CHICKPEA BREEDING

ANNUAL REPORT 1976-77

Prepared by :

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FOREWORD

This is the first detailed annual report of the ICRISAT chickpea breeding program since its inception in 1973-74. It summarizes the activities of the first three years and gives in detail the progress reports for 1976-77. This report is primarily prepared for the chickpea breeders, but we are pleased to share it with other interested scientists.

An attempt was made in the past four years to identify problems and explore prospects of genetic improvement of this crop. Many crosses have been made and a great deal of breeding material has been generated. A sincere effort has also been made to establish contacts with the active chickpea breeders throughout the world for exchange of breeding materials and ideas for mutual benefit. The progress made in these directions has been compiled in this report.

We have included information on genetic studies and breeding methodology experiments in progress, in addition to summarizing the breeding work. This should in no way be considered a formal publication. The conclusions drawn are mostly tentative and therefore citation is not permitted. We would welcome suggestions from all those who read a part or all of this report.

In this report the accession number of germplasm lines is the "ICRISAT No." The abbreviation "ICRI" is used to designate cross numbers.

CHICKPEA BREEDING STAFF AND COOPERATING SCIENTISTS

June 1, 1976 to May 31, 1977

Dr. John M. Green	Leader, Pulse Improvement Program

<u>Breeding staff</u>

Dr. A.K. Auckland	Plant Breeder
Dr. K.B. Singh	Plant Breeder (S-4)
Mr. K.C. Jain+	Plant Breeder (S-1)
Mr. Onkar Singh	" " " (Hissar)
Dr. S.C. Sethi	" " "
Dr. C.L.L. Gowda	" " "
Mr. B. Yadav**	Research Technician (Hissar)
Mr. M.D. Gupta*	" "
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Mr. B. Venkateswar Rao	" "
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Mr. C.H. Damodar Rao**	" "
Mr. Omvir Singh Tomar*	" " (Hissar)
Mr. Mohd. Aziz	Field Helper
Mr. Ramkishore	" " (Hissar)
Mr. S.C. Saxena	" "
Mr. K.J. Reddy	" "
Mr. Rambhaj	" " (Hissar)
Mr. K. Shivraj*	" "
Mr. K. Shankeriah*	" "
Mr. A.J. Rama Rao	Secretary
Mr. Syed Liaqatullah	Driver/General Assistant (Hissar)
Mr. Phool Singh*	" " "

\+ Joined Ph.D. on 19th July 1976

* Joined the program during the year

** Left the program during the year

Cooperating Scientists

Entomology

Dr. J.C. Davies
Dr. W. Reed
Entomologists

Dr. S.S. Lateef
Entomologist (S-1)

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Microbiologist

Dr. O.P. Rupela
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Germplasm Botanist

Mr. R.P.S. Pundir
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Pathology

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Pathologist

Dr. M.V. Reddy
Pathologist (S-1)

Dr. M.P. Haware
Pathologist (S-1)

Agronomy

Dr. R.W. Willey
Agronomist

Dr. M.R. Rao
Agronomist (S-1)

Physiology

Dr. A.R. Sheldrake
Physiologist

Dr. N.P. Saxena
Physiologist (S-1)

Biochemistry

Dr. R. Jambunathan
Biochemist

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Year 1976/7

SUMMARY

1. Of the 319 strains/cultivars included in the crossing block nursery, 167 were actually utilized in making crosses. During 1976-77, 1829 crosses were made. This includes 816 single and 1013 multiple crosses. We have made nearly 7000 crosses since the inception of the program in 1973.

2. We grew 1901 F_1 crosses in off-season nursery at the Lahaul Valley during 1976. Due to unfavorable weather conditions we succeeded in producing F_2 seeds from only 40 per cent of the crosses. In the rabi season of 1976-77, 558 F_1's were grown at Hyderabad.

3. Approximately 850 F_2 populations were planted at Hyderabad and Hissar. The approximate number of F_3, F_4, F_5, and F_6 progenies for desi type at each site was 3330, 2050, 3250, and 1000, respectively.

4. We had grown 2630, 154, 428, and 135 progenies in F_3, F_4, F_5, and F_6 progenies, respectively at each location for developing kabuli type cultivars.

5. A total of 10,750 individual plants were selected for desi and kabuli types from F_2 thru F_6 generations.

6. High yielding and agronomically uniform progenies numbering 120 for desi type and 25 for kabuli type were bulked in F_5 and F_6 generations.

7. Analysis of data to determine the effectiveness of visual selection for yield in segregating populations indicated, in general, that our judgement appeared to be satisfactory.

8. Testing of advanced generation lines for two years in two environments under high (60 kg P_2O_5/ha) and low (30 kg P_2O_5/ha) fertility conditions did not show any differential response of lines for yield. Further basic studies are needed to ascertain the nutritional requirements of chickpea.

9. A preliminary evaluation of crosses involving various proportions of desi and kabuli germplasm for their improvement indicated that the desi type can be improved

by making crosses within the same group, though a small proportion of genes from the kabuli type may be sometimes beneficial. There was indication that for improving yield in kabuli types, introgression of desi 'yield genes' may be useful. A limited number of crosses involving only kabuli types did not permit us to infer that kabuli types cannot be improved by making crosses among themselves.

10. Hyderabad and Hissar sites differ in growing conditions. Analysis of data with regard to growing and selecting materials at both the sites indicated that it might be valuable to grow F_2 and F_3 generations of the same material at both sites, but in later generations (F_4 thru F_6) early maturing lines should be planted at Hyderabad and late maturing at Hissar.

11. Breeding material from F_1 thru F_6 generations involving wilt resistant strains have been developed. With the development of a Fusarium wilt sick-plot, these materials will be available for screening next season.

12. The range of protein content in our crossing block entries was 13.9 to 28.6 per cent. It was observed that the protein content for desi and kabuli types was of the same magnitude. Seed size also did not affect protein content.

13. In our search for a new plant type, a mid-tall and compact plant type was considered feasible. Estimation of yield from unreplicated F_3 derivatives from tall x traditional dwarf types indicated that this plant type has potential for high yield.

14. Selective mating was initiated in 1976-77 in double cross F_1's of an 11 x 11 diallel made in 1974-75 for yield improvement through recurrent selection.

15. A study on adaptation of chickpea with reciprocal back-crosses of Rabat x F-378 as (D x K) x D and (D x K) x K indicated that chickpea cultivar adaptation for Hissar and West Asia is closer than for Hyderabad and West Asia

16. From a partially concluded experiment regarding rejection of poor performing F_1's, we have observed that poor performing F_1's also performed poorly in F_2, whereas medium and high performers performed more or less equall well. This suggests that crosses performing poorly in F_1 can be rejected.

17. An inheritance study of plant height in two crosses involving tall and dwarf parents indicated partial dominance for tallness.

18. Analysis of an 18 parent diallel showed that additive gene effects were predominant for all traits studied. Per se performance and combining ability were in good agreement for all characters except yield. This study has helped in identifying good combining parents.

19. A line x tester (31 x 7) study indicated that non-additive gene action was predominant for yield, pod number and primary branches. This result was contrary to the findings of the diallel study reported above.

20. The character, two flowers per peduncle, was found to be governed by a single recessive gene, single flower being dominant. Anthocyanin pigment in leaves was controlled by a single dominant gene.

21. An experiment conducted for two years at two locations to choose an efficient plot size for yield trials indicated that with increasing plot size, precision of the experiment increased. Plots 6 x 0.9 m (with 3 rows @ 30 cm) appeared to be acceptable.

22. The second international nursery/trial was furnished to 67 cooperators in 28 countries. Through these nurseries we furnished seed for cultivars, advanced breeding lines (F_5 bulk), and early generation segregating populations (F_3 bulk). We have received results from 10 countries.

23. Three scientific workers, two from Ethiopia and one from Sudan, were provided training in chickpea breeding from October 1976 thru April 1977.

24. The Third Annual Chickpea Breeders' Meet was organized in February, 1977, in which 29 breeders from India and one from Israel participated.

INTRODUCTION

Chickpea was grown on approximately 10.8 million hectares in 34 countries during 1976, producing 7.5 million metric tons of grain. The average yield of 700 kg/ha was rather low. Among the several reasons for low productivity, the one we are directly concerned with is the lack of high yielding, disease resistant cultivars. Therefore, our major emphasis in the past four years has been to increase the yield level by upgrading genetic potential of the cultivars and by incorporating resistance to factors reducing yield, especially diseases.

Two types of chickpeas are grown: 'desi' type (small seeded with variable seed color from brown to bright yellow) and 'kabuli' type (large seeded with salmon white color). More than 80 per cent of the world production is of desi types, but the number of countries producing kabuli types is approximately double that of those producing desi type. In our program we have been generating breeding material for both types, with better success to date with desi type. Chickpea is normally grown on conserved moisture and barely 10 per cent of the area receives irrigation. Hence the first priority is to generate material suited to rainfed conditions. *Fusarium* wilt disease is common in some countries while *Ascochyta* blight is prevalent in others. Therefore, different material is being generated for different regions.

The breeding work is simultaneously carried out at Hyderabad (located at 17°N) and Hissar (located at 29°N) for generating material suited to short and long duration growth periods, respectively. The crop is raised in black soil at Hyderabad and sandy loam soil at Hissar. Hissar site seems to be more suited for kabuli types in comparison to Hyderabad; thus future work on kabuli type will be done primarily at Hissar. The facilities for screening material to *Fusarium* wilt are currently available only at Hyderabad. We have raised off-season nurseries in the Bekka valley of Lebanon and Lahaul valley in North India until 1976. Owing to poor crop growth and for other reasons we have discontinued these nurseries after 1976.

