COMBINING ABILITY IN CHICKPEA

C. L. L. Gowda* and P. N. Bahl

Division of Genetics, Indian Agricultural Research Institute, New Delhi–110 012

To form a sound basis for any breeding programme aimed to achieve higher yields, breeders must have genetic information on the nature of the combining ability of the elite parents to be used in hybridization programmes. The present investigation was undertaken to get information on the combining ability for yield and yield components of seven chickpea (*Cicer arietinum* L.) cultivars by diallel analysis.

Materials and Methods

Seven chickpea cultivars, P-813 (Mexico), P-851 (USSR), P-1139 (India), C-235 (India), P-9624 (Mexico), ICP-71 (Jordan) and P-1821 (USA) were crossed in all possible combinations, without reciprocals. The 21 F_1's and 7 parents were planted during *rabi* 1973–74 in a randomized block design with two replications at the Division of Genetics, IARI, New Delhi. The seeds were dibbled in 1·5 meter long rows at 15 cm intervals and row to row distance was 60 cm. Observations were recorded on three random plants in each plot. In rabi 1974–75, the 21 F_2's and 7 parents were planted in randomized block design with four replications. Each entry was sown in a plot of 5 rows of 2 meter length at a spacing of 60 × 20 cm. Twenty random plants were selected from the middle three rows for taking observations. Data were recorded on seven characters, viz., plant height (cm), number of branches per plant, flowering time (number of days from seedling to flowering), number of pods per plant, number of seeds per pod (in F_2), 100-seed weight (gm) and seed yield (gm) per plant. The combining ability analysis was done according to Model I, Method 2 of Griffing (1956).

Results

The analysis of variance for general and specific combining ability are presented in Table 1. In F_1, mean squares due to general and specific combining ability were significant for plant height, flowering time, pod number and seed yield. Branch number and 100-seed weight showed significant variation for s.c.a. and g.c.a. respectively. In F_2, mean squares due to g.c.a. were significant for all characters except branch number and seed yield.

Variance for general combining abilty for plant height (F_1, F_2) 100-seed weight (F_1, F_2), flowering time (F_2) and pod number (F_2) were higher than s.c.a. variances for these traits. The magnitude of s.c.a. variances were higher than g.c.a. variances in case of branch number and seed yield in both the generations.

Combining ability effects: Estimates of g.c.a. effects for different characters in F_1 and F_2 generations are given in Table 2. P–1821, P–9624 and ICP–71

A part of thesis submitted by C. L. L. Gowda for the Ph.D. degree of the Indian Agricultural Research Institute, New Delhi.

*Present address: ICRISAT, 1–11–256, Begumpet, Hyderabad-500 016, INDIA.

TABLE 1

Analysis of variance (Mean squares) for general and specific combining ability for various characters in F_1 and F_2

Generation	Source	d.f.	Plant height	Branch number	Flowering time	Pod number	Seeds per pod	100-seed weight	Seed yield
F_1	G C.A.	6	166·061**	2·552	84·798**	980·328**	—	83·068**	65·564**
F_2		6	51·857**	1·016	124·911**	6348·722**	0·019**	150·884**	26·134
F_1	S.C.A.	21	16·852*	3·346*	20·910**	601·872**	—	1·372	15·259**
F_2		21	13·458	1·019	42·381	593·918	0·004**	0·559	33·629
F_1	Error	—	8·609	1·628	3·625	206·769	—	0·799	4·856
F_2		—	9·189	0·737	45·491	591·030	0·001	0·749	27·726
F_1	Vgca		17·495	0·103	9·019	85·951	—	9·141	6·745
F_2			4·740	0·031	8·824	639·743	0·002	16·681	0·000
F_1	Vsca		8·243	1·720	17·285	395·103	—	0·573	10·403
F_2			4·269	0·282	0·000	2·888	0·003	0·000	5·903

* and **=significant at 5% and 1% levels respectively.

showed g.c.a. for tallness, while P–813, C–235 and P–851 for dwarfness either in F_1 and F_2. P–9624 and C–235 contributed towards earliness and P–813 and P–821 for lateness in both the generations. For high pod number P–813 and C–235 were good combiners. P–9624 followed by ICP–71 and P–1821 was the best general combiner for 100-seed weight in F_1 as well as F_2 generations. For seed yield *per se* P–9624 and ICP–71 were the good combiners. Also, considering the overall performance for all the characters, P–9624 and ICP–71 were the best general combiners.

