Drs N.C. Rachaputi and S.N. Nigam discussing results with Technical Officer Mr Manohar at ICRISAT Centre, Andhra Pradesh, India.

Multi-location trial plots at Tirupati, Andhra Pradesh, India.

Evaluation of Trait-based and Empirical Selections for Drought Resistance at ICRISAT Centre, Patancheru, Andhra Pradesh, India

S.N. Nigam, S. Chandra, B. Manohar, H.S. Talwar, A.G.S. Reddy and Rupa Kanchi[1]

Introduction

PEANUT IS CULTIVATED on 25.5 M ha worldwide with a total in-shell production of 35.1 million tons (Food & Agriculture Organisation of the UN 2001). Production of peanut is concentrated in developing countries of Asia and Africa, which account for 95 per cent of the world peanut area and about 93 per cent of total production. Peanut is grown in these countries mostly by smallholders under rain-fed conditions with almost no inputs other than land and labour. More than 80 per cent of the world's peanut production comes from rain-fed agriculture where productivity is much lower (<1.0 t/ha) than the developed world (2.9 t/ha).

Drought is a major abiotic stress affecting yield and quality of rain-fed peanut. Yield losses due to drought are highly variable in nature depending on its timing, intensity, and duration coupled with other location-specific environment factors such as irradiance and temperature (Nigam *et al*. 2001). On a global basis, the estimated annual loss in peanut production caused by drought alone is equivalent to US$520 million in 1994 prices. ICRISAT's mid-term plan (1994–98) projected that half of the losses (US$208 million) could be recovered through genetic enhancement for drought-resistance with a benefit:cost ratio of 5:2 (Johansen and Nigam 1994).

The present study is of global significance and its results will help developing countries to alleviate the adverse effects of drought on peanut production by reorienting their peanut-breeding programs.

Materials and Methods

ICRISAT Centre, Patancheru is located at 17.53ºN, 78.27ºE and 545 m above mean sea level. The soils of the experimental sites are lithic rhodustalf with high clay and silt contents. The Centre receives, on average, 781 mm annual rainfall. Most of the rains are received from mid-June to mid-October with erratic distribution.

[1] ICRISAT, Patancheru, Andhra Pradesh, India

The experiment was conducted in 2000 rainy and 2000-01 post-rainy seasons with 192 lines selected following trait-based and empirical approaches and eight parents in an Alpha design with three replications. For details of the materials and selection methods, see elsewhere in these Proceedings; for example, see Vasundhara and Yellamanda Reddy (2003). The plot size consisted of four four-metre rows 30 cm apart. In the 2000 rainy season, the experiment was grown under both rain-fed and irrigated conditions. In the 2000-01 post-rainy season, it was grown with full irrigation and also under imposed mid-season drought conditions (irrigation was withheld from 40 DAS to 80 DAS).

The experiment received single super phosphate at 375 kg/ha as a basal dose and gypsum at 400 kg/ha at the time of peak flowering. Weeds were controlled by pre-emergence application of *Alachlor* and two manual weedings at 60 and 90 DAS. Intensive measures were taken to protect the crop from diseases and insect damage.

The 2000 rainy season experiment was sown on 3 July. The irrigated treatment received seven irrigations of 50 mm applied using overhead sprinklers on 19 & 29 July, 8 August, 4 & 11 September, and 4 & 15 October, while the rain-fed treatment received no irrigation. The post-rainy season experiment was sown on 2 December 2000, in which the irrigated treatment received 15 sprinkler irrigations, one each on 2, 8, 18, & 31 December, 6, 13, & 27 January, 8 & 19 February, 6, 17, & 26 March, 10 & 21 April, and 6 May, 2001. In the mid-season drought treatment, drought was imposed by withholding from the full irrigation schedule described earlier irrigations scheduled on 8 & 19 February and 6 & 17 March.