Chickpea requires mild cool temperature. Therefore, this crop is grown during winter season in the tropics and during summer in the temperate regions. Day length and diurnal temperature variations differ widely between the two regions during the crop season. Our limited experience of raising off-season nurseries in the Lebanon indicated some similarity in performance of the material between Lebanon and Hissar. Hence, material for West Asian countries is usually chosen from the Hissar site. Material generated at Hyderabad is performing well in countries located closer to the equator having a short duration season.

The planting of the crop started on October 14 and was completed by October 28 both at Hyderabad and Hissar. All segregating populations were grown at a row spacing of 75 cm and 60 cm at Hyderabad and Hissar, respectively. Fertilizer was broadcast at the rate of 60 kg P_2O_5/ha. We evaluated our advanced generation material at low fertility also, where only 30 kg P_2O_5/ha was applied. Rainfall during the season was normal and above normal at Hyderabad and Hissar, respectively (Table 1) but ceased much before planting. Thus, we were compelled to give come-up irrigation at both sites. However, the season as a whole was very favorable for crop growth, particularly at Hissar. Unfortunately, a portion of the crop was partially destroyed by a hail storm and untimely rains in the first week of May at Hissar.

Heliothis armigera is a serious threat to the chickpea crop at Hyderabad. Insecticidal sprays were applied by the plant protection unit on the recommendation of the entomologists. At Hissar site termites do considerable damage to germinating plants. Soil application of insecticide was done before planting to reduce the damage.

Table 1. Monthly rainfall (mm) during 1976-77 compared with long term averages at Hyderabad and Hissar

Month	Hyderabad		Hissar	
	1976-77	Av. of 70 years	1976-77	Av. of 53 years
June	86.0	104.4	58.0	32.7
July	219.3	191.2	212.5	124.8
August	299.3	127.1	365.8	198.5
September	75.7	162.6	77.7	60.9
October	0.6	83.5	0.0	11.6
November	29.7	20.9	0.0	3.2
December	0.0	6.2	2.5	6.5
January	0.0	7.6	15.7	20.0
February	0.0	9.5	0.0	12.0
March	0.0	11.1	8.4	11.2
April	7.5	28.5	25.8	6.3
May	24.4	31.2	51.8	12.1
Total	742.5	783.8	818.2	399.8

PROJECT 1 : BREEDING 'DESI' TYPE CULTIVARS WITH HIGH YIELD AND STABILITY OF PERFORMANCE

OBJECTIVES:

i. To breed high yielding and disease resistant desi cultivars with stability of performance and good consumer acceptance.

ii. To contribute early and advanced breeding lines to 'desi' chickpea producing countries for strengthening regional and national research programs.

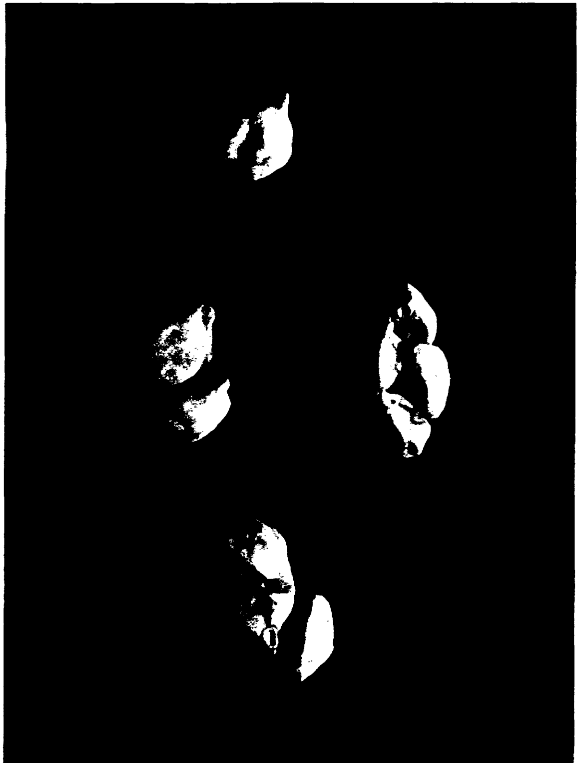
PROCEDURES AND RESULTS

Chickpea is essentially a rainfed crop and is usually grown on conserved moisture with little inputs. Thus our endeavour has been to generate breeding material suited for low input and rainfed conditions. Very little is known about cultivar performance under varying environmental conditions. Therefore, we have initiated a large-scale hybridization program for creating a large amount of variability. It is believed that 'desi' and 'kabuli' types have been separated for centuries, hence introgression of "yield genes" from kabuli to desi and vice-versa through crosses is envisaged for developing high yielding cultivars. With access to a large and diverse germplasm maintained at ICRISAT, we have started breeding program with a very wide genetic base.

Chickpea is a strictly self-pollinated crop, hence mostly the traditional breeding methods for self-pollinated crops are being used for cultivaral improvement. To date pedigree method of breeding has been used predominantly and modified bulk method and backcross-pedigree method less frequently. We expect to make initial gains through "eye selection".

CROSSING BLOCK

Material for the crossing program is drawn mainly from the world collection maintained at ICRISAT center with a few from cooperators. The germplasm lines have been grouped according to their origin and characteristics and the best ones in a group are included in the crossing block. Major characteristics which form the basis for selection of strains



VARIABILITY FOR SEED NUMBER/POD

VARIABILITY FOR POD NUMBER/PEDUNCLE

are high yield; wide adaptation; pod number; seed size, shape, color and type; maturity; combining ability; disease resistance; high protein content; eco-geographic diversity; etc.

On the basis of observations made by us and cooperators, many lines are dropped from the crossing block nursery and new ones are added each year. Thus, we try to maintain crossing block as dynamic as possible. Since the inception of the program 485 strains were used in making crosses. Of the 229 strains included in the 1976-77 crossing block nursery, 150 lines were actually used in the crosses. Many cultivars were used once or twice but 39 lines have been utilized every year since the program started. Of these, 5 cultivars, H-208, JG-62, 850-3/27, C-235, and L-550 have been utilized most extensively and have combined well to produce high yielding segregants. The cultivars used in the crossing program during 1976-77 along with their origin and special characteristics are listed in Table 2. The strains used most extensively have been indicated by an asterisk. Table 3 gives the geographic distribution of strains used in the crossing program.

The entries included in the crossing block nursery were made available to a few cooperators through the nursery called International Chickpea Observational Nursery. Other cooperators were supplied the list and were asked to indicate their preferences for seed supply. On receiving specific requests we furnished seed to them for their use.

CROSSES MADE

Type of crosses made

While attempting crosses, the biggest problem a breeder faces is the right choice of parents. Various schemes have been devised but none of them works like a cook book. We have been adopting different methods, which are briefly described below.

1. Conventional method: One parent is chosen for proven capability and the other which complements the weaknesses of the first.

2. According to ecogeographic diversity: We have been making such crosses as: North Indian desi x South Indian desi; North Indian desi x West Asian desi;

Table 2. List of Desi cultivars used in the crossing program during rabi 1976-77

Sl No	Pedigree	ICC No.	Origin	Seed Color	Special characteristic(s)
1	2	3	4	5	6
1	*Annigeri	4918	Karnataka	Yellow	High yield and early maturity
2	B-108	4919	W.Bengal	Yellow	Released variety
3	*B-110	4920	W.Bengal	Brown	Released variety
4	*Bengal gram	4925	Tamilnadu	Yellow	High yield, wide adaptation
5	*BG-1	4921	I.A.R.I.	Yellow	Promising culture
6	BG-203	8294	I.A.R.I.	Brown	Promising culture
7	C-8	5035	Punjab	Black	Tall, erect, late, shy bearer
8	*C-214	4930	Punjab	Yellow	Drought and frost tolerant
9	*C-235	4935	Punjab	Yellow	High harvest index, high yield
10	Caina	5063	Iran	Black	Very early maturity
11	*Chafa	4934	Maharashtra	Yellow	Released variety
12	Coll.255	10524	Rajasthan	Y.Brown	Drought endurance
13	Coll.319	10588	Rajasthan	Yellow	-do-
14	Coll.326	10595	Rajasthan	Brown	-do-
15	Coll.327	10596	Rajasthan	Y.Brown	-do-
16	Coll.328	10597	Rajasthan	Y.Brown	-do-
17	CPI-36071	8930	USSR	Brown	Tall, erect, good plant type
18	Dubie III	7531	Ethiopia	Brown	Mid-late, good podding
19	*E-100	4936	Greece	Yellow	Salinity resistant
20	*F-61	4939	Punjab	Yellow	Wilt and drought resistant
21	F-187	4940	Punjab	Yellow	High harvest index
22	F-272	4942	Punjab	Yellow	Promising culture
23	F-370	4943	Punjab	Yellow	More pods per primary branch
24	*F-378	4944	Punjab	Yellow	High yield and wide adaptation
25	F-404	4945	Punjab	Yellow	Double podded

