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Research Article

Genetic analysis for water use efficiency traits, yield and yield attributes in groundnut (*Arachis hypogaea* L.)

K.John, P.Raghava Reddy[1], P.Hariprasad Reddy, P.Sudhakar and N.P.Eswar Reddy
Regional Agricultural Research Station, Tirupati-517502
[1]Former Vice- Chancellor, N>G.Ranga Agricultural University, Andhra Pradesh
Email: johnlekhana@rediffmail.com

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Abstract:
JL-220 recorded the highest *per se* performance for number of well-filled and mature pods per plant, 100-kernel weight, harvest index and protein per cent. ICGV-99029 recorded the maximum *per se* performance for number of secondary branches per plant, stomatal conductance, kernel yield per plant and pod yield per plant Number of secondary branches per plant had high heritability coupled with high genetic advance as per cent of mean is controlled by additive gene effects and is least influenced by environment and therefore selection would be very effective. Moderate heritability and high genetic advance as per cent of mean were observed for specific leaf weight, number of well-filled and mature pods per plant and dry haulms yield per plant indicating importance of both additive and non-additive gene action in the inheritance of these traits.

Key words: Groundnut, Water use efficiency, Heritability, Genetic advance.

Introduction:
Groundnut is an important oilseed crop grown in India and is largely cultivated in dry lands. Drought is the most important factor limiting the yield potential of the rain-fed crop. Although high yield potential is the target of most crop breeding programs, it might not be compatible with superior drought resistance. On the other hand, high yield potential can contribute to yield in moderate stress environments. Recent research breakthroughs have revived interest in targeted drought resistance breeding and use of new genomic tools to enhance crop water use efficieny._However, with the fast progress in genomics, a better understanding of the gene functions and physiological mechanism for drought tolerance will be essential for the progress of genetic enhancement of crop for water use efficieny. Crop physiologists have identified a number of traits that would help the breeder in development and identification of moisture stress tolerant genotypes with high yield potential (Basu *et al*.,2004) The present study is aimed at evaluating the genetic parameters for water use efficiency traits, yield and yield attributes for efficient selection in segregating generations.

Material and methods
The material for the present study considered of parents and F_1 crosses involving eight parents *viz.*, Tirupati-4, TIR-25, ICGV-91114, TCGS-584, JL-220, ICGV-99029, K-1375 and TCGS-647. Eight parents were crossed in a half-diallel manner to generate 28 crosses during *rabi* 2008. Twenty eight F_1s along with eight parents were sown in a Randomised Block Design (RBD) with three replications during *kharif* 2009. Each parent was sown in 3 rows of 3 m length while F_1s were raised in a single row of 3 m length. The traits that confer water use efficieny are SPAD chlorophyll meter reading (SCMR), , Specific leaf area (SLA), specific leaf weight, leaf area index, transpiration rate, photosynthetic rate, stomatal conduce and water use efficiency which were recorded at 60 days after sowing (DAS). SCMR was measured on all four-leaflets of third leaf from the top on main axis at 60 DAS under normal sunlight using SPAD meter of Minolta Company, NJ, USA (SPAD-502). Specific leaf area (SLA) was recorded at 60 days after sowing. Ten leaves (3^{rd} fully expanded leaf from the top on the main axis) were collected from each treatment in each replication for calculating SLA. These leaves were cleaned and their leaf area was estimated using a leaf area meter (LICOR model-3100). They were dried in a hot air oven at 80°C and dry weight recorded. Transpiration rate, photosynthetic rate, stomatal conductance and water use efficieny were measured on all four-leaflets of third leaf from the top on main axis at 60 DAS using artificial sunlight (1000 µEim m^{-2} sec^{-1}) with portable photosynthetic meter with light control (Licor company, LI 6400). The important yield attributes were recorded on ten random selected plants. The number of days taken from the date of sowing to 50 % of the plants flowering were recorded. The number of days taken from the date of sowing to complete maturity of the crop by

visual maturity symptoms of leaves and pods on plot basis was recorded. . The data were analyzed statistically and genetic parameters *viz*., Phenotypic and Genotypic coefficients of variation (PCV and GCV) were computed according to Burton (1952). Heritability in broad sense was estimated using the formula of Allard (1960). Genetic advance (GA) was calculated as per the formula suggested by Johnson *et al.* (1955).