In each plot observations were recorded on SPAD chlorophyll meter reading, specific leaf area (SLA), plant number, vegetative weight; pod weight, and kernel weight. The SPAD observations were recorded during 50 to 70 DAS. In each plot, eight randomly selected second leaves from the top of the main stem were sampled from the middle two rows. These leaves were plucked and brought to the laboratory for further observations in plastic bags. On each leaflet, two readings were taken. For each genotype, 64 observations were averaged. These leaves were also used to measure specific leaf area. The leaves were soaked in water for three hours; then, after drying them with blotting paper, their leaf area was measured. Subsequently, these leaves were oven-dried at 60ºC for two days, and their dry weight measured. From these two observations, SLA values were derived. For other observations at final harvest, one-metre row length was selected from the middle two rows and plants were counted and harvested. Then, plants were separated into vegetative parts (including pegs) and pods. The vegetative and pod fresh weights were recorded. Samples were oven-dried at 60ºC for 24 hours. The dry vegetative, pod, and seed weights were recorded. HI, T, and TE were derived from these and other observations.

Weather

2000 rainy season

The total rainfall during the cropping season was 899.9mm but it was very unevenly distributed. There were three unusually heavy downpours during the 32nd week (105.8 mm), the 34th week (517.3 mm), and 38th week (117.2 mm) (Figure 1). Of the total 899.9 mm rainfall received during the cropping season, 740.3 mm were received in these three downpours, resulting in very uneven distribution. The maximum temperature was 27.5–32.8ºC and the minimum was 17.5–20.2ºC during the cropping season. The solar radiation during the rainy season averaged 15.8 MJm^{-2} per day and ranged between 9.6 MJm^{-2} and 20.8 MJm^{-2}.

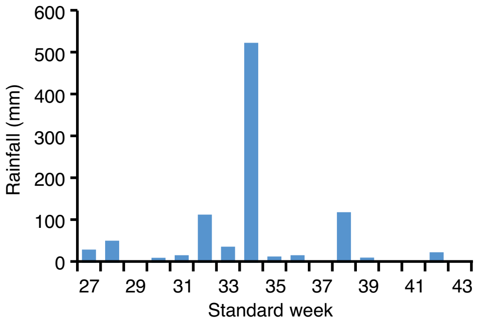

Figure 1. Rainfall distribution during July to October 2000 at ICRISAT.

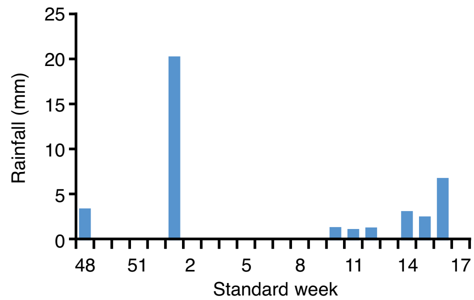

Figure 2. Rainfall distribution during December 2000 to May 2001 at ICRISAT Centre, Patancheru.

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2000-01 post-rainy season

The rainfall was very low during the cropping season (32.9 mm). The highest rainfall of 20 mm was received during the 1st standard week (Figure 2). Near absence of rains created conducive conditions for applying mid-season stress to one of the experiments. The maximum temperature was 26.5–39.0ºC and the minimum 9.1–23.7ºC, with maximum and minimum temperatures increasing gradually as the crop season progressed. The solar radiation averaged 18.0 MJm^{-2} per day and ranged between 11.8 MJ m^{-2} and 23.2 MJ m.

Statistical analyses

For individual experiment analysis, observation Y_{ijk} on genotype i recorded in block j of replication k was modelled as:

$$Y_{ijk} = \mu + r_k + b_{jk} + g_i + \Sigma_{ijk}$$

where:

μ, r_k, b_{jk}, g_i, and Σ_{ijk}, respectively, denote the general mean, effect of replication k, effect of block j within replication k , effect of genotype i, and the residual effect.

For combined analysis over experiments, observation Y_{ijkl} on genotype i recorded in block j of replication k in experiment l was modelled as:

$$Y_{ijkl} = \mu + e_l + r_{kl} + b_{jkl} + g_i + (ge)_{il} + \Sigma_{ijkl}$$

where:

μ, e_l, r_{kl}, b_{jkl}, g_i, $(ge)_{il}$, and Σ_{ijkl}, respectively, denote the general mean, effect of experiment l, effect of replication k within experiment l, effect of block j within replication k within experiment l, effect of genotype i, effect of interaction of genotype i with experiment l, and the residual effect.