Contd...Table 2

1	2	3	4	5	6
26	F_3 Parner 4-14-1	5780	India	Brown	Overlapping pods
27	G-24	4949	Punjab	Brown	Drought tolerant
28	*G-130	4948	Punjab	Yellow	High yield and wide adaptation
29	G-543	4950	Punjab	Yellow	Wilt tolerant
30	*GW-5/7	4953	M.P.	Y.Brown	Large seed size
31	*H-208	4954	Haryana	Yellow	High yield, drought tolerant, high harvest index
32	H-208 x F-61	731-8-3	ICRISAT	Brown	Top yielder at Hyderabad
33	H-208 x F-370	7332-7-2	"	Brown	Top yielder at Hissar
34	H-208 x EC-12409	7330-10-4	"	Y.D.Br.	Top yielder at Hissar
35	850-3/27 x F-378	7389-18-5	"	Brown	Top yielder at Hyderabad
36	850-3/27 x GW-5/7	73114-15-3	"	Y.Brown	-do-
37	JG-62 x Annigeri	73143-5-1	"	Brown	-do-
38	850-3/27 x F-378	7389-15-1	"	Brown	-do-
39	850-3/27 x H-208	73111-8-3	"	Yellow	Top yielder at Hissar
40	850-3/27 x E-100	73126-6-2	"	Brown	-do-
41	850-3/27 x H-208	73111-8-2	"	Brown	-do-
42	H-208 x K-4	7312-4-1	"	L.Orange	Top yielder
43	*H-355	4956	Haryana	Yellow	Promising culture
44	JG-35	6062	M.P.	Yellow	Promising culture in ICCT
45	JG-39	6067	M.P.	Brown	High protein content
46	*JG-62	4951	M.P.	Yellow	Double podded, early, high yielder
47	JG-71	6094	M.P.	Yellow	SC yet to be identified
48	*JG-221	4961	M.P.	Yellow	Good culture
49	JM-583	8542	Netherlands	Yellow	Promising culture at Hissar site

Contd...Table 2

50	JM-995	8565	Nether-lands	Black	Genetic diversity
51	K-368	8919	USSR	D.Brown	Tall, erect, late, bronze leaves, shy fruiting
52	K-468	4963	U.P.	Yellow	Promising culture
53	K-56566	8928	USSR	Y.Brown	Tall, erect, good podded
54	Kaka	7509	Iran	Black	Released variety
55	L-345	4969	Punjab	Green	Released cultivar
56	Malkan-A/2	5332	Pakistan	Yellow	Promising culture
57	N-59	4983	Maharashtra	"	Released cultivar
58	No. 22	4974	India	Yellow	High pod number, good plant type
59	No. 296	4982	Punjab	Green	Dwarf culture
60	NEC-18	6153	Jordan	Y.Brown	High pod number (Pulse Germplasm)
61	*NEC-123	6250	Morocco	Black	Erect, tall, late
62	NEC-229	6321	India	Brown	Dwarf, very good pod-ding, early (to be crossed with tall cultivars)
63	NEC-240	7734	USSR	Yellow	Erect, many pods
64	*NEC-249	7735	India	Brown	Upright habit, good plant type
65	NEC-293	8962	India	Brown	Good local type (Hawtin's observation)
66	NEC-318	8970	Iran	Yellow	Promising culture from Hissar site
67	NEC-421	8999	Iran	Yellow	Top yielder at Hyderabad (Pulse Germplasm)
68	NEC-426	9001	Iran	D.Brown	-do-
69	NEC-472	6462	Iran	Brown	Promising culture from Hissar site
70	NEC-495	6479	Iran	Brown	Promising culture
71	NEC-550	6506	Iran	Yellow	One of the highest yielders at Hissar site
72	NEC-555	6609	Iran	Yellow	-do-
73	NEC-556	9049	Iran	Yellow	Promising culture from Hissar site

Contd...Table 2

1	2	3	4	5	6
74	NEC-562	9051	Iran	Yellow	Mid-late, dwarf, excellent podding
75	NEC-578	9060	Iran	Brown	Promising culture from Hissar site
76	NEC-584	6524	Iran	Yellow	Promising culture from Hissar site
77	NEC-607	9070	Unknown	Yellow	-do-
78	NEC-639	6563	Iran	Y.Brown	-do-
79	NEC-721	7752	Iran	Yellow	Upright habit
80	NEC-746	9085	Iran	Yellow	Promising culture from Hissar site
81	NEC-750	6652	Iran	Brown	-do-
82	NEC-802	6679	Iran	Brown	High number of pods
83	NEC-847	9117	Iran	Brown	Top yielder at Hyderabad (Pulse Germplasm)
84	NEC-850	6708	Iran	Y.Brown	Promising culture from Hissar site
85	NEC-901	6744	Iran	Brown	Good culture
86	NEC-902	6745	Iran	Brown	Good culture
87	NEC-920	6761	Iran	Y.Brown	Promising culture from Hissar site
88	NEC-951	6786	Iran	Y.Brown	-do-
89	NEC-970	6805	Iran	Brown	-do-
90	NEC-974	6808	Iran	Brown	-do-
91	NEC-989	6819	Iran	Yellow	Multiseeded (Pulse Germplasm)
92	NEC-1077	7764	Iran	Yellow	Good fruiting, small seeded
93	NEC-1128	6901	Iran	Y.Brown	Promising culture from Hissar site
94	NEC-1135	6905	Iran	Brown	-do-
95	NEC-1196	6952	Iran	Brown	Promising culture
96	NEC-1639	7777	Pakistan	Y.Brown	Erect and tall
97	NEC-2305	8158	USA	Brown	Promising culture from Hissar site
98	NEC-2368	8209	Unknown	Yellow	-do-
99	NEC-2383	8222	Unknown	Yellow	-do-
100	NEC-2404	8241	India	Yellow	-do-
101	NEC-2413	8250	Unknown	Yellow	-do-
102	NEC-2438	8265	Turkey	Y.Brown	-do-

Contd...Table 2

1	2	3	4	5	6
103	P-6	9	U.P.	D.Brown	Multiseeded (Pulse Germ-plasm)
104	P-10	17	U.P.	Brown	More secondary branches and pods
105	P-30	38	U.P.	Y. Brown	Promising culture from Hyderabad site
106	*P-36	43	U.P.	Brown	Responds to fertilizer
107	P-45	57	U.P.	Yellow	High harvest index (Pulse Germplasm)
108	P-82	104	U.P.	Brown	Multiseeded
109	P-99	121	U.P.	Y.Brown	Multiseeded
110	P-134-1	159	U.P.	Y.Brown	Promising culture from Hyderabad site
111	P-156	190	U.P.	Yellow	High harvest index (Pulse Germplasm)
112	P-200	251	U.P.	Y.Brown	Promising culture from Hyderabad site
113	*P-271	364	U.P.	Brown	Double podded
114	P-317	431	Bihar	D.Brown	Multiseeded
115	P-319	434	Bihar	Y.Brown	Promising culture from Hissar site
116	P-324	438	Bihar	Y.Brown	
117	P-326	440	Bihar	Y.Brown	Promising culture from Hissar site
118	P-345	459	Bihar	Brown	Double podded
119	P-372-2	461	Bihar	Brown	High number of pods, early
120	P-388	508	A.P.	Yellow	High pod number
121	P-394-1	520	A.P.	Y.Brown	Promising culture from Hyderabad site
122	P-416	535	I.A.R.I.	Y.Brown	-do-
123	P-431	547	I.A.R.I.	Yellow	Multiseeded
124	P-436	552	I.A.R.I.	Yellow	More pods
125	P-485	615	I.A.R.I.	Y.Brown	Promising culture from Hissar site
126	P-505	645	I.A.R.I.	L.Brown	Double podded
127	P-514	653	I.A.R.I.	Brown	Multiseeded
128	P-538	686	Punjab	O.Brown	Good seed size among 'desi' type
129	P-619-1	780	Punjab	Brown	Promising culture
130	P-623	788	Punjab	Brown	Multiseeded

Contd...Table 2

131	P-662	839	I.A.R.I.	Brown	Tall, more pods
132	P-678	858	U.P.	Brown	Promising type
133	P-690	867	U.P.	D.Brown	Attractive plant type
134	P-735-1	926	India	L.Yellow	Promising culture from Hissar site
135	P-753	954	I.A.R.I.	L.Brown	-do-
136	P-810	996	Mexico	Brown	Good combiner (Bahl's observation)
137	P-840	1009	Morocco	Brown	More primary branches
138	P-856	1026	Iran	Yellow	Promising culture from Hissar site
139	P-896	1057	Afghanis-tan	L.Yellow	Promising culture
140	P-946	1082	Iran	Y.Brown	Promising culture from Hissar site
141	P-947	1083	Iran	Y.Brown	Attractive habit of growth
142	P-992	1109	Pakistan	Brown	Late, dark leaves
143	P-993	1110	Pakistan	Brown	Late, dark leaves
144	P-1025-1	1130	India	L.Yellow	Promising culture from Hissar site
145	P-1027-1	1134	U.P.	L.Yellow	-do-
146	P-1037	1140	U.P.	L.Brown	-do-
147	P-1041-1	1143	U.P.	L.Yellow	-do-
148	P-1042	1144	U.P.	L.Yellow	-do-
149	P-1081	1163	Nigeria	Y.Brown	Responds to fertilizer
150	P-1081-1	1164	Nigeria	L.Yellow	Attractive growth habit
151	P-1137	1230	U.P.	Y.Brown	Top yielder in ICCT
152	P-1162	1265	U.P.	Brown	High yield
153	P-1179	7681	U.P.	Y.Brown	Good podding
154	P-1181-A	1294	U.P.	Brown	Attractive plant type
155	P-1198-1	1315	U.P.	Brown	Multiseeded (Pulse Germplasm)
156	P-1208	1337	U.P.	Y.Brown	Promising culture from Hissar site
157	P-1209	1341	U.P.	Y.Brown	High harvest index (Pulse Germplasm)
158	P-1209-1	1342	U.P.	Brown	Promising culture from Hissar site
159	P-1214-1	1352	U.P.	Yellow	High harvest index (Pulse Germplasm)