Results and discussion

The analysis of variance revealed significant differences for all the traits studied. The results are presented in the Tables 1, 2 and 3. Out of the eight parents used in the study, TCGS-584 and JL-220 showed the lowest *per se* performance for 50% flowering and days to maturity. These two genotypes came to maturity early. JL-220 recorded the highest *per se* performance for number of well-filled and mature pods per plant, 100-kernel weight, harvest index and protein per cent. TPT-4 showed the highest *per se* performance for shelling per cent (Table 1). The parental genotype, K-1375 exhibited the highest *per se* performance for number of primary branches per plant, SCMR (SPAD chlorophyll meter reading), specific leaf weight, leaf area index, sound mature kernel per cent and oil per cent. The other parent *viz*., ICGV-99029 recorded the maximum *per se* performance for number of secondary branches per plant, stomatal conductance, pod and kernel yield per plant. The highest *per se* performance for water use efficiency and dry haulms yield per plant were registered by TIR-25 while TCGS-647 exhibited the lowest *per se* performance for specific leaf area and highest *per se* performance for transpiration rate and photosynthetic rate.

F_1s from TPT-4 x ICGV-99029 was distinct for its highest mean value for number of primary branches per plant, number of mature pods per plant, shelling per cent, dry haulms yield per plant, pod and kernel yield per plant during *kharif*. (Table 1). Other F_1s, involving TPT-4 as one of parents showing lowest *per se* performance is TPT-4 x TCGS-584 for days to 50 per cent flowering and highest *per se* performance was recorded by the F_1s, TPT-4 x TCGS-647 for both specific leaf weight and transpiration rate, TPT-4 x TIR-25 for water use efficiency, TPT-4 x JL-220 for SMK per cent and low *per se* performance for specific leaf area. The F_1 s involving ICGV-99029 as one of the parents *viz*., ICGV-91114 x ICGV-99029 for number of secondary branches per plant, ICGV-99029 x TCGS-647 for both SCMR and photosynthetic rate, TCGS-584 x ICGV-99029 for both leaf area index and protein per cent showed the highest *per se* performance. The F_1 crosses, TIR-25 x ICGV-91114 recorded the lowest *per se* performance for days to 50 per cent flowering and K-1375 x TCGS-647 for plant height. The other F_1s, *viz*., Jl-220 x TCGS-647 for 100-kernel weight, TIR-25 x JL-220 for harvest index and ICGV-91114 x K-1375 for oil per cent showed the highest *per se* performance. These results were confirmed with the findings of Nath and Alam, 2002.

Higher PCV was recorded for number of primary branches per plant and stomatal conductance and moderate values for leaf area index, number of mature pods per plant, dry haulms yield per plant, kernel yield per plant and pod yield per plant and rest of the characters showed lower PCV values.

GCV values revealed that all the characters except number of secondary branches per plant, number of well-filled and mature pods per plant and dry haulms yield per plant had narrow genetic variability and thereby offering a limited opportunity to improve further these characters (Table 2). Similar results were obtained by Quadri and Khunti (1982), Mishra and Yadava (1992), Nisar Ahmed (1995), Naik *et al.* (2000), Parameshwarappa *et al.* (2004) and Korat *et al.* (2009).

Heritability estimates indicate the heritable portion of the variation and the estimation of genetic advance would show the extent of genetic gain that could be expected through selection in the character to be improved upon (Burton, 1952 and Johnson *et al.*, 1955). Heritability in broad sense includes additive and epistatic gene effects, and therefore it will be reliable only if accompanied by high genetic advance Ramanujam and Thirumalachari (1967).

In the present investigation, high heritability estimates were observed for days to 50 per cent flowering, days to maturity and number of secondary branches per plant. Reddy and Gupta (1992) and Seethala Devi (2004) reported high heritability for harvest index. Moderate heritability was recorded for plant height, specific leaf area, specific leaf weight, number of well-filled and mature pods per plant, harvest index and dry haulms yield per plant. Moderate to high heritability for SPAD chlorophyll meter reading values was observed by Seethala Devi (2004). Parmar *et al.* (2000) and Naik *et al.* (2000) reported low genotypic coefficient of variation and heritability for sound mature kernel per cent. Seethala Devi (2004) reported high genotypic coefficient of variation and moderate heritability for sound mature kernel per cent. Low heritability values were obtained for pod yield per plant and number of well-filled and mature pods per plant as observed ealier by Wang *et al.* (1987).

