod yield per plant, kernels per plant, kernel yield and shelling percentage was observed. Rahman and Bahl (1986) also found similar result in chickpea.

This lack of associations was attributed to environmental, genotypic effect and nature of gene action involved in expression of trait which had a pronounced effect on such association. Hence, making selection for such traits in early generation will be of little or no value since genetic difference is masked by genotype × environment interaction.

Significant and positive correlation were obtained for F_4 to F_5, F_4 to F_6 and F_5 to F_6 for pods per plant, kernels per plant, pod yield per plant, kernel yield per plant, SCMR and SLA. This indicated that prediction can be made for these characters from F_4 generation to identify the lines that will give higher pod yield and higher water use efficiency.

Comparison between correlation and regression for growth parameters, traits related to WUE and yield component traits in F_3, F_4, F_5 and F_6 segregating generations

Study revealed that kernel yield per plant, pods per plant, kernels per plant and SCMR consistently showed (Table 5) the positive correlation and positive effect in all the four segregating generations. Hence selection for these traits could be excised to develop high yielding with high water use efficient genotypes. Similar conclusion were made by Varsheny (1995) Moinuddin (1996) and also Singh (1999), Sabeta (2000), Nagda *et al.*, *(*2001), Mahalakshmi *et al.,* (2005), Kalmeshwar *et al.*, (2006), John *et al., (2007)*, Mane *et al.*, (2008) and Sudhir *et al.*, (2008) in groundnut. Whereas other traits like, SLA and shelling percentage showed negative association and negative effect on pod yield per plant in of all the four generations.

Comparison of narrow sense and broad sense heritability for growth parameters, traits related to WUE and yield component traits in F_3, F_4, F_5 and F_6 segregating generations

High broad sense heritability (Table 6) was observed for all the characters in F_3, F_4, F_5 and F_6 segregations populations for all the characters indicating that presence of high magnitude of genetic variability for the characters.

Moderate narrow sense heritability was observed for most of the traits, which contribute to pod yield *i.e.* number of pods per plant, kernels per plant, kernel yield and shelling percentage only in F_4 and F_5 segregating populations.

This indicates both dominance and additive variance (epistasis) for these traits. Hence, selection based on phenotypic observations may not be effective. Under such situation, the progeny test will be required to confirm the worth of genotypes.

High narrow sense heritability was observed for days to flowering, number of pods per plant, kernels per plant kernel yield per plant, SLA, SCMR and shelling percentage in F_6 segregating population, which indicates that these characters were governed by additive variance. Therefore, selection will be effective for such traits based on phenotypic observations.

Selected superior segregantes in F_6 segregating generations

Top high yielding progenies were selected (Table 7) from F_6 segregating populations based on important traits like SCMR, SLA, pods per plant, kernels per plant, kernel yield per plant, pod yield per plant and shelling percentage. From the selection it was observed that high yielding progenies are having higher SCMR coupled with lower SLA value and higher pod yield per plant. Since, these progenies were still segregating hence one more generation need to be test to predict their performance before releasing for either station trial or multi location trail.

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