Contd...Table 2

1	2	3	4	5	6
160	P-1231	1376	U.P.	Brown	Promising culture from Hyderabad site
161	P-1238	1388	U.P.	Y.Brown	Responds to fertilizer
162	P-1242	1395	U.P.	Y.Brown	Promising culture from Hissar site
163	P-1265	1443	U.P.	Yellow	Responds to fertilizer
164	P-1305-1	1519	U.P.	Brown	High number of pods
165	P-1363-1	1635	U.P.	Y.Brown	Promising culture from Hyderabad site
166	*P-1387	1669	U.P.	Y.Brown	Multiseeded
167	P-1497	1856	India	Brown	Large pods, good fruiting
168	P-1539-1	1909	Unknown	Yellow	Promising culture from Hissar site
169	P-1613	1994	India	Brown	High no. of pods and primary branches
170	P-1630	2021	India	Brown	Multiseeded
171	P-1774	2204	Ceylon	Yellow	Promising culture
172	P-1781	2210	Algeria	Yellow	Promising culture from Hissar site
173	P-1784-1	2215	Egypt	Yellow	-do-
174	P-1798	2230	Pakistan	L.Yellow	-do-
175	P-1845	7354	Karnataka	L.Yellow	-do-
176	P-2019-1	2334	Iran	Y.Brown	-do-
177	P-2170	2396	Iran	Black	High pod number (Pulse Germplasm)
178	P-2202	2427	Iran	L.Brown	Promising culture from Hissar site
179	P-2202-2	2427	Iran	Yellow	-do-
180	P-2422-1	2525	Iran	Brown	Semi-spreading
181	P-2774	2695	Iran	Yellow	Multiseeded
182	*P-2974	2784	Iran	Y.Brown	Vigorous, more pods
183	P-2994	2796	Iran	Black	Promising culture
184	*P-3090	2828	Iran	White	Tall, more pods
185	P-3482	8010	Iran	White	Promising culture from Hissar site
186	P-3642-1	3124	Iran	Y.Brown	-do-
187	P-3743-2	3193	Iran	Y.Brown	-do-
188	P-3765	3210	Iran	Y.Brown	-do-
189	P-4032	3356	Iran	Y.Brown	-do-
190	P-4087	3399	Iran	L.Brown	Cream color, excellent podding, early

Contd...Table 2

1	2	3	4	5	6
191	P-4203	3500	Turkey	Brown	Double podded
192	P-4227	3523	Iran	Brown	High harvest index (Pulse Germplasm)
193	P-4249-1	3567	Iran	Brown	Promising culture from Hissar site
194	P-4275	3607	Iran	Yellow	Promising culture
195	P-4301	3651	Iran	Y.Brown	Promising culture from Hissar site
196	P-4328-2	3694	Iran	Black	-do-
197	P-4341-2	3718	Iran	L.Brown	-do-
198	P-4353-1	3735	Iran	Y.Brown	-do-
199	P-6099	4552	India	Black	Large seed size, upright habit
200	P-6308	4716	India	Y.Brown	Good podding, upright, dwarf
201	P-9668	4873	India	Y.Brown	Early, med. seed size, very good podding
202	*Pant-102	4988	U.P.	Yellow	Good plant type and high yielder
203	*Pant-104	4989	U.P.	Yellow	Good yielder
204	PG-72-8	10080	U.P.	Yellow	Promising culture
205	PG-72-84	10081	U.P.	Brown	Promising culture from Pantnagar
206	Ponaflar-2	5434	Bihar	Y.Brown	Creeping on ground
207	PRR-1	10301	Mexico	Brown	Simple leaf mutant, early, good plant type
208	Pyrouz	7511	Iran	Brown	Released variety
209	*RS-11	4992	Rajasthan	Yellow	High no. of pods and branches
210	SL-972-A	8589	Ethiopia	Yellow	Mid-late, good podding
211	*T-3	4998	U.P.	Yellow	Large seed size, upright habit
212	T-37	5907	Pakistan	Brown	Good podding, med. maturity, bushy type, good podding, C.tall
213	*T-103	5981	U.P.	D.Brown	Early good culture
214	*USA-613	5001	USA	Y.Brown	Tall culture
215	V-4	5465	Mexico	Brown	High yield
216	V-165	5585	Mexico	Yellow	Promising culture from Hissar site

Contd...Table 2

1	2	3	4	5	6
217	WFWG-III	6012	Maharash-tra	Brown	More pods, very tiny pods and seeds
218	WP-2654-A	8619	Ethiopia		Mid-late, dwarf
219	12-071-05432	7517	Iran	Black	Blight tolerant
220	12-071-10054	7520	Iran	Black	Blight tolerant
221	310479	7337	USA	Yellow	Promising culture
222	*WR-315	8933	U.P.	Y.Brown	Wilt resistant
223	12-071-04244	7512	Iran	Black	Blight resistant
224	12-071-05093	7514	Iran	Black	Blight tolerant
225	100-C-1	7617	Afghanis-tan	Yellow	Semi-erect, very good podding
226	231-C-2	9791	Afghanis-tan	L.Brown	Promising culture from Hissar site
227	723-C-2	9836	Afghanis-tan	L.Brown	-do-
228	*850-3/27	5003	U.P.	Brown	Good combiner, large seed size, upright habit
229	869-C-1	9762	Afghanis-tan	L.Brown	Promising culture from Hissar site

N.B. Most of the special characteristics were reported from the originating centers.

* Strains used extensively every year since 1973-74.

A WORKER MAKING CROSSES

A VIEW OF CROSSING BLOCK NURSERY

Table 3. Geographic distribution of desi strains used in 1976-77 crossing block at ICRISAT

Country/ Institute	No. of strains	Country/ Institute	No. of strains
ICRISAT	11	Morocco	2
India	111	Afghanistan	5
Iran	59	Algeria	1
USSR	5	USA	3
Ethiopia	5	Turkey	2
Greece	1	Mexico	4
Pakistan	6	Nigeria	2
Netherlands	2	Ceylon	1
Jordan	1	Unknown	8
	Total	229	

South Indian desi x West Asian desi; Indian desi x Exotic desi etc. Similar combinations are made for kabuli types.

3. Introgression of "yield genes" from 'kabuli' to 'desi' and vice-versa: We believe that there is quite a bit of divergence between 'desi' and 'kabuli' types. Therefore, introgression of 'kabuli' germplasm into 'desi' germplasm and vice-versa may lead to a substantial increase in yield. We have made various types of crosses as follows:

D x K
(D x K) x D
(D x K) x K
(D x D) x K
(K x K) x D

(Note: D = Desi, K = Kabuli)

4. Multiple crosses: In view of the limited work done on this crop, it was found difficult to select two parents which possess most of the attributes that a breeder would like to combine into one. Hence it was thought desirable to resort to multiple crosses. The following types of crosses have been attempted.

   a) Three-way crosses

   b) Four-way crosses

   c) Composite crosses : The theory behind this type of crosses is that the chances of any one individual carrying all or most of the potentially coadapted gene blocks are too remote in an F_2, therefore, strict inbreeding will rarely produce the best genotype. Recombining two partially balanced genotypes increases the chances that the maximum number of harmoniously functioning gene blocks will be assembled together and subsequent inbreeding may throw relatively better adapted and high yielding cultivars.

   The steps involved in making composite crosses are: (1) Selection of most productive superior recombining F_2 crosses, (2) Selection of plants in chosen F2's, (3) Intercrossing of best plants between and among F_2 populations, (4) Reselecting crossed plants in the F_2 populations at the end of the season.

Number of crosses made

We have been making a large number of crosses each year to create variability suitable for different agroclimatic regions. During 1976-77, we made 994 crosses. A total of 6971 crosses have been produced since 1973-74 mainly at Hyderabad, plus a few at Hissar and off-season nursery sites (Table 4, Fig. 1). A total of 485 parental lines having diverse origin and characteristics have been utilized in making these crosses.

Crossing Technique

The chickpea flower is small, about 1 cm in length. It has five sepals, five petals, ten diadelphous stamens and one pistil. Emasculation requires opening of the bud and removal of the stamens which is an intricate task. We inves-

Table 4. Chickpea crosses made at ICRISAT through 1976-77 Rabi

Year	Place	Single cross	Three-way cross	Double cross	Composite cross	Total no. of crosses
1973-74	Hyderabad	424			-	424
1974	Lahaul	167	77	3	-	247
1974	Lebanon	40	21	25	-	86
1974-75	Hyderabad	839	151	94	253	1337
1975	Lahaul	183	235	180	-	598
1975	Lebanon	23			-	23
1975-76	Hyderabad	659	276	167	484	1586
1975-76	Hissar	371	-	-	322	693
1976	Lahaul	39	75	34	-	148
1976-77	Hyderabad	542	202	36	452	1232
1976-77	Hissar	274	-	-	323	597
	Total	3538	1037	539	1834	6971