The genetic gain that can be expected by selection for a character is given by the estimates of genetic advance. Among the characters studied, number of secondary branches per plant, specific leaf weight, number of well-filled and mature pods per plant and dry haulms yield per plant showed high genetic advance as per cent of mean (GAM). Reddy and Gupta (1992) reported similar results. Moderate GAM recorded for specific leaf area, harvest index, kernel yield per plant and pod yield per plant. However days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, SPAD chlorophyll meter reading, leaf area index, transpiration rate, photosynthetic rate, stomatal conductance, water use efficiency, shelling per cent, sound mature kernel per cent, 100-kernel weight, oil per cent and protein per cent exhibited low genetic advance as per cent of mean. Nagabhushanam *et al.* (1982), Vasanthi and Raja Reddy (2002) and Seethala Devi (2004) reported low genetic advance as per cent of mean for pod yield per plant.

Moderate heritability and moderate GAM recorded for specific leaf area and harvest index showed additive gene effects. High heritability and low GAM was observed for days to 50 per cent flowering and days to maturity which indicated the importance of non-additive gene action. Low heritability and moderate GAM was noticed for pod and kernel yield per plant indicating the importance of additive gene effects and selection for such characters may be rewarding.

Moderate heritability and low GAM was observed for plant height, whereas low heritability and low gain was observed for number of primary branches per plant, SPAD chlorophyll meter reading values, leaf area index, transpiration rate, photosynthetic rate, stomatal conductance, shelling per cent, sound mature kernel per cent, 100-kernel weight, oil per cent and protein per cent indicating the preponderance of non-additive gene action in inheritance of these characters. Hence, selection for these characters is not effective in early segregating generations and has to be carried in later generations.

It is evident that number of secondary branches per plant had high heritability coupled with high GAM which indicated this trait is controlled by additive gene effects and is least influenced by environment (Table 3), facilitating very effective selection. Moderate heritability and high GAM was observed for specific leaf weight, number of well-filled and mature pods per plant and dry haulms yield per plant indicating importance of both additive and non-additive gene action in the inheritance of these traits.

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Table 1 : Performance of F_1s and parents for different water use efficiency traits, yield and yield attributes in groundnut during *kharif* , 2009