All the terms in the model, except μ, were assumed to be random. Each random effect was assumed to be identically and independently normally distributed with a mean of zero and a constant variance. The unbiased estimate of variance component and best linear unbiased predictions (BLUPs), the latter where necessary, for each random effect were obtained using the restricted maximum likelihood (ReML) method in GenStat computing software.

The plant population was used as a covariate to adjust the estimates for varying plant populations. The statistical significance of estimates of variance components was tested using their respective standard errors assuming an asymptotic normal distribution.

Results and Discussion

Irrigated experiment, 2000 rainy season

The genotypic differences for kernel yield, HI, TE, and T were highly significant (Table 1a). The top 20 genotypes for kernel yield consisted of 11 trait-based and 9 empirical selections (Table 1b). Although these genotypes showed superiority in kernel yield (2.5–16.0%) over the highest-yielding parent ICGS 76, the differences were not significant. Similarly for HI, the differences were not significant. No genotype showed significant superiority over ICGS 76 for TE. On the other hand, eight genotypes recorded significantly lower TE than the parent. Trait-based and empirical selections were equally represented in this group. However, for T, four genotypes showed significant superiority over ICGS 76 with equal number of genotypes coming from the two selection methods. This superiority of T in four genotypes however was not translated into significantly greater kernel yield.

Ignoring statistical significance, 20 genotypes for kernel yield, 12 for HI, 4 for TE, and 19 for T showed positive increases over ICGS 76. T in six genotypes and HI in one genotype were positive. In the rest, it was a positive combination of HI, TE, or T in pairs or trios. Both trait-based and empirical selections were equally represented among the 12 positive genotypes for HI. For TE, three were trait-based and one empirical; for T, ten were trait-based and nine empirical among the genotypes showing positive improvement for these traits. No selection method showed superiority in selecting for kernel yield, HI, TE, or T.

Rain-fed experiment, 2000 rainy season

The genotypic differences for all the traits were highly significant (Table 2a). The top 20 genotypes for kernel yield comprising 12 trait-based and 8 empirical

Table 1a. Variance components, Irrigated experiment, ICRISAT Centre, 2000 rainy season.

Variance Component	Kernel Yield (kg/ha)	HI	TE (g/kg)	T (mm)
σ_G^2	71027***	1148***	61.29×10^{-3}***	0.99×10^{-3}***
Se	17038	208	7.22×10^{-3}	0.19×10^{-3}
σ_e^2	253301	2280	28.90×10^{-3}	2.34×10^{-3}
Se	20640	190	2.47×10^{-3}	0.19×10^{-3}

Notes: G = genotype, e = error, SE = standard error, ***P < 0.001

Table 1b. Performance of the highest-yielding 20 genotypes for kernel yield (KY), harvest index (HI), transpiration efficiency (TE), and transpiration (T), Irrigated experiment, ICRISAT Centre, 2000 rainy season. Percentage change in these traits over parent ICGS 76 is also presented.

