CROP PRODUCTION

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Phenotypic stability of yield and related characters in *desi* gram (*Cicer arietinum*)

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ABSTRACT

A set of 22 advanced lines and 3 control varieties of gram or chickpea (*Cicer arietinum* L.) was evaluated in 4 environments during 1988–89 and 1989–90, to determine the stability for seed yield along with days to 50% flowering and to maturity, and 100-seed weight. Significant differences were observed among genotypes and environments along with significant genotype x environment (G x E) interaction for means of these characters. Stability analysis showed that both linear and non-linear components significantly contributed towards G x E interaction for days to 50% flowering, whereas non-linear component predominantly contributed toward seed yield, days to maturity and 100-seed weight. 'K 850' and 'ICCV 89360' were found the most stable genotypes with high yield performance (1 985 and 1 850 kg/ha respectively). Absence of correlation between seed yield and the sensitivity of genotypes to different environments indicated the possibility of selection for high yield without compromising on its stability.

Instability of seed yield due to large genotype x environment (G x E) interaction is a major reason for stagnation in production of gram or chickpea (*Cicer arietinum* L.) (Smithson *et al.* 1985). Therefore breeding programmes get high priority for stability in yield by multi-locational testing of advanced genotypes in different years. The lack of soil moisture and occurrence of biotic stresses, especially gram podborer [*Helicoverpa armigera* (Hübn.)] and soil-borne diseases such as fusarium wilt [*Fusarium oxysporum* Schlecht. emend. Snyd. & Hans. f. sp *ciceri* (Padwick) Snyd. & Hans.] and dry root rot [*Rhizoctonia bataticola* (Taub.) Butler], are the major factors causing instable yield in gram (Singh 1987). Therefore an understanding of the response of different gram genotypes to irrigated and rainfed, and protected and unprotected (without application of fungicide and insecticide) conditions would be useful to gram breeders to identify genotypes with stable yield. Hence an experiment was conducted to determine the phenotypic stability of seed yield and related characters in a set of promising gram lines under different environments.

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MATERIALS AND METHODS

Twenty-two advanced breeding lines of gram along with control varieties were evaluated at the main centre of the institute at Patancheru (18°N) and the subcentre at Gwalior (26°N), during 1988–89 and 1989–90. At Patancheru the crop was sown in 3 different environments, ie irrigated and protected, rainfed and protected, and rainfed and unprotected. The crop at Gwalior was irrigated and protected. All the trials were laid out in a 5 x 5 balanced lattice-square design with 3 replications and the crops were sown in October or November. Each plot consisted of 4 rows of 4 m length, spaced at 30 cm with plants at 10 cm within the rows. Total precipitation during the rainy season (June–October) in 1988–89 and 1989–90 was 900 and 937 mm at Patancheru and 641 and 535 mm at Gwalior respectively. Crop seasons were dry in both the years with total precipitation of 6.7 and 15.1 mm at Patancheru (October–February), and 28 and 20 mm at Gwalior (November–March). Besides the rain, 4 irrigations were provided to the crops sown under irrigated condition. The seeds sown in the protected trials were treated with thiram (Thiram) and benomyl (Benlate) before planting. Insecticides were sprayed in the protected trials to control the gram-podborer as and when needed. Days to 50% flowering and to maturity, 100-seed weight and seed yield were recorded in each plot. All the plots in unprotected environments were scored for pod-borer damage on 1–9 scale (1, resistant; 9, susceptible). The environments and genotypes were assumed to be fixed for statistical analysis. The phenotypic stability of genotypes was estimated using the parameters developed by Eberhart and Russell (1966). Rank correlations between the mean performance of genotypes and their regression coefficients on the environmental indices were also calculated for the characters under study.

RESULTS AND DISCUSSION

The mean seed yield for environments was 716–2 758 kg/ha (Table 1). The irrigated and protected environments at both locations were favourable for gram production. Gwalior in particular was found more favourable because of longer crop duration, as indicated by environmental means for days to 50% flowering and to maturity. For 100-seed weight the means for different environments were 17.4–20.8 g.

The pooled analysis of variance revealed significant variation among genotypes and environments for all the 4 characters (Table 2). The presence of significant G x E interaction indicated that the relative rankings of genotypes were different in the 2 environments. Further partitioning of the G x E interaction into linear and non-linear (pooled deviation) components showed that both the components were significant for all the 4 characters. However, when linear component of G x E interaction was compared with the pooled deviation, it was found significantly different only for days to 50% flowering, indicating differences in linear response among genotypes in different environments. For the remaining characters a relatively high proportion of G x E interaction was non-linear, indicating that prediction of the performance of different genotypes for different environments will not be feasible. In this situation the deviation from regression (S^2_{di}) is a more important criterion for assessing the stability of genotypes. The result is in agreement with the reports of Jain *et al.* (1984), Singh and Bejiga (1990) and Singh and Singh (1990).