Parents/crosses	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	SPAD chlorophyll meter reading at 60 DAS	Specific leaf area ($cm^2 g^{-1}$) at 60 DAS	Specific leaf weight ($g cm^{-2}$) at 60 DAS	Leaf area index at 60 DAS	Transpiration rate (mmol H_2O $m^{-2} sec^{-1}$) at 60 DAS	Photosynthetic rate (µmol co_2 $m^{-2} sec^{-1}$) at 60 DAS	conductance ((mol H_2O $m^{-2} sec^{-1}$)	WUE (%) at 60 DAS
Parents													
TPT-4	22.33	106.33	45.37	4.33	2.53	45.30	232.07	0.44	0.95	7.13	22.70	2.46	0.32
TIR-25	25.00	108.33	49.67	4.43	1.97	45.00	207.87	0.51	1.13	7.51	24.73	2.87	0.43
ICGV-91114	21.00	100.33	48.40	4.13	0.87	44.33	236.03	0.44	1.20	8.27	22.93	3.36	0.36
TCGS-584	25.33	101.00	43.77	4.57	1.37	43.00	354.97	0.46	1.07	7.05	23.80	2.64	0.37
JL-220	20.67	101.33	44.13	4.57	1.37	43.93	192.17	0.43	1.09	7.46	21.90	1.96	0.30
ICGV-99029	29.00	115.00	50.47	4.70	5.53	43.43	254.60	0.40	1.14	7.98	23.40	3.73	0.30
K-1375	24.33	108.67	48.47	5.17	2.97	46.60	246.10	0.54	1.25	7.59	23.03	2.75	0.31
TCGS-647	28.67	109.00	45.73	4.30	3.13	43.93	170.23	0.44	1.09	8.30	25.80	3.14	0.31
Crosses													
TPT-4 x TPT-25	21.33	103.00	41.73	3.87	0.70	45.10	201.73	0.50	0.90	7.45	26.43	3.38	0.43
TPT-4 x ICGV-91114	21.00	103.67	46.03	4.37	0.83	46.07	208.87	0.43	1.18	7.99	24.07	3.00	0.31
TPT-4 x TCGS-584	20.00	104.00	44.97	4.83	2.30	46.67	225.07	0.39	1.13	8.35	23.40	2.46	0.28
TPT-4 x JL-220	20.77	104.00	43.07	4.07	0.97	45.63	182.17	0.52	0.84	8.76	24.77	2.74	0.31
TPT-4 x ICGV-99029	23.67	106.00	47.53	5.73	8.60	44.93	218.30	0.40	0.97	7.80	24.57	2.57	0.30
TPT-4 x K-1375	23.67	103.00	42.40	4.27	1.70	43.73	193.20	0.41	1.08	8.56	23.43	2.49	0.31
TPT-4 x TCGS-647	23.33	103.00	43.10	4.17	1.27	46.80	241.10	0.61	1.00	9.36	21.87	1.81	0.23
TIR-25 x ICGV-91114	21.67	100.33	41.13	4.13	2.03	46.10	205.60	0.46	1.08	8.23	23.70	2.89	0.30
TIR-25 x TCGS-584	21.33	102.67	41.60	4.27	2.10	45.67	215.10	0.45	0.92	9.16	22.23	2.44	0.25
TIR-25 x JL-220	20.67	102.00	40.87	4.50	1.50	44.47	223.13	0.55	0.90	8.39	27.07	2.08	0.32
TIR-25 x ICGV-99029	26.33	112.67	44.37	6.07	6.93	48.40	221.90	0.46	0.94	9.02	23.40	1.95	0.26
TIR-25 x K-1375	21.33	104.00	42.13	4.25	2.57	47.10	191.33	0.52	0.96	8.59	22.70	1.78	0.29
TIR-25 x TCGS-647	21.67	102.00	42.80	5.67	7.27	44.90	236.40	0.45	1.06	8.93	23.23	1.91	0.25
ICGV91114X TCGS-584	25.33	101.00	39.23	3.70	1.57	44.63	220.80	0.54	0.92	7.79	19.60	1.89	0.27
ICGV91114 X JL-220	20.00	103.00	37.97	4.03	0.40	45.83	252.97	0.45	0.95	8.28	22.80	1.80	0.28
ICGV91114XICGV99029	23.67	103.00	45.33	5.13	11.73	46.03	281.87	0.47	1.11	7.65	24.17	1.94	0.35
ICGV91114 X K-1375	23.33	106.00	41.07	4.07	1.80	47.40	184.20	0.53	0.69	6.86	23.57	1.81	0.36
ICGV91114X TCGS-647	24.67	105.33	39.87	4.57	4.07	44.87	184.67	0.43	0.98	7.49	21.67	1.99	0.29
TCGS-584 X JL-220	25.67	104.00	39.33	4.37	1.20	45.27	245.87	0.38	1.26	7.28	20.47	3.59	0.28
TCGS-584XICGV99029	27.33	106.00	42.80	4.40	7.57	47.17	218.53	0.36	1.30	6.06	21.60	1.58	0.28

Table 1 : contd.