Geno-ID	Selection	KY (kg/ha)	HI	TE (g/kg)	T (mm)	Percent change over ICGS 76			
						KY	HI	TE	T
ICR 07	TRT	2563	0.35	2.89	275	16.0	7.2	1.4	9.7
TIR 47	EMP	2446	0.34	2.41	309	10.7	3.2	-15.4	23.0
ICR 09	TRT	2443	0.35	2.72	272	10.5	6.8	-4.3	8.4
TIR 36	EMP	2432	0.29	2.73	330	10.0	-10.3	-4.0	31.3
JAL 32	EMP	2416	0.35	2.53	286	9.3	7.8	-11.1	14.1
TIR 19	TRT	2408	0.33	2.53	297	9.0	2.3	-11.2	18.1
ICR 14	TRT	2398	0.31	2.76	295	8.5	-3.6	-3.2	17.6
TIR 31	EMP	2386	0.35	2.67	274	8.0	6.3	-6.4	9.0
ICR 17	TRT	2373	0.31	2.51	320	7.4	-4.9	-11.8	27.6
JUG 38	EMP	2342	0.34	2.54	281	6.0	4.2	-10.7	12.0
ICR 16	TRT	2341	0.29	2.48	337	5.9	-10.2	-12.9	34.2
JAL 29	EMP	2339	0.32	2.85	275	5.8	-1.5	0.2	9.6
JAL 02	TRT	2333	0.34	2.95	254	5.6	5.8	3.6	1.0
ICR 29	EMP	2326	0.30	2.64	316	5.2	-8.3	-7.4	25.9
ICR 08	TRT	2316	0.37	2.73	251	4.8	12.3	-4.3	0.0
JUG 25	EMP	2308	0.36	2.55	262	4.4	10.7	-10.3	4.5
ICR 44	EMP	2287	0.33	2.79	265	3.5	1.7	-1.9	5.5
TIR 22	TRT	2275	0.36	2.28	285	2.9	10.1	-20.0	13.3
JAL 13	TRT	2272	0.30	2.96	271	2.8	-7.2	4.1	7.8
ICR 24	TRT	2266	0.31	2.84	266	2.5	-4.8	-0.3	6.1
ICGS 44		1996	0.31	2.59	250				
ICGS 76		2210	0.33	2.85	251				
CSMG 84-1		2129	0.31	2.68	275				
ICGV 86031		1878	0.27	2.69	248				
TAG 24		1932	0.29	2.38	284				
JL 220		1962	0.30	2.48	267				
GG 2		1886	0.29	2.50	256				
K 134		1976	0.31	2.16	289				
Grand Mean		2033	0.30	2.58	265				
SED		279.9	0.030	0.133	31.2				
LSD		548.6	0.058	0.261	61.1				

Table 2a. Variance components, Rainfed experiment, ICRISAT Centre, 2000 rainy season.

Variance Component	Kernel Yield (kg/ha)	HI	TE(g/kg)	T(mm)
σ_G^2	51069***	551***	62.6 x 10-3***	1.29 x 10-3***
Se	11739	150	8.08 x 10-3	0.18 x 10-3
σ_e^2	171296	2441	45.6 x 10-3	1.51 x 10-3
Se	13950	197	3.89 x 10-3	0.13 x 10-3

Notes: G = genotype, e = error, SE = standard error, ***P < 0.001

selections did not differ significantly from ICGS 76 (Table 2b). Similarly, differences for HI and T for these genotypes and ICGS 76 were non-significant. However, four of these genotypes had significantly lower TE than ICGS 76. Ignoring statistical significance, genotypes showed positive improvement over ICGS 76 for: kernel yield (2 = 1 trait-based + 1 empirical); HI (10 = 6 + 4), TE (3 = 1 + 2), and T (10 = 6 + 4). Among these genotypes, only five had the positive combination of both HI, TE, or T. Under rain-fed conditions also, no selection method showed superiority in selecting for kernel yield, HI, TE, and T.

Irrigated experiment, 2000-01 post-rainy season

Like the 2000 season experiments, the genotypic differences for the traits studied were significant in this experiment (Table 3a). However, the top 20 genotypes for kernel yield did not differ significantly from the parent ICGS 76 (Table 3b). Similarly, these genotypes did not differ significantly for TE and T with ICGS 76. However, seven genotypes (3 trait-based + 4 empirical) showed significantly greater HI than ICGS 76. But these positive gains in HI were not translated into significantly greater kernel yield.

Table 2b. Performance of the highest-yielding 20 genotypes for kernel yield (KY), harvest index (HI), transpiration efficiency (TE), and transpiration (T), Rainfed experiment, ICRISAT Centre, 2000 rainy season. Percentage change in these traits over parent ICGS 76 is also presented.