Eberhart and Russell (1966) defined stable genotypes as those having unit regression coefficient (b = 1.0) and non-significant deviation from the regression (S^2_{di}). A simultaneous evaluation of the stability parameters (b_i and S^2_{di}) and mean for seed yield showed that 8 genotypes had stable performance, as evident from their unit regression and a non-significant deviation from the regression (Table 3). Out of these, 'K 850' and 'ICCV

Table 1 Effect of location, irrigation and plant protection on performance of gram

Environment	Planting date	Mean performance			
		Days to 50% flowering	Days to maturity	100-seed weight (g)	Seed yield (kg/ha)
		1988			
Patancheru					
Irrigated + protected	26 Oct	52	109	17.57	2 496 (14)
Non-irrigated + protected	9 Oct	56	111	18.52	1 386 (15)
Non-irrigated + unprotected	11 Oct	56	114	17.70	1 060 (11)
Gwalior					
Irrigated + protected	22 Nov	73	141	20.23	2 758 (12)
		1989			
Patancheru					
Irrigated + protected	30 Oct	49	105	19.23	1 860 (12)
Non-irrigated + protected	3 Oct	53	112	17.36	1 089 (27)
Non-irrigated + unprotected	3 Oct	54	112	20.75	716 (12)
Gwalior					
Irrigated + protected	5 Nov	69	136	20.15	2 511 (15)
CD (P = 0.05)		1.32	1.58	0.59	163.9
Mean		58	118	18.94	[illegible]

Figures in parentheses are coefficients of variation (%) for seed yield

Table 2 Pooled analysis of variance for different characters in gram

Source of variation	df	Mean squares			
		Days to 50% flowering	Days to maturity	100-seed weight (g)	Seed yield (kg/ha)
Genotypes (G)	24	272.2**	79.4**	103.43**	81 878**
Environment (E)	7	1 817.4**	4 299.1**	44.85**	15 214 811**
G x E	168	9.6**	8.6**	1.26**	91 921**
E (linear)	1	12 721.5**	30 094.6**	314.02**	106 503 512**
G x E (linear)	24	31.2**	8.8**	1.65**	89 741**
Pooled deviation	150	5.7**	7.9**	1.13**	87 368**
Pooled error	384	1.3	1.8	0.34	23 936

*P = 0.01

89360' were also among the 5 highest yielding genotypes. This indicates the possibility of identifying genotypes giving relatively high yields in different environments. Singh *et al.* (1986) also identified genotypes with high mean yield and stability in changing environ-

Table 3 Stability parameters for different characters in gram

Genotype	Days to 50% flowering			Days to maturity			100-seed weight (g)			Seed yield (kg/ha)		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
'ICCV 89342'	64	0.63**	11.92**	120	0.93	10.41**	24.69	1.37	0.14	1 776	1.19	93 156**
'ICCV 89343'	61	1.02	—0.35	119	1.04	5.66**	19.81	0.92	0.64**	1 889	0.93	28 556*
'ICCV 89345'	64	0.88	14.15**	121	0.92	—0.39	23.84	2.11**	1.89**	1 819	1.25	132 821**
'ICCV 89346'	61	0.94	1.57*	120	1.00	4.29**	20.42	1.49	0.24	1 688	0.90	216 756**
'ICCV 89347'	54	1.20	0.19	117	1.01	2.77*	24.37	1.43	1.10**	1 626	0.98	8 460
'ICCV 89348'	66	0.63**	5.10**	122	0.93	3.87**	19.28	1.35	1.04**	1 600	1.34*	115 286**
'ICCV 89349'	50	1.21*	2.94**	115	1.03	6.22**	15.65	0.67	0.05	1 732	1.00	22 667
'ICCV 89350'	53	1.22*	1.89*	114	1.11	1.45	14.82	0.74	0.32	1 720	0.93	47 061**
'ICCV 89351'	50	1.38**	3.91**	114	1.12	11.30**	21.67	0.77	0.31	1 708	0.78	73 952**
'ICCV 89352'	52	1.17	4.99**	111	1.15	12.82**	18.33	1.10	3.62**	1 801	1.14	53 881**
'ICCV 89353'	51	1.14	5.13**	112	1.16	10.54**	18.11	0.90	1.30**	1 710	1.00	97 919**
'ICCV 89354'	52	1.22*	2.26*	114	1.06	15.33**	20.88	0.62	0.52**	1 636	0.95	21 515
'ICCV 89355'	54	0.99	1.29	118	1.00	1.73	18.09	0.80	1.05**	1 701	1.04	100 660**
'ICCV 89356'	58	1.03	2.38*	117	0.97	3.80**	15.00	0.89	0.22	1 695	1.01	38 259*
'ICCV 89357'	62	0.86	1.45	120	0.94	6.10**	18.40	0.96	1.04**	1 874	0.96	73 203**
'ICCV 89358'	63	0.81	3.29**	120	0.93	9.16**	15.82	0.46	0.99**	1 760	0.77	108 673**
'ICCV 89359'	64	0.79*	—0.98	121	0.95	7.86**	18.74	1.08	0.09	1 704	0.81	—3 466
'ICCV 89360'	55	1.32**	5.22**	118	1.03	2.93*	19.66	1.18	0.27	1 850	0.99	17 206
'ICCV 89361'	60	0.85	2.19*	118	0.96	3.89**	15.50	0.38*	0.57*	1 554	0.81	65 878**
'ICCV 89362'	67	0.79*	14.46**	121	0.92	6.82**	16.44	1.12	0.08	1 722	0.99	—3 292
'ICCV 89363'	52	1.43**	5.05**	117	0.99	9.23**	15.76	0.81	0.20	1 591	0.88	70 444**
'ICCV 89364'	53	1.09	0.65	116	1.04	1.29	21.44	0.98	0.63**	1 633	1.11	7 745
'K 850'	61	0.76*	0.77	120	0.96	0.78	27.03	1.10	0.99**	1 985	0.96	4 074
'Annigeri'	52	1.14	1.89*	113	1.10	5.76**	19.19	0.91	2.11**	1 866	1.16	75 345**
'Pant G 114'	67	0.48**	19.09**	123	0.79**	8.95**	11.40	0.89	0.44*	1 723	1.13	119 050**
Mean	58			118			18.97			1 735		
SE ±	0.9	0.106		1.0	0.081		0.38	0.300		104.5	0.143	
r between mean and b_i		—0.88**			—0.91**			0.60**			0.07	