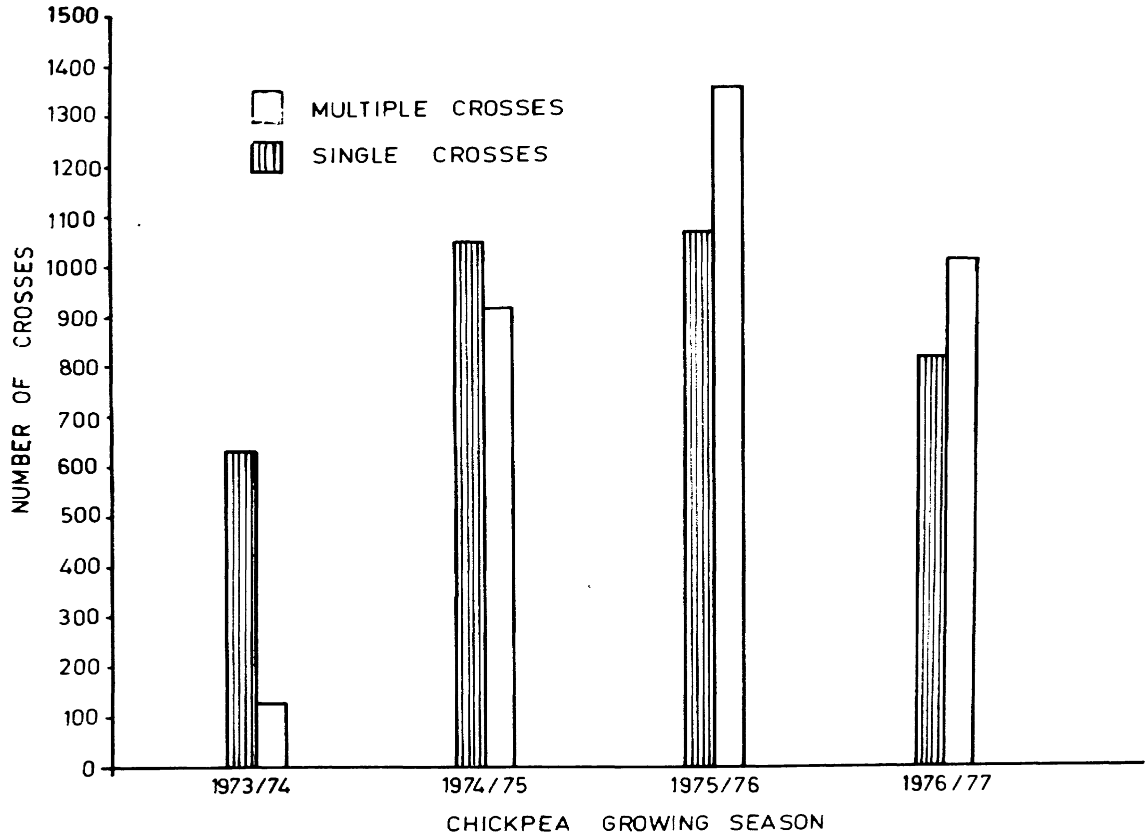


FIG. 1 : CHICKPEA CROSSES MADE AT ICRISAT UPTO 1976/77.

tigated several variables dealing with emasculation and pollination.

i) Time of Day

We gathered data on seed set related to pollination during different time periods. We observed that under Hyderabad conditions, pollination can be done at any time of day between 0800 and 1700 hours (Table 5).

Table 5. Seed-set percentages according to time of day the flower was pollinated during January 1974 at Hyderabad

Time of Day	Percentage of Seed-set
0800 to 1000 hours	19.7
1001 to 1200 hours	21.4
1300 to 1500 hours	21.2
1501 to 1700 hours	23.1
Average temperature	26.6^{o}C
Average relative humidity	59.8%
Average hours of sunshine	10.4

ii) Time of Emasculation and Pollination

In chickpeas generally emasculation has been done one day and pollination the next day. In some grain legumes the two processes are done simultaneously. We experimented with both methods. Data in Table 6 show that the simultaneous emasculation and pollination method gave better results under Hyderabad conditions.

Table 6. Seed-Set Percentages According to Simultaneous or Consecutive-Day Emasculation and Pollination, Hyderabad, 1974.

Method	Percentage of Seed-Set
Consecutive days (n = 713 flowers)	15.0
Simultaneous (n = 576 flowers)	23.6

iii) Crossing without emasculation

Emasculation and to a certain extent pollination can cause injury to the pistil and reduce seed set. We tried to investigate the possibility of pollinating a flower without emasculation. This requires the right choice of bud where the pistil is mature but anthers are still intact (not burst) The pollen from a mature flower is applied in the hope that cross-pollination will precede the maturity of the anthers of the flower. There are chances of self-pollination in this process. We have observed upto 14 per cent self-pollination. If there is a dominant marker, roguing of selfed plants is possible in the F_1 generation. For example, in kabuli x desi crosses, use kabuli type as a female and desi as a male. Any white flowered plant in the F_1 generation can be removed as that would be a self.

iv) Other Variables

We have observed a few other variables related to success in making crosses. They are listed below:

(a) The success of seed set varied from person to person; some achieving high per cent of success while others very low.

(b) The seed set in some cross combinations was higher than others indicating that seed set varied from cross to cross.

(c) The per cent of seed set was more in crosses involving desi parents than kabuli parents.

(d) The seed set was low when buds were picked up for crossings in very early or advanced stage of plant growth.

(e) The seed set was adversely affected when temperature was comparatively high.

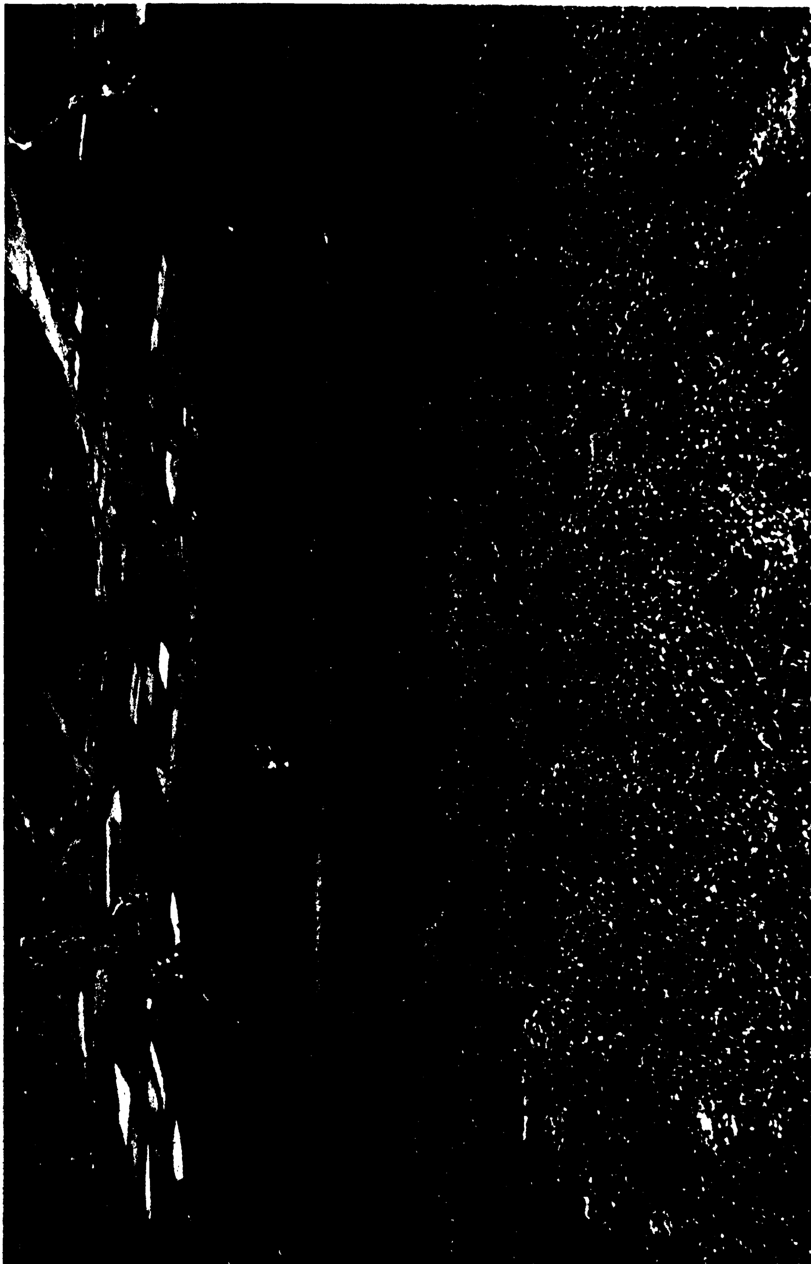
(f) The success in crossing was higher on a clear sunny day than a cloudy day.

F_1 GENERATION

With the availability of off-season advancement facilities in the Bekka Valley (Lebanon) during 1974 and 1975 and in the Lahaul Valley (North India) during 1974 thru 1976, we grew our F_1's in the off-season. During 1976, we grew 1494 F_1's in the off-season nursery at the Lahaul Valley. Due to unfavorable weather in the valley, we could produce F_2 seeds from only 40% of the crosses.

Despite heavy loss of material during 1976, these off-season nurseries were of great value in advancing the material and saving a crop season. Unfortunately, we had to close our work at both locations. The political situation in Lebanon and problems of processing so many samples through quarantine forced us to discontinue our work there. The Lahaul location had to be abandoned because of unfavorable growth conditions and the problem of acquiring land for raising the crop.

We grew 30 plants of each single cross F_1 flanked on either side by their parents, and approximately 75 plants of each multiple cross. Very poor performing F_1's were rejected Within the multiple crosses, selection was made for good plants based on general plant appearance, maturity, pod number, disease reaction etc. Selected plants in each multiple cross were harvested in bulk to grow the F_2 generation.



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In the main season of 1976/77, we raised 312 F_1's. We also grew 303 F_1's of those multiple crosses which were lost in the Lahaul Valley due to unfavorable weather.