Geno-ID	Selection	KY (kg/ha)	HI	TE (g/kg)	T (mm)	Percent change over ICGS 76			
						KY	HI	TE	T
JAL 15	TRT	2187	0.32	2.91	250	4.7	6.7	-2.2	1.8
TIR 34	EMP	2101	0.28	2.69	278	0.6	-9.2	-9.5	13.3
ICR 03	TRT	2080	0.29	2.77	276	-0.4	-5.6	-6.9	12.3
ICR 10	TRT	2054	0.31	2.51	264	-1.6	3.3	-15.7	7.4
TIR 31	EMP	2036	0.30	3.03	236	-2.5	0.0	1.7	-4.1
ICR 11	TRT	2013	0.29	2.94	246	-3.6	-3.7	-1.2	0.0
ICR 02	TRT	2001	0.29	2.91	246	-4.2	-4.0	-2.3	0.0
ICR 25	EMP	1991	0.30	2.76	249	-4.6	-2.1	-7.3	1.4
ICR 14	TRT	1956	0.27	2.77	259	-6.3	-11.4	-6.8	5.5
JAL 35	EMP	1951	0.31	2.46	249	-6.6	2.0	-17.4	1.5
ICR 48	EMP	1947	0.34	2.71	230	-6.8	11.4	-9.1	-6.5
TIR 19	TRT	1943	0.31	2.46	262	-6.9	3.6	-17.3	6.8
JAL 20	TRT	1936	0.27	2.88	250	-7.3	-10.9	-3.2	1.9
JAL 14	TRT	1921	0.28	3.05	235	-8.0	-6.8	2.5	-4.4
ICR 46	EMP	1914	0.31	2.54	245	-8.3	2.5	-14.6	-0.1
ICR 43	EMP	1895	0.33	3.03	219	-9.2	9.7	1.6	-10.7
JAL 29	EMP	1892	0.27	2.88	249	-9.4	-12.3	-3.2	1.3
ICR 09	TRT	1892	0.32	2.82	227	-9.4	5.0	-5.1	-7.4
TIR 17	TRT	1887	0.31	2.91	228	-9.6	2.8	-2.3	-7.3
ICR 23	TRT	1886	0.32	2.82	226	-9.7	4.2	-5.4	-8.0
ICGS 44		1627	0.31	2.64	213				
ICGS 76		2088	0.30	2.98	246				
CSMG 84-1		1731	0.26	2.78	239				
ICGV 86031		1882	0.26	2.74	260				
TAG 24		2003	0.34	2.39	254				
JL 220		1762	0.31	2.18	252				
GG 2		1546	0.29	2.57	215				
K 134		1373	0.25	2.36	215				
Grand Mean		1689	0.28	2.63	231				
SED		233.5	0.027	0.164	25.7				
LSD		457.7	0.053	0.321	50.4				

Table 3a. Variance components, Irrigated experiment, ICRISAT Centre, 2000/01 post-rainy season.

Variance Component	Kernel Yield (kg/ha)	HI	TE	T (mm)
σ_G^2	350913***	6532***	3.45 x 10^{-3}***	3.11 x 10^{-3}***
Se	44093	842	0.47 x 10^{-3}	0.39 x 10^{-3}
σ_e^2	253697	4731	3.41 x 10^{-3}	2.28 x 10^{-3}
Se	21303	403	0.28 x 10^{-3}	0.19 x 10^{-3}

Notes: G = genotype, e = error, Se = standard error, ***p < 0.001

Table 3b. Performance of the highest-yielding 20 genotypes for kernel yield (KY), harvest index (HI), transpiration efficiency (TE), and transpiration (T), Irrigated experiment, ICRISAT Centre, 2000-01 post-rainy season. Percentage change in these traits over parent ICGS 76 is also presented.