*P = 0.05; **P = 0.01

b_i, Regression coefficient; S^2_{di}, deviation from regression; r, correlation coefficient ments. However, Singh and Bejiga (1990) reported that their stable lines were average yielders whereas the unstable lines were high yielders. Non-correlation of mean seed yield with regression coefficient (b_i) (Table 3) also indicated that selection for high seed yield is possible without affecting the ability of a genotype to perform well in every environment. 'ICCV 89347', 'ICCV 89364' and 'ICCV 89354' were stable ($b_i = 1$ and $S^2_{di} = 0$), but undesirable due to low yield. 'Annigeri' and 'ICCV 89357' gave high yield and showed average sensitivity to variation in the environments ($b_i = 1$) but their deviation from the regression was high, indicating that such genotypes were unpredictable in their performance. Similarly, 'ICCV 89348' was responsive to better growing conditions ($b_i > 1$) but its performance was not stable. 'K 850' showed stable performance for days to maturity in addition to seed yield. Kumar *et al.* (1994) also established 'K 850' as one of the most stable genotypes in International Chickpea Adaptation Trials conducted in 22 countries. 'ICCV 89360' with high and stable yield also showed stability for 100-seed weight. 'ICCV 89360' also combined resistance to wilt and root rots (16% total mortality) and moderate tolerance to gram podborer (5.3 in 1-9 scale). Therefore 'K 850' and 'ICCV 89360' can be suitable for environments characterized by irregular water availability and biotic stresses and may also be useful as donor parents for stability in future breeding programmes.

Five genotypes showed regression coefficient close to unity ($b_i = 1$) and the deviation from regression approaching 0 ($S^2_{di} = 0$) for days to 50% flowering. This indicated their average sensitivity to environmental fluctuation for time taken for flowering. Among these, 'ICCV 89347', 'ICCV 89355' and 'ICCV 89364' showed significantly earlier flowering than the mean. 'K 850' and 'ICCV 89359' also showed non-significant deviation from regression ($S^2_{di} = 0$) with $b_i > 1$, indicating that these genotypes tended to flower early in rainfed and unprotected environments.

Five genotypes ('ICCV 89345', 'ICCV 89350', 'ICCV 89355', 'ICCV 89364' and 'K 850') with unit regression and 0 deviation from regression showed phenotypic stability for days to maturity. Among these, 'ICCV 89350' and 'ICCV 89364' were the only genotypes maturing earlier than the average. 'ICCV 89355' and 'ICCV 89364', which showed stability for both days to 50% flowering and maturity, may be utilized as donors in the breeding programmes.

Ten genotypes had regression values closer to unity and non-significant deviation from regression for 100-seed weight, indicating their stable performance for this trait in different environments. Out of these, 'ICCV 89342', 'ICCV 89351' and 'ICCV 89346' had significantly higher 100-seed weight than the mean. Their use is desirable as donor parents for stabilizing seed size in the breeding programmes.

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