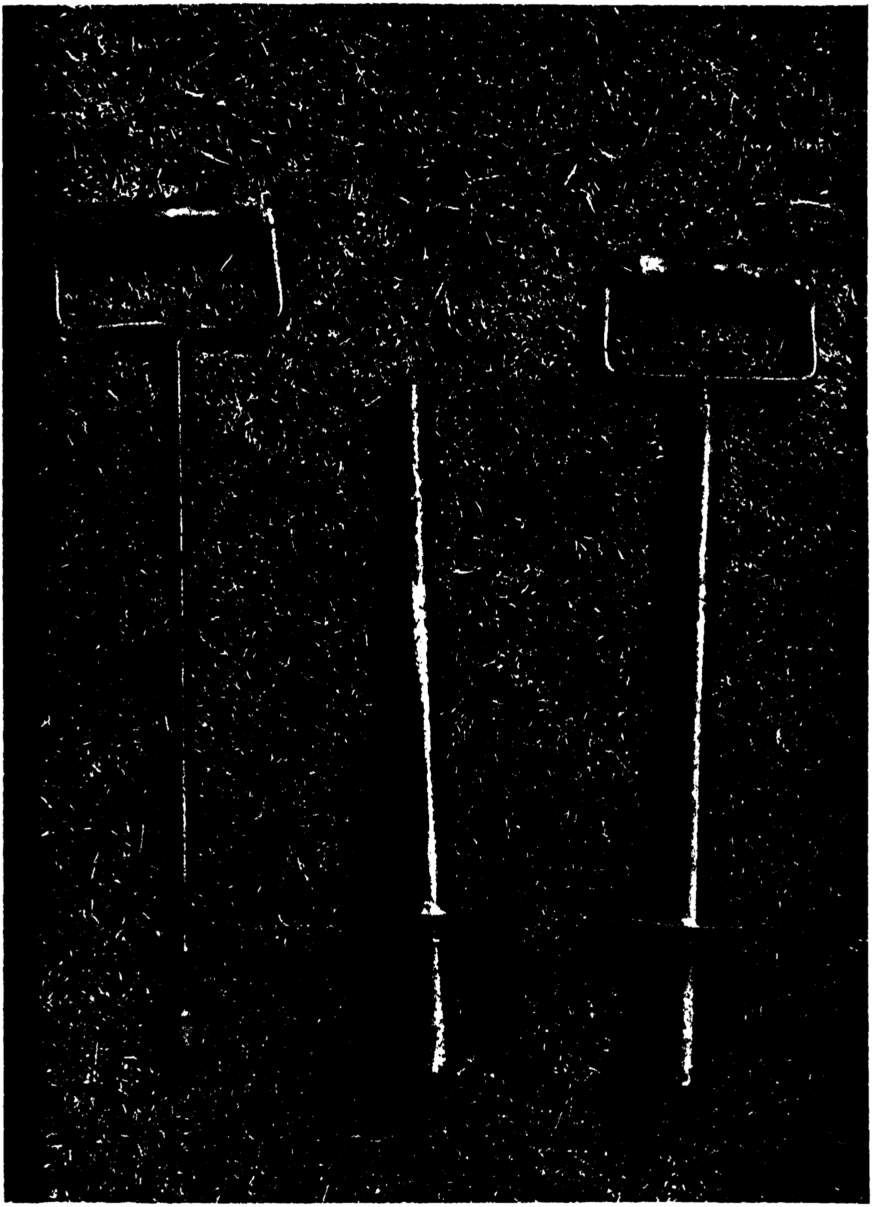
F_2 POPULATIONS

We planted F_2 populations both at Hyderabad and Hissar. The F_2's were space planted, giving 75 x 20 cm^2 and 60 x 20 cm^2 at Hyderabad and Hissar, respectively, to each plant. We dibbled the seed by hand-dibbler.

During 1976-77 we planted 167 populations of single crosses, and 107 populations of multiple crosses. The total number of F_2 populations grown from 1974-75 onwards is given in Table 7. We planted 500 seed of each single cross and 1500 seed of each multiple cross, both at Hyderabad and Hissar. Thus a total of 1000 plants for single crosses and 3000 plants for multiple crosses were grown at the two locations. We have observed wider differences among F_2's than within F_2 populations. Hence we prefer to grow a larger number of F_2 populations rather than more plants per F_2 population. We planted four standard checks, JG-62 (south Indian cultivar), G-130 (north Indian cultivar), L-550 (best kabuli check), and 850-3/27 (medium duration cultivar), at the borders and center for comparison.

Table 7. Total number of F_2 populations grown upto 1976-77

Year	Season	Hyderabad	Hissar	Lebanon/Lahaul
1974-75	rabi	324	-	
1975	off-season	-	-	204
1975-76	rabi	508	386	
1976-77	rabi	274	328	



HAND DIBBLER USED FOR PLANTING CHICKPEA

As the material approached maturity, we evaluated the F_2 populations visually in 3 categories; very promising, promising, and discard. While classifying the populations into various classes the overall growth, podding, plant habit, maturity, amount of segregation, etc., were taken into consideration. The scoring of populations was normally done by a team of 2 to 3 plant breeders.

Of the 274 F_2 populations involving desi x desi parents, 6 populations were rated very promising, 62 rated promising, and 206 discard at Hyderabad. At Hissar we planted 194 single crosses and 134 multiple crosses. Out of these 15 were rated very promising, 112 rated promising, and 207 rated as discard.

On completion of scoring of F_2 populations, we made individual plant selections. We based our selection on pod numbers, maturity, morphological and seed character, disease reaction, plant vigour, etc. Generally we selected more plants in populations evaluated as very promising than those rated promising. A few promising plants were also selected even from some of the populations which were rated as discard. After plants were individually selected, the number of pods on each was counted. Random pod counting in a few plants was also done on standard cultivars for comparing with our selected plants in F_2 populations. Plants having more pods than the checks were finally selected. The plants which were finally retained had a minimum of 200 pods. There were many plants having more than 500 pods, a few even exceeding 1000. The number of pods per plant was considerably higher at Hissar than at Hyderabad.

A total of 1553 and 1772 plants were selected at Hyderabad and Hissar, respectively. The selected plants were individually harvested and kept in separate envelopes for planting in the next season.

All plants in the populations rated as very promising were bulk harvested for furnishing to cooperators as early generation segregating material. The number of F_2 populations (F_3 seed) retained were 14 each from Hyderabad and Hissar. The details of these crosses are presented in Table 8.

Table 8. F_3 Bulks of Desi x Desi crosses selec ed for supplying to cooperators during 1977-78

S.No.	Pedigree	Cross
		Hyderabad
1	741229-BP	P-472 x Pant-104
2	741479-BP	P-481 x GW-5/7
3	741528-BP	NEC-249 x P-3090
4	741572-BP	P-314 x P-388
5	7547-BP	G-130 x WR-315
6	75147-BP	N-59 x P-319-1
7	75209-BP	(F-378 x NEC-240) x (P-472 x P-896)
8	75315-BP	(P-436 x P-3090) x (F-378 x C-235)
9	75394-BP	NEC-249 x (C-214 x P-493)
10	75459-BP	(P-472 x P-6218) x JG-62
11	75769-BP	P-1363-1 x P-3090
12	75793-BP	NEC-249 x NP-34
13	75909-BP	P-1488 x 12-071-10054
14	751016-BP	NEC-249 x P-1245-1
		Hissar
1	75756-BH	P-1013 x C-214
2	75787-BH	G-130 x NP-34
3	75789-BH	C-214 x NP-34
4	752170-BH	F_2 (JG-39 x NEC-759) x F_2 (Ceylon-2 x P-662)-1
5	752198-BH	F_2 (Ceylon-2 x P-1243) x F_2 (F-61 x NEC-759)-1
6	752199-BH	F_2 (Ceylon-2 x P-1243) x F_2 (F-61 x NEC-759)-2
7	752202-BH	F_2 (Ceylon-2 x P-1243) x F_2 (F-61 x NEC-759)-5
8	752243-BH	F_3 (RS-11 x Ceylon-2) x NEC-759 X F_3 (H-223 x GW-5/7) x P-1243
9	752288-BH	F_3 (GW-5/7 x BEG-482) x F_3 (Pb-7 x RS-11)-3
10	752590-BH	F_4 (JG-62 x K-468) x (K-468 x F-378)
11	741229-BH	P-472 x Pant-104
12	7589-BH	P-1863 x P-3827
13	75482-BH	P-2940 x (T-3 x P-514)
14	75188-BH	(C-235 x NEC-249) x (F-61 x NEC-721)

F_3 PROGENIES

All the individual plants selected either at Hyderabad or at Hissar in F_2 generation were grown as F_3 progeny rows at both locations. Forty plants were grown for each F_3 progeny in two rows, 4 m long. The row spacing of 75 cm and 60 cm was maintained at Hyderabad and Hissar, respectively. The plants within a row were spaced at 20 cm. Three check cultivars, JG-62 (south Indian desi), G-130 (north Indian desi) and L-550 (kabuli type), were planted alternately after every twenty progenies for comparison.

At Hyderabad 3331 progenies including 794 from single crosses, 983 from three-way crosses, 1253 from double crosses, and 301 from composite crosses were grown in 1976-77. At Hissar 3246 progenies were grown which included 785 from single crosses, 923 from three-way crosses, 884 from double crosses and 654 from composite crosses.