Geno-ID	Selection	KY (kg/ha)	HI	TE (g/kg)	T (mm)	Percent change over ICGS 76			
						KY	HI	TE	T
JAL 15	TRT	3826	0.41	1.75	527	9.5	20.0	3.6	-13.3
JAL 28	EMP	3662	0.39	1.71	543	4.8	13.3	1.5	-10.5
JUG 01	TRT	3657	0.36	1.63	626	4.6	3.9	-3.7	3.1
JAL 01	TRT	3648	0.38	1.74	538	4.4	11.7	3.0	-11.4
TIR 01	TRT	3632	0.34	1.61	662	3.9	-0.9	-4.5	9.0
JUG 14	TRT	3618	0.42	1.71	491	3.5	22.7	1.2	-19.2
JAL 02	TRT	3615	0.37	1.74	570	3.4	7.3	3.0	-6.1
JAL 26	EMP	3536	0.40	1.67	533	1.2	17.7	-0.8	-12.3
JAL 29	EMP	3529	0.42	1.70	476	1.0	23.6	0.5	-21.6
JAL 03	TRT	3514	0.39	1.75	514	0.5	13.9	3.6	-15.3
JUG 03	TRT	3450	0.40	1.74	494	-1.3	16.0	3.0	-18.7
JUG 13	TRT	3413	0.37	1.73	532	-2.3	7.9	2.3	-12.4
JUG 30	EMP	3387	0.41	1.69	485	-3.1	20.6	0.3	-20.2
JAL 18	TRT	3380	0.42	1.62	486	-3.3	23.3	-4.1	-20.0
ICR 28	EMP	3377	0.35	1.70	565	-3.4	0.9	0.9	-7.0
TIR 28	EMP	3371	0.34	1.61	613	-3.5	-1.7	-4.4	1.0
ICR 45	EMP	3310	0.44	1.65	452	-5.3	28.8	-2.2	-25.6
ICR 43	EMP	3264	0.43	1.65	456	-6.6	26.1	-2.0	-24.9
JUG 27	EMP	3258	0.37	1.61	542	-6.8	9.2	-4.6	-10.8
JAL 04	TRT	3255	0.35	1.60	582	-6.9	2.0	-5.3	-4.2
ICGS 44		2787	0.41	1.60	430				
ICGS 76		3495	0.34	1.69	607				
CSMG 84-1		2470	0.29	1.64	505				
ICGV 86031		2883	0.31	1.68	538				
TAG 24		1925	0.35	1.55	362				
JL 220		1965	0.28	1.60	432				
GG 2		1615	0.27	1.55	382				
K 134		1406	0.20	1.54	444				
Grand Mean		2530	0.33	1.63	479				
SED		369.6	0.035	0.041	52.8				
LSD		724.4	0.069	0.081	103.5				

Ignoring statistical significance, genotypes showed positive improvement over ICGS 76 for: kernel yield (10 = 7 trait-based + 3 empirical); HI (18 = 10 + 8), TE (11 = 7 + 4), and T (3 = 2 + 1). There was a preponderance of trait-based genotypes which showed positive gains over ICGS 76. In the top 20 genotypes for kernel yield, eight showed superiority only in one trait and the remaining 12 in two of the three traits associated with kernel yield, HI, TE, and T. As stated earlier, these positive gains in traits associated with kernel yield did not result in significant increase in kernel yield of the genotypes. No selection method was superior in selecting for kernel yield, HI, TE, and T.

Table 4a. Variance components, Imposed mid-season drought experiment, ICRISAT Centre, 2000-01 post-rainy season.

Variance Component	Kernel Yield (kg/ha)	HI	TE (g/kg)	T (mm)
σ_G^2	77872***	2678***	2.79 x 10^{-3}***	2.78 x 10^{-3}***
Se	16110	395	0.46 x 10^{-3}	0.38 x 10^{-3}
σ_e^2	217385	3517	4.9 x 10^{-3}	2.56 x 10^{-3}
Se	17740	291	0.4 x 10^{-3}	2.16 x 10^{-3}

Notes: G = genotype, e = error, SE = standard error, ***P < 0.001

Table 4b. Performance of the highest-yielding 20 genotypes for kernel yield (KY), harvest index (HI), transpiration efficiency (TE), and transpiration (T), Imposed mid-season drought experiment, ICRISAT Centre, 2000-01 post-rainy season. Percentage change in these traits over parent ICGS 76 is also presented.