Parents/crosses	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	SPAD chlorophyll meter reading at 60 DAS	Specific leaf area (cm^2 g^{-1}) at 60 DAS	Specific leaf weight (g cm^{-2}) at 60 DAS	Leaf area index at 60 DAS	Transpiration rate (mmol H_2O m^{-2} sec^{-1}) at 60 DAS	Photosynthetic rate (µmol co_2 m^{-2} sec^{-1}) at 60 DAS	conductance ((mol H_2O m^{-2} sec^{-1})	WUE (%) at 60 DAS
TCGS-584 X K-1375	22.67	102.67	36.93	3.80	1.10	50.67	256.03	0.55	1.01	8.35	23.83	2.46	0.28
TCGS-584 X TCGS-647	23.33	103.67	45.30	4.80	3.03	46.77	221.20	0.55	1.12	7.32	20.90	1.99	0.29
JL-220 X ICGV-99029	24.33	112.33	49.80	4.30	7.20	48.23	236.53	0.47	0.68	7.76	24.13	2.71	0.31
JL-220 X K-1375	23.33	103.33	49.53	4.37	6.50	45.40	239.50	0.39	0.81	8.17	25.10	3.99	0.31
JL-220 X TCGS-647	24.00	105.67	46.63	4.93	8.63	45.50	195.43	0.45	1.07	7.87	26.57	3.01	0.32
ICGV-99029 x K-1375	24.33	107.00	44.87	4.43	2.50	51.10	203.17	0.43	0.94	7.00	22.33	3.34	0.33
ICGV-99029 x TCGS-647	24.33	107.00	45.97	4.53	5.63	51.57	192.33	0.51	0.82	7.44	26.90	2.13	0.36
K-1375 x TCGS-647	24.33	110.33	36.20	5.30	5.80	44.13	193.57	0.56	0.94	7.12	20.90	3.15	0.32
Mean of parents	25.54	106.25	47.00	4.53	2.47	44.44	224.25	0.46	1.12	7.66	23.54	2.86	0.34
Range among parents	20.67-29.00	100.33-115.00	43.77-50.47	4.13-5.17	0.87-5.53	43.00-46.60	170.23-354.97	0.40-0.54	0.95-1.25	7.05-8.30	21.90-25.80	1.96-3.73	0.3 0 - 0.43
Mean of F_1s	24.03	104.67	42.95	4.53	3.84	45.99	218.57	0.47	0.98	7.97	23.44	2.55	0.30
Range among F_1s	20.00-27.33	100.33-112.67	36.20-49.80	3.80-6.07	0.40-8.63	43.73-51.57	182.17-281.87	0.36-0.0.61	0.68-1.26	6.06-9.36	19.60-26.90	1.58-3.99	0.25-0.43
CD at 5% level	1.44	2.18	5.320	1.09	2.48	4.20	41.73	0.15	0.26	1.57	3.08	1.40	0.08

Table 1 : contd.

Parents/crosses	No. of well-filled and mature pods per plant	Shelling per cent	Sound mature kernel per cent (%)	100-kernel weight (g)	Dry haulm weight per plant (g)	Harvest index (%)	Oil per cent	Protein per cent	Kernel yield per plant (g)	Pod yield per plant (g)
Parents										
TPT-4	12.47	81.83	87.93	39.77	23.23	38.35	47.63	26.20	14.07	17.30
TIR-25	16.10	73.42	83.83	35.63	27.83	36.27	47.67	26.30	11.51	15.70
ICGV-91114	17.63	79.48	93.50	43.14	16.93	38.29	47.63	26.40	11.51	14.53
TCGS-584	19.07	70.01	90.17	40.71	25.70	40.57	47.73	26.23	10.27	14.67
JL-220	20.90	73.87	90.67	45.28	23.77	41.08	47.80	26.27	12.24	16.57
ICGV-99029	12.33	74.63	89.17	43.03	27.47	32.94	47.60	26.03	14.37	18.53
K-1375	14.97	80.18	92.40	40.98	26.50	38.87	47.93	26.03	13.55	16.90
TCGS-647	10.23	65.72	84.57	43.34	24.70	39.10	47.57	26.33	6.92	10.53

Table 1 : contd.