Table 9 gives the number of F_3 progenies grown each year upto 1976-77. During 1975-76 we had grown F_3 modified bulk populations. These populations were the bulk progeny of F_2 populations grown in the Lebanon during 1975 where the crop growth was poor and there was little visible phenotypic variability in the population. Therefore, these were advanced by modified bulk method where poor plants were rejected and the rest bulked.

At the time of maturity all the progenies were evaluated on a 1 to 5 visual rating scale:

1 - Excellent
2 - Very good
3 - Good
4 - Fair
5 - Poor

The criteria for evaluating progenies and plants were the same as in F_2, except that more weight was given to pod number which is highly correlated with yield. Since selection for yield is more effective in F_3, we made stringent selection at this stage.

From the progenies rated 1, 2, and 3, good individual plants were selected. Depending upon the degree of segrega-

Table 9. F_3 Progenies grown through 1976-77

Year/Season	Hyderabad	Hissar	Off-season
1975/off-season	--	--	2000
1975-76/rabi	143(B)*; 139	157(B)*; 134	--
1976/off-season	--	--	1014
1976-77/rabi	3331	3246	--

(B)* denotes F_3 modified bulk populations.

tion and availability of good plants, 1 to 3 plants were selected from each of these progenies. The progenies rated 4 and 5 were discarded.

At Hyderabad the visual rating was: 17 progenies rated 2, 212 rated 3 and 3102 were rated 4 and 5. At Hissar one progeny was rated as 1, 28 rated as 2, 822 rated as 3 and the remaining rated in 4 and 5 categories.

Thus far we have been growing all selected material at both sites. We had originally decided that after 2 years we would evaluate this practice. We critically examined the performance of material at both locations and found that the material selected at one location also appeared to be suitable for the other location. Therefore, we have decided to continue this practice for 1 or 2 more seasons before arriving at a final decision.

F_4 PROGENIES

The F_4 generation material was grown in the same manner as that of F_3 generation. The crop condition at Hissar was generally good, whereas at Hyderabad it was poor in some places because of soil heterogeneity.

Any plant selected in the F_3 generation either at Hyderabad or at Hissar was grown at both the locations this season. A total of 2054 F_4 progenies were planted at both sites during 1976-77.

The progenies were visually scored on a 1 to 5 scale. The characters which were taken into consideration at the time of evaluation were the same as in F_3 generation.

The progenies which were rated as 1, 2, 3, 4, and 5 were 0, 13, 174, 1312, and 555 respectively at Hyderabad. The number of progenies falling in different categories at Hissar was 3 in 1, 31 in 2, 342 in 3, 1436 in 4 and 242 in 5 categories.

In addition to visual scoring, we recorded the actual yield of each progeny at both locations. The progenies exceeding the nearest check and the highest yield of the best check are given in Table 10.

Table 10. Comparison of F_4 progenies with best check (JG-62 at Hyderabad; G-130 at Hissar) during 1976-77

Progenies yielding	Hyderabad (No.)	Hissar (No.)
More than the nearest check	859	479
Higher than the highest check	106	15

It can be seen that 859 and 479 progenies outyielded the nearest best check at Hyderabad and Hissar respectively. At Hyderabad 106 entries and at Hissar 15 entries yielded higher than the highest check yield. These progenies merit special attention in the next generation. Their performance is shown in Tables 11 and 12 for Hyderabad and Hissar, respectively.

The highest yield recorded by a particular progeny at Hyderabad was 2417 kg/ha, giving 701 kg/ha (40%) more yield than JG-62. At Hissar the highest yielding progeny (4981 kg/ha) exceeded G-130 by 25 per cent.

Table 11. Mean yield in kg/ha of the progenies exceeding the highest yield of the check at Hyderabad

Pedigree	Cross	Yield	% increase over highest JG-62 yield
74125-B-1H-BP	(H-208 x P-1630)	2417	40.85
74324-B-6H-BP	(F-378 x JG-62) x L-550	2375	38.40
74111-B-3H-BP	(P-505 x F-378)	2373	38.29
74279-B-1P-BP	(850-3/27 x T-3) x P-4245-1	2309	34.56
74270-B-1H-BP	(850-3/27 x Chafa) x G-130	2292	33.57
74274-1-3P-BP	(850-3/27 x Chafa) x JG-62	2275	32.58
74144-B-7H-BP	(BG-1 x C-235)	2267	32.11
74279-B-2P-BP	(850-3/27 x T-3) x P-4245-1	2250	31.12
74109-B-5H-BP	(P-436 x G-130)	2250	31.12
7472-B-6H-BP	(F-61 x L-550) x P-272	2217	29.19
74113-B-2H-BP	(P-505 x BG-1)	2167	26.28
74109-B-10H-BP	(P-436 x G-130)	2150	25.29
74249-B-7P-BP	(P-502 x No. 42)	2133	24.30
74278-B-5P-BP	(850-3/27 x N. 59) x P-1387	2133	24.30
74324-B-5H-BP	(F-378 x JG-62) x L-550	2125	23.83
74273-B-8H-BP	(850-3/27 x H-223) x P-82	2118	23.43
74274-1-2P-BP	(850-3/27 x Chafa) x JG-62	2090	21.79
74156-B-5H-BP	(JG-221 x C-235)	2083	21.38
74111-B-1H-BP	(P-505 x F-378)	2070	20.63
7472-B-13H-BP	(F-61 x L-550) x P-272	2067	20.45
74157-B-5H-BP	(USA-613 x C-235)	2042	19.00
74258-B-2H-BP	(H-208 x B-108) x 850-3/27	2042	19.00
74223-B-2H-BP	(H-223 x No. 42)	2022	17.83
74310-B-3P-BP	(GW-5/7 x Pant-104) x JG-62	2017	17.54
74273-B-6H-BP	(850-3/27 x H-223) x P-87	2000	16.55
74126-B-1H-BP	(P-99 x F-378)	2000	16.55
74324-B-13H-BP	(F-378 x JG-62) x L-550	2000	16.55
74249-B-3P-BP	(P-502 x No. 42)	1997	16.38
7472-B-3H-BP	(F-61 x L-550) x P-272	1988	15.85
74117-B-11P-BP	(JG-62 x P-1387)	1983	15.56
74223-B-4H-BP	(H-223 x No. 42)	1983	15.56
73414-9-1P-BP	(P-4746 x Sel.544)	1977	15.21
74156-B-3P-BP	(JG-221 x C-235)	1977	15.21
74224-B-1P-BP	(CP-66 x No. 42)	1967	14.63
74303-B-4P-BP	(JG-62 x T-3) x P-431	1967	14.63
74304-B-1H-BP	(JG-62 x Chafa) x P-1022	1958	14.10

Contd... Table 11

Pedigree	Cross	Yield	% increase over highest JG-62 yield
74109-B-7H-BP	(P-436 x G-130)	1958	14.10
74161-B-2H-BP	(T-3 x BEG-482)	1958	14.10
74257-B-1H-BP	(H-208 x T-3) x JG-62	1958	14.10
74324-B-8H-BP	(F-378 x JG-62) x L-550	1958	14.10
74203-B-1H-BP	(N. 59 x Pant-102)	1952	13.75
74144-B-6H-BP	(BG-1 x C-235)	1950	13.64
7453-B-1P-BP	(H-208 x BG-1) x (JG-62 x Ceylon-2)	1942	13.17
74256-B-3P-BP	(CP-66 x F-496) x H-208	1933	12.65
74303-B-1P-BP	(JG-62 x T-3) x P-431	1933	12.65
74161-B-3H-BP	(T-3 x BEG-482)	1930	12.47
74213-B-2H-BP	(F-378 x E-100)	1917	11.71
74324-B-2H-BP	(F-378 x JG-62) x L-550	1917	11.71
74324-B-3H-BP	(F-378 x JG-62) x L-550	1915	11.60
73385-B-2P-BP	(F-378 x P-3090)	1902	10.84
74159-B-1H-BP	(H-355 x BEG-482)	1900	10.72
74274-B-3P-BP	(850-3/27 x Chafa) x JG-62	1887	9.97
73418-B-2P-BP	(F-370 x P-502)	1883	9.73
74113-B-3H-BP	(P-505 x BG-1)	1883	9.73
74304-B-1P-BP	(JG-62 x Chafa) x P-1022	1883	9.73
74290-B-1P-BP	(JG-62 x Chafa) x P-271	1875	9.27
747-B-3H-BP	(H-208 x P-4779)	1875	9.27
74109-B-3H-BP	(P-436 x G-130)	1875	9.27
74270-B-6H-BP	(850-3/27 x Chafa) x G-130	1875	9.27
73418-1-1P-BP	(F-370 x P-502)	1867	8.80
74320-B-9H-BP	(JG-62 x F-496) x L-550	1867	8.80
74249-14-1P-BP	(P-502 x No. 42)	1855	8.10
74320-B-1H-BP	(JG-62 x F-496) x L-550	1850	7.81
74276-B-1P-BP	(850-3/27 x H-208) x JG-62	1842	7.34
7466-B-1H-BP	(GW-5/7 x L-550) x RS-11	1833	6.82
74129-B-2H-BP	(P-99 x G-130)	1833	6.82
74148-B-3H-BP	(JG-24 x C-235)	1833	6.82
74255-B-5H-BP	(850-3/27 x GW-5/7) x (JG-62 x No. 56)	1833	6.82
73385-1-2P-BP	(F-378 x P-3090)	1825	6.35
74276-B-8P-BP	(850-3/27 x H-208) x JG-62	1825	6.35
741661-B-2H-BP	(Pant-102 x H-208) x JG-62	1825	6.35