Estimates of s.c.a. effects of the 21 crosses are summarised in Table 3. Four crosses, P–813 × ICP–71, P–813 × P–1821, C–235 × P–9624 and ICP–71 × P–1821 showed significant s.c.a. effects for seed yield and pod number. Out of the five parents involved in these four crosses, two were high combiners for yield as well as 100-seed weight, two for pod number and one for 100-seed weight only. Two of the crosses, P–813 × P–1821 and P–851 × C–235 exhibited positive significant s.c.a. effects for plant height. For higher branch number three cross combinations, P–851 × P–1821, P–1139 × P–9624 and P–1139 × ICP–71 showed highly significant s.c.a. effects. P–813 × P–1821 gave highly significant s.c.a. for earliness though both the parents of this cross are good combiners for late flowering.

Discussion

In the present investigation, variances due to g.c.a. were of higher magnitude than corresponding s.c.a. variances in respect of plant height, 100-seed weight, flowering time (F_2) and pod number (F_2). However, for seeds per pod, both g.c.a. and s.c.a. variances were equally important. Combining ability analysis, therefore, suggests that additive genetic variance is playing more important role in the inheritance of these characters. Earlier studies by Athwal and Sandha (1967), Zafar and Khan (1968), Lal (1972) and Dhaliwal and Gill (1973) also showed predominantly additive genetic control for one or more of these characters. However, Gupta and Ramanujam (1974) reported non-additive gene action to be more prominent for these characters in their material. In case of branch number and seed yield s.c.a. variances were higher than the corresponding g.c.a. indicating the predominance of non-additive gene action. Such results were reported earlier by Gupta and Ramanujam (1974).

Estimates of g.c.a. effects showed that it was difficult to pick good combiners for all the characters together because the combining ability effects were not consistent for all the yield components, possibly because of negative association among some of the characters. However, P–9624 and ICP–71 were found to be good combiners for seed yield *per se* and for most of the yield components. From the tabulated data it could be generalized that parents which showed high g.c.a. effects for pod number and 100-seed weight resulted in specific cross combinations which excelled in seed yield. Also, crosses showing positive significant s.c.a. effects for seed yield invariably showed significant s.c.a. effects for high pod

TABLE 2

Estimates of general combining ability effects for various characters in F_1 and F_2

Parent	Generation	Plant height	Branch number	Flowering time	Pod number	Seeds per pod	100-seed weight	Seed yield
P-813	F_1	–1·199*	–0·046	2·458**	5·360	—	–2·887**	–1·511*
	F_2	–2·462**	0·485	2·123**	17·372*	0·072**	–3·441**	–1·301
P-851	F_1	–6·255**	–0·285	0·882	–10·436*	—	–2·558**	–2·804**
	F_2	–2·402**	0·306	2·000**	25·504**	–0·006	–3·566**	–1·236
P-1139	F_1	0·754	–0·637	–1·541*	–3·751	—	–0·438	–1·116
	F_2	–1·434	0·122	0·972	19·116**	–0·018	–1·215**	2·021
C-235	F_1	–4·365**	–0·599	–1·116*	11·525*	—	–2·359**	–0·318
	F_2	–0·297	–0·085	–0·915	22·025**	0·043**	–3·526**	–0·558
P-9624	F_1	4·550**	0·659	–5·560**	4·842	—	5·580**	5·254**
	F_2	2·609**	–0·401	–8·004**	–35·122**	–0·067**	7·009**	2·618
ICP-71	F_1	5·327**	0·492	1·161*	8·821	—	1·483**	1·745*
	F_2	0·287	–0·022	1·014	–23·860**	–0·009	3·304**	0·165
P-1821	F_1	1·188	0·417	3·716**	–16·361**	—	1·180**	–1·248
	F_2	3·700**	–0·404	2·808**	–25·035**	–0·013	1·435**	–1·708
SE (gi)	F_1	±0·901	N.S.	±0·579	±4·437	—	±0·276	±0·680
SE (gi)	F_2	±0·936	N.S.	±0·628	±7·502	±0·011	±0·267	N.S.

* and **=significant at 5% and 1% levels respectively; NS=Non-significant.