Parents/crosses	No. of well-filled and mature pods per plant	Shelling per cent	Sound mature kernel per cent (%)	100-kernel weight (g)	Dry haulm weight per plant (g)	Harvest index (%)	Oil per cent	Protein per cent	Kernel yield per plant (g)	Pod yield per plant (g)
Crosses										
TPT-4 x TPT-25	14.97	72.74	82.17	35.76	22.33	36.39	47.57	25.63	9.04	12.33
TPT-4 x ICGV-91114	11.67	71.06	89.47	43.25	23.13	35.63	47.93	26.27	9.20	12.80
TPT-4 x TCGS-584	19.80	74.34	91.47	40.80	22.90	41.59	47.37	25.93	11.29	15.30
TPT-4 x JL-220	14.07	79.71	92.83	41.99	22.03	39.70	47.97	25.77	11.46	14.57
TPT-4 x ICGV-99029	23.53	84.48	86.77	42.01	64.43	25.84	47.77	26.47	18.51	21.97
TPT-4 x K-1375	14.67	63.57	90.90	42.43	37.80	33.02	47.73	26.47	11.81	18.43
TPT-4 x TCGS-647	14.10	75.39	90.63	41.71	19.90	40.74	47.80	26.20	10.11	13.53
TIR-25 x ICGV-91114	11.00	82.68	90.47	38.75	18.60	32.81	47.73	26.00	7.67	9.17
TIR-25 x TCGS-584	16.20	82.12	92.67	42.43	15.13	41.80	47.53	26.33	9.22	11.13
TIR-25 x JL-220	19.00	61.64	86.30	40.38	25.47	44.56	47.93	26.13	9.61	15.53
TIR-25 x ICGV-99029	14.73	71.83	87.20	42.57	45.73	29.73	46.87	26.37	11.18	15.63
TIR-25 x K-1375	14.73	75.28	88.83	39.51	25.23	41.73	47.67	26.33	14.00	18.50
TIR-25 x TCGS-647	15.53	77.14	85.70	42.49	34.90	34.21	47.43	26.37	13.58	17.67
ICGV-91114 X TCGS-584	10.00	74.19	89.50	30.29	17.07	35.29	47.50	26.10	6.87	9.27
ICGV-91114 X JL-220	7.80	80.35	88.73	38.86	12.00	40.91	47.20	26.63	6.78	8.47
ICGV-91114 X ICGV-99029	18.63	62.38	82.90	37.50	34.30	27.23	47.67	26.27	11.47	18.00
ICGV-91114 X K-1375	11.33	63.10	85.57	36.82	21.87	35.87	48.07	26.23	7.54	11.90
ICGV-91114 X TCGS-647	12.80	71.23	83.60	34.73	25.53	32.22	47.00	26.43	8.78	12.17
TCGS-584 X JL-220	11.77	71.20	79.60	37.91	17.23	37.16	47.90	26.40	7.34	10.23
TCGS-584 X ICGV-99029	20.60	69.91	86.30	48.64	42.80	32.40	47.53	26.70	13.62	20.20
TCGS-584 X K-1375	9.40	74.11	84.90	45.74	13.87	42.30	47.63	26.73	7.57	10.13
TCGS-584 X TCGS-647	12.00	66.72	85.43	45.33	26.10	33.36	47.20	26.60	8.57	12.80
JL-220 X ICGV-99029	11.40	69.24	87.57	39.75	30.17	27.59	46.83	26.40	7.78	11.20
JL-220 X K-1375	11.47	68.66	89.93	47.95	33.53	27.27	47.10	26.23	8.16	11.90
JL-220 X TCGS-647	14.07	63.16	87.43	49.33	34.23	32.73	45.37	26.33	10.33	16.57
ICGV-99029 x K-1375	15.73	75.31	87.70	36.76	21.63	38.41	46.73	25.80	10.27	13.53
ICGV-99029 x TCGS-647	20.33	73.13	91.30	40.91	28.53	37.93	46.33	25.93	12.42	17.13
K-1375 x TCGS-647	7.03	70.48	84.43	41.12	21.83	27.68	46.37	26.43	5.85	8.37

Table 1 : contd.

Parents/crosses	No. of well-filled and mature pods per plant	Shelling per cent	Sound mature kernel per cent (%)	100-kernel weight (g)	Dry haulm weight per plant (g)	Harvest index (%)	Oil per cent	Protein per cent	Kernel yield per plant (g)	Pod yield per plant (g)
Mean of parents	15.46	74.83	89.03	41.49	24.52	38.18	47.70	26.22	11.81	15.60
Range among parents	10.23-20.90	65.72-81.33	83.83-93.50	35.63-45.28	16.93-27.83	32.94-41.08	47.57-47.93	26.03 -26.40	6.92-14.37	10.53-18.53
Mean of F_1s	14.23	72.33	87.51	42.05	27.08	35.21	47.35	26.26	10.46	13.87
Range among F_1s	7.03-23.53	61.64-84.48	79.60-92.83	30.29-49.33	12.00-64.43	27.27-44.56	45.37-48.07	25.63-26.73	5.85-18.51	8.37-21.97
CD at 5% level	5.31	14.30	7.24	7.72	13.91	7.51	1.03	0.55	4.63	5.74