Geno-ID	Selection	KY (kg/ha)	HI	TE (g/kg)	T (mm)	Percent change over ICGS 76			
						KY	HI	TE	T
TIR 31	EMP	3032	0.43	1.67	457	19.0	20.3	0.5	5.5
JUG 26	EMP	2881	0.45	1.69	413	13.1	24.4	1.6	-4.6
ICR 24	TRT	2819	0.44	1.65	418	10.6	21.1	-0.8	-3.4
JAL 29	EMP	2788	0.37	1.69	466	9.4	3.0	1.4	7.5
JUG 15	TRT	2786	0.46	1.67	399	9.3	27.5	0.1	-8.0
JAL 13	TRT	2767	0.44	1.70	395	8.6	22.7	2.0	-8.8
ICR 25	EMP	2724	0.43	1.66	414	6.9	19.0	-0.5	-4.5
ICR 04	TRT	2707	0.38	1.59	487	6.2	5.0	-4.8	12.5
ICR 26	EMP	2688	0.39	1.64	446	5.5	8.2	-1.3	2.9
JAL 25	EMP	2668	0.41	1.68	414	4.7	12.9	1.1	-4.5
JAL 05	TRT	2665	0.45	1.55	416	4.6	24.8	-7.0	-3.8
ICR 38	EMP	2664	0.36	1.64	476	4.6	-0.2	-1.6	10.0
JAL 03	TRT	2660	0.37	1.67	455	4.4	2.0	0.3	5.0
JAL 26	EMP	2645	0.38	1.69	434	3.8	5.0	1.5	0.3
ICR 13	TRT	2626	0.41	1.65	409	3.1	12.9	-0.9	-5.5
JUG 01	TRT	2616	0.39	1.64	426	2.7	9.5	-1.4	-1.6
ICR 23	TRT	2616	0.44	1.68	385	2.7	21.2	0.6	-11.0
TIR 16	TRT	2608	0.38	1.67	430	2.4	5.8	0.0	-0.7
ICR 08	TRT	2597	0.39	1.63	426	1.9	9.2	-2.0	-1.6
JUG 03	TRT	2585	0.44	1.69	371	1.5	22.4	1.5	-14.3
ICGS 44		2408	0.36	1.65	405				
ICGS 76		2548	0.36	1.67	433				
CSMG 84-1		2288	0.29	1.65	465				
ICGV 86031		2266	0.28	1.67	485				
TAG 24		1997	0.41	1.62	300				
JL 220		2060	0.34	1.64	353				
GG 2		2490	0.38	1.61	426				
K 134		2603	0.35	1.60	481				
Grand Mean		2327	0.35	1.63	413				
SED		275.5	0.037	0.045	40.4				
LSD		540.0	0.073	0.089	79.2				

Table 5a. Combined analysis: Variance components, ICRISAT Centre, 2000 rainy and 2000-01 post-rainy seasons.

Variance Component	Kernel Yield (kg/ha)	HI	TE (g/kg)	T (mm)
σ_E^2	113922	12493	311.9 x 10^{-3}	0.93 x 10^{-3}
Se	94687	10260	257.2 x 10^{-3}	0.78 x 10^{-3}
σ_G^2	57047***	989***	15.6 x 10^{-3}***	0.99 x 10^{-3}***
Se	9931	177	2.2 x 10^{-3}	0.15 x 10^{-3}
σ_{GE}^2	81216***	1748***	16.98 x 10^{-3}***	1.06 x 10^{-3}***
Se	9478	173	1.44 x 10^{-3}	0.11 x 10^{-3}
σ_e^2	225463	3256	20.6 x 10^{-3}	0.22 x 10^{-3}
Se	9245	136	0.87 x 10^{-3}	0.09 x 10^{-3}

Notes: E = environments (experiments), G = genotype, GE = genotype x environment interaction, e = error, SE = standard error, ***P < 0.001

Mid-season drought experiment, 2000-01 post-rainy season

The genotypic differences for the traits studied were also significant in this experiment (Table 4a). The top 20 genotypes for kernel yield (12 trait-based and 8 empirical) did not differ significantly from ICGS 76 for kernel yield, TE, and T (Table 4b). However, 7 genotypes (6 + 1) did show significant superiority over ICGS 76 for HI. As in earlier experiments, the superiority in HI in this experiment was not translated into significantly greater kernel yield in these genotypes.

Ignoring statistical significance, genotypes showed positive improvement over ICGS 76 for: kernel yield (20 = 12 trait-based + 8 empirical); HI (19 = 11 + 8), TE (10 = 5 + 5), and T (7 = 2 + 5). Many genotypes had positive gains in two or three traits (HI, TE, or T), but this did not result in any significant gains for them in kernel yield. Although, there was preponderance of trait-based genotypes among the 20 genotypes in this experiment also, no method showed superiority in selecting for kernel yield, HI, TE, and T.