TABLE 3

Estimates of specific combining ability effects for various characters in F_1

Sl. No.	Cross	Plant height	Branch number	Flowering time	Pod number	100-seed weight	Seed yield
1.	P-813 × P-851	–2·005	0·638	–2·100	23·401*	0·241	1·005
2.	P-813 × P-1139	0·064	–0·349	–0·505	11·546	2·238**	0·978
3.	P-813 × C-235	2·934	0·612	–0·431	–28·236*	0·450	–3·690*
4.	P-813 × P-9624	2·188	–0·806	2·513	–31·377*	0·580	–5·523**
5.	P-813 × ICP-71	–0·508	0·020	0·460	45·803**	–0·493	6·385**
6.	P-813 × P-1821	5·630*	0·765	–5·264**	31·326*	0·490	7·349**
7.	P-851 × P-1139	3·871	–0·110	–0·260	9·173	–0·040	0·571
8.	P-851 × C-235	5·821*	0·021	4·144**	6·895	–0·598	0·572
9.	P-851 × P-9624	3·074	–0·737	4·918**	–1·250	–0·878	–2·649
10.	P-851 × ICP-71	–2·121	–1·400	1·856	2·600	1·407	1·929
11.	P-851 × P-1821	–10·063**	5·173**	–1·519	–5·876	–1·248	–0·647
12.	P-1139 × C-235	–3·348	1·043	2·568	8·881	0·961	1·924
13.	P-1139 × P-9624	3·814	3·115**	5·013**	18·394	0·271	2·632
14.	P-1139 × ICP-71	0·708	1·951*	1·209	6·085	–0·332	0·141
15.	P-1139 × P-1821	–1·493	–1·813	2·594	–13·060	0·721	–2·115
16.	C-235 × P-9624	1·514	0·907	1·757	31·616*	–0·967	3·833**
17.	C-235 × ICP-71	3·408	–1·086	–1·964	–13·361	–0·641	–1·157
18.	C-235 × P-1821	–3·533	–0·511	–0·360	–26·008*	–0·267	–2·844
19.	P-9624 × ICP-71	–3·758	–0·344	3·309**	–23·838	–2·161**	–5·409**
20.	P-9624 × P-1821	2·630	0·229	9·084**	–1·825	0·112	–2·706
21.	ICP-71 × P-1821	1·683	1·556	1·361	38·025**	0·088	5·692**
	SE (Sij)	±2·633	±0·948	±1·709	±12·900	±0·802	±1·978

* and **=significant at 5% and 1% levels respectively.

number. These results suggest that grain yield is largely dependent upon pod number and 100-seed weight. Similar conclusions were reported earlier by path coefficient analysis in chickpea (Bahl, Mehra and Raju, 1976).

Predominance of additive genetic variability for plant height, flowering time, pod number, seeds per pod and 100-seed weight indicates that genetic advance in these characters can be made by simple breeding procedures involving selection based on progeny performance. Non-additive genetic variances in case of branch number and yield *per se*, as indicated by the predominance of s.c.a. variances, can possibly be exploited through heterosis breeding. However, in the absence of biological feasibility—a pre-requisite for heterosis breeding—such genetic variability could be exploited by recurrent selection. Also, it can be concluded from the data that genetically diverse and high combining parents should be used in formulating cross combinations. Selection by progeny testing as well as recurrent selection can then be used to evolve lines which may transgress both the combining parents.

Summary

The present investigation was undertaken to study combining ability for yield and yield components in chickpea (*Cicer arietinum* L.). Of the seven parents in this study, P–9624 and ICP–71 were good combiners for yield *per se* and also for most of the yield characters. It is evident from the results of g.c.a. and s.c.a. effects that seed yield is largely dependent upon pod number and 100-seed weight. General combining ability variances were higher than s.c.a. variances for plant height, flowering time, pod number and 100-seed weight. Simple breeding procedure involving selection based on progeny performance, which is expected to mop up additive variances effectively, has been suggested for improving these traits. For branch number and yield *per se* s.c.a. variances were more important indicating the predominance of non-additive genetic variances in the inheritance of these characters. Therefore, genetic advance for branch number and yield *per se* will be difficult by simple selection. Recurrent selection can be effectively used for making improvement in these two characters. It is further concluded that simple selection by progeny testing and recurrent selection should be used to evolve high yielding lines in this crop.

Acknowledgements

The authors express their deep sense of gratitude to Dr. H. K. Jain, Director, IARI, for suggesting the problem and for constant guidance and constructive criticism throughout the course of this investigation. Thanks are also due to Mr. R. B. Mehra, who went through the manuscript critically and offered very useful suggestions. Senior author gratefully acknowledges the grant of research fellowship by ICAR for his post-graduate study.

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