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Table 2. Estimates of co-efficient of variation, heritability and genetic advance for water use efficiency traits, yield and yield attributes among 28 F_1s and parents in groundnut during *kharif*, 2009

Character	MEAN	Co-efficient of variation		h^2 (BS)	GA	GAM
		PCV	GCV			
Days to 50 per cent flowering	24.03	6.69	5.54	68.53	2.14	8.91
Days to maturity	104.67	1.76	1.39	62.81	2.35	2.25
Plant height (cm)	42.95	9.53	6.59	47.80	4.16	9.69
Number of primary branches per plant	4.53	16.54	8.61	27.07	0.42	9.27
Number of secondary branches per plant	3.84	88.29	78.10	78.26	5.27	137.24
SPAD chlorophyll meter reading at 60 DAS	45.99	6.02	3.08	26.09	1.487	3.23
Specific leaf area (cm^2 g^{-1})	218.57	16.41	12.36	56.70	41.79	19.12
Specific leaf weight (g cm^{-2}) at 60 DAS	0.47	19.72	12.73	41.68	0.79	168.09
Leaf area index at 60 DAS	0.98	20.37	8.73	18.35	0.08	8.16
Transpiration rate (mmol H_2O m^{-2} sec^{-1}) at 60 DAS	7.97	15.92	1.13	0.51	0.01	0.13
Photosynthetic rate (µmol Co_2 m^{-2} sec^{-1}) at 60 DAS	23.44	10.88	2.58	5.61	0.30	1.28
Stomatal conductance (mol H_2O m^{-2} sec^{-1})	2.55	41.32	11.17	7.31	0.15	5.88
Water use efficiency (%) at 60 DAS	0.31	19.44	9.77	25.27	0.03	9.68
Number of well-filled and mature pods per plant	14.23	30.87	21.68	49.33	4.80	33.73
Shelling per cent	72.33	14.63	5.32	13.23	2.93	4.05
Sound mature kernel per cent	87.51	5.83	0.70	1.44	0.15	0.17
100-kernel weight (g)	42.05	11.81	5.00	17.92	1.84	4.38
Dry haulm weight per plant (g)	27.08	45.86	32.46	50.11	13.30	49.11
Harvest index (%)	35.21	17.46	12.03	47.47	6.20	17.61
Oil per cent	47.35	1.65	0.86	27.06	0.44	0.93
Protein per cent	26.26	1.34	0.48	12.70	0.09	0.34
Kernel yield per plant (g)	10.46	32.53	16.95	27.14	2.04	19.50
Pod yield per plant (g)	13.87	28.26	15.08	28.48	2.53	18.24

Table 3:Comparative statement based on estimates of different genetic parameters for 23 quantitative characters in F_1 generation of groundnut during *kharif*, 2009

Character	Genetic parameters	Gene effects	Influence of environment
Days to 50 per cent flowering Days to maturity	High h^2(b) and low GAM	Non additive	Low
Plant height	Moderate h^2(b) and low GAM	Non additive	Medium
Number of primary branches per plant Leaf area index Transpiration rate Photosynthetic rate Stomatal conductance Water use efficiency Sound mature kernel per cent SPAD chlorophyll meter reading Shelling per cent 100-kernel weight Oil per cent Protein per cent	Low h^2(b) and low GAM	Non additive	High
Number of secondary branches per plant	High h^2(b) and high GAM	Additive	Low
Specific leaf area Harvest index	Moderate h^2(b) and moderate GAM	Additive and non additive	Medium
Number of well-filled and mature pods per plant Dry haulm weight per plant Specific leaf weight	Moderate h^2(b) and high GAM	Additives	Medium
Kernel yield per plant Pod yield per plant	Low h^2(b) and moderate GAM	Additive and non additive	Medium