Combined analysis

The combined analysis over all experiments showed significant differences among genotypes for kernel yield, HI, TE, and T (Table 5a). Similarly, genotype x experiment (environment) interaction was also significant for all the traits.

The kernel yield of the top 20 genotypes did not differ significantly from the highest yielding parent ICGS 76 (Table 5b). Fifteen of these genotypes were trait-based and five empirical. Only three of these genotypes (two empirical and one trait-based) had greater kernel yield (statistically non-significant) than ICGS 76. Preponderance of trait-based genotypes among the top 20 test genotypes for kernel yield suggests the effectiveness of the Selection Index

Table 5b. Performance of the highest-yielding 20 genotypes for kernel yield (KY), harvest index (HI), transpiration efficiency (TE), and transpiration (T), combined analysis ICRISAT Centre, 2000 rainy and 2000-01 post-rainy seasons.

Geno-ID	Selection	KY (kg/ha)	HI	TE (g/kg)	T (mm)
TIR 31	EMP	2912	0.37	2.29	385.8
JAL 29	EMP	2801	0.35	2.31	376.7
JAL 15	TRT	2771	0.36	2.37	356.0
JAL 01	TRT	2643	0.37	2.38	344.8
JAL 02	TRT	2639	0.34	2.37	372.9
JAL 03	TRT	2636	0.35	2.33	361.9
JAL 26	EMP	2625	0.35	2.37	355.3
ICR 24	TRT	2617	0.37	2.24	341.3
JUG 01	TRT	2568	0.33	2.18	387.1
ICR 07	TRT	2565	0.34	2.30	346.6
TIR 16	TRT	2559	0.38	2.04	355.0
JUG 15	TRT	2538	0.38	2.38	315.3
ICR 09	TRT	2526	0.38	2.23	329.2
ICR 14	TRT	2525	0.31	2.22	390.7
JUG 03	TRT	2519	0.37	2.36	316.2
ICR 10	TRT	2505	0.34	2.16	371.4
JAL 13	TRT	2502	0.36	2.38	323.7
ICR 48	EMP	2496	0.38	2.21	337.0
JUG 26	EMP	2493	0.35	2.42	331.3
JAL 14	TRT	2469	0.32	2.41	352.2
ICGS 44		2204	0.35	2.12	318.3
ICGS 76		2719	0.34	2.32	389.6
CSMG 84-1		2180	0.29	2.20	379.2
ICGV 86031		2235	0.27	2.21	394.8
TAG 24		1959	0.35	1.97	302.3
JL 220		1905	0.31	1.95	330.6
GG 2		1864	0.30	2.04	315.0
K 134		1814	0.27	1.89	358.9
Grand Mean		2145	0.32	2.12	346.8
SED		450.2	0.046	0.151	56.58
LSD		342.0	0.035	0.115	42.98

(described elsewhere in these proceedings) in picking up high yielding genotypes, however the Selection Index was not effective enough in picking up genotypes that were higher yielding than the highest yielding parent. Four genotypes (three trait-based and one empirical) for HI and one trait-based genotype for T showed significant positive gains over ICGS 76. But eight other genotypes for T and three genotypes for TE had significant decrease relative to ICGS 76. Most of these selections were trait-based. This requires a reconsideration of the Selection Index and weighting given to its constituents (HI, TE, and T).

Conclusions

Results from the present experiments did not show significant superiority of trait-based selection over the empirical selection method for yield under either limited-moisture or normal-moisture conditions. However, there was a strong trend for increased kernel yield in trait-based genotypes among the top 20 genotypes, although the yield gains were statistically non-significant when compared with the highest-yielding parent ICGS 76. Even so there were significant yield gains among the top 20 genotypes compared to the other five parents.

These results suggest that that the inclusion in peanut breeding programs of some of the constituent traits of the Selection Index, or their easily measurable surrogate traits, would be useful. The Selection Index used in the present studies needs revision and improvement.

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