Contd... Table 11

Pedigree	Cross	Yield	% increase over highest JG-62 yield
7391-B-2P-BP	(P-9623 x P-1387)	1817	5.88
74311-B-4H-BP	(Ceylon-2 x CP-66) x G-543	1817	5.88
74157-B-3H-BP	(USA-613 x C-235)	1817	5.88
7466-15-1P-BP	(RS-11 x GW-5/7) x L-550	1800	4.90
74302-B-1P-BP	(JG-62 x Pant-110) x P-150	1800	4.90
74298-B-1P-BP	(JG-62 x B-110) x C-104	1793	4.49
74157-B-3P-BP	(USA-613 x C-235)	1792	4.43
74273-B-4H-BP	(850-3/27 x H-223) x P-87	1792	4.43
7466-B-3H-BP	(GW-5/7 x L-550) x RS-11	1792	4.43
74148-B-1H-BP	(JG-24 x C-235)	1792	4.43
7457-B-5H-BP	(Radhey x L-550) x (E-100 x NP-34)	1792	4.43
74660-B-1P-BP	(JG-62 x C-235) x P-104	1790	4.31
74249-12-1P-BP	(P-502 x No. 42)	1783	3.90
73418-3-1H-BP	(F-370 x P-502)	1783	3.90
74324-B-10H-BP	(F-378 x JG-62) x L-550	1783	3.90
74159-B-2P-BP	(H-355 x BEG-482)	1775	3.44
74256-B-4P-BP	(CP-66 x F-496) x H-208	1758	2.50
74270-B-1P-BP	(850-3/27 x Chafa) x G-130	1758	2.50
741663-9-1P-BP	(H-208 x RS-11) x (JG-221 x L-550)	1757	2.39
74156-B-2P-BP	(JG-221 x C-235)	1750	1.98
74274-B-7H-BP	(850-3/27 x Chafa) x JG-62	1750	1.98
7466-9-1H-BP	(GW-5/7 x L-550) x RS-11	1750	1.98
74213-B-1H-BP	(F-378 x E-100)	1750	1.98
74159-B-2H-BP	(H-355 x BEG-482)	1750	1.98
7486-B-7P-BP	(850-3/27 x F-378) x C-156	1747	1.81
74270-B-5P-BP	(850-3/27 x Chafa) x G-130	1747	1.81
74135-B-1P-BP	(G-130 x GW-5/7)	1738	1.28
74145-B-1P-BP	(T-3 x C-235)	1733	0.99
74317-B-1H-BP	(JG-62 x C-235) x Radhey	1733	0.99
7442-B-2P-BP	(Pant-110 x JG-62) x (L-550 x BG-1)	1733	0.99
7442-B-1P-BP	(Pant-110 x JG-62) x (L-550 x BG-1)	1730	0.82
74156-B-1H-BP	(JG-221 x C-235)	1727	0.64

Contd... Table 11

Pedigree	Cross	Yield	% increase over highest JG-62 yield
7442-B-7P-BP	(Pant-110 x JG-62) x (L-550 x BG-1)	1723	0.41
74303-B-2P-BP	(JG-62 x T-3) x P-431	1717	0.06
74310-B-5P-BP	(GW-5/7 x Pant-104) x JG-62	1717	0.06
Check	JG-62	1716	

Table 12. Mean yield in kg/ha of the progenies exceeding the highest yield of the check at Hissar

Pedigree	Cross	Yield	% increase over highest G-130 yield
74142-B-11H-BH	(F-378 x C-235)	4981	25.21
7446-B-5H-BH	(H-355 x L-550) x (JG-62 x G-543)	4770	19.90
74223-B-3H-BH	(H-223 x No. 42)	4541	14.15
74263-B-1H-BH	(H-208 x F-370) x P-505	4458	12.02
7457-B-5H-BH	(Radhey x L-550) x (E-100 x NP-34)	4270	7.34
74263-B-10H-BH	(H-208 x F-370) x P-505	4249	6.81
74263-B-6H-BH	(H-208 x F-370) x P-505	4228	6.28
74258-B-2H-BH	(H-208 x B-108) x 850-3/27	4208	5.78
7457-B-6H-BH	(Radhey x L-550) x (E-100 x NP-34)	4187	5.25
74157-B-5H-BH	(USA-613 x C-235)	4187	5.25
74161-B-3H-BH	(T-3 x BEG-482)	4187	5.25
74263-B-7H-BH	(H-208 x F-370) x P-505	4166	4.73
74138-B-4H-BH	(G-130 x Pant-104)	4104	3.17
74142-B-13H-BH	(F-378 x C-235)	4104	3.17
74324-B-3H-BH	(F-378 x JG-62) x L-550	4020	1.06
Check	G-130	3978	

After visual evaluation of the progenies, individual plants were selected from those progenies rated in the first three categories. The criteria for plant selection were the same as in F_3 except that the number of pods per plant and the seed characters were given more weight. A total of 794 plants including 584 at Hissar and 210 at Hyderabad were finally selected. These plants were individually harvested and kept in separate bags for growing in the following season.

F_5 PROGENIES

Approximately 400 crosses were made during 1973-74 season when the chickpea breeding program started at ICRISAT. Their F_1's were grown in Bekka valley, Lebanon and Lahaul valley in north India during 1974 summer. The F_2 populations of these crosses were raised at Hyderabad during 1974-75 and F_3 progenies grown in Lebanon during 1975. Nearly 4000 F_4 progenies were grown at Hyderabad and Hissar during 1975-76 and several hundred plants were selected. The plants chosen from this F_4 generation formed the material for 1976-77 F_5 generation. This was grown both at Hyderabad and Hissar. This was the first season when we had our material in this generation.

All selections were grown under two fertility conditions; high (60 kg P_2O_5/ha) and low (30 kg P_2O_5/ha). The plot size was 2 rows 4 m long spaced at 60 and 75 cm at Hissar and Hyderabad, respectively.

The entire material was grown in both environments to identify genotypes with wide adaptation. Wherever enough seed was not available, the material was sown only at one location. We planted 2741 and 3248 progenies under high and low fertility conditions, respectively, at Hyderabad and 3101 progenies both under high and low fertility conditions at Hissar.

The material was classified into early, medium and late at the time of flowering. As in the previous generation, the material was scored visually on a 1 to 5 scale at maturity. The basis for scoring the progenies has already been described. Two additional factors that received major attention were the uniformity of the material and acceptable seed color. The progenies uniform for morphological and seed characters with high yield were bulked. Individual plant selections were made in the progenies classified in the first three grades. A total of 1008 plants including 413 from Hyderabad and 595 from Hissar were chosen for raising F_6 progenies. The progenies placed in the last two categories were rejected.

Besides visual scoring, actual yield of each progeny was recorded. The numbers of progenies exceeding the nearest check and the highest check yield are presented in Table 13.

Table 13. Comparison of F_5 progenies with best check (JG-62 at Hyderabad; G-130 at Hissar) during 1976-77

Progenies yielding	Hyderabad	Hissar
More than the nearest check	1293	1081
Higher than the highest check yield	45	15

It can be seen from this Table that 1293 and 1081 progenies exceeded the standard check at Hyderabad and Hissar, respectively.

Table 13 indicates that 45 and 15 progenies at Hyderabad and Hissar, respectively, yielded more than the best check. The yield of the progenies exceeding the highest check yield for Hyderabad and Hissar is given in Tables 14 and 15, respectively.

It can be seen from Table 14 that the highest yielding progeny, 74279-B-5P-LB-BP (850-3/27 x T-3) x P-4245-1, yielded 3278 kg/ha as against 2503 kg/ha for JG-62. Thus, this progeny recorded 31 per cent more yield than the highest check yield. The highest yielding progeny at Hissar produced 4083 kg/ha against 3895 kg/ha of the highest check yield (G-130).

Table 14. Mean yield in kg/ha of the progenies exceeding highest yield of the check at Hyderabad

Pedigree	Cross	Yield	% increase over highest JG-62 yield
74279-B-5P-LB-BP	(850-3/27 x T-3) x P-4245-1	3278	30.96
73129-9-3-1P-BP	(JG-62 x Radhey)	3037	21.33
73114-20-1-1P-BP	(850-3/27 x GW-5/7)	2950	17.86
7457-B-4H-LB-BP.	(Radhey x L-550) x (E-100 x NP-34)	2933	17.18
7472-B-5H-LB-BP	(F-61 x L-550) x P-272	2933	17.18
7370-15-4-1P-BP	(L-550 x GW-5/7)	2892	15.54

Contd... Table 14

Pedigree	Cross	Yield	% increase over highest JG -62 yield
7472-B-2H-LB-BP	(F-61 x L-550) x P-272	2867	14.54
73105-14-2-1P-BP	(850-3/27 x B-108)	2842	13.5
7367-8-3-1H-BP	(L-550 x P-1786)	2783	11.19
74193-B-3P-LB-BP	(K-468 x F-61)	2767	10.55
74193-12-1H-LB-BP	(K-468 x F-61)	2762	10.35
7497-5-2P-LB-BP	(JG-62 x P-3111)	2760	10.27
7360-1-1-1H-BP	(L-550 x Annigeri)	2753	9.99
7394-18-2-1P-BP	(850-3/27 x N-59)	2704	8.03
73114-20-1-2P-BP	(850-3/27 x GW-5/7)	2700	7.87
73157-1-2-1H-BP	(JG-62 x Pant-102)	2683	7.19
73167-8-1-1H-BP	(JG-62 x F-496)	2653	5.99
7361-2-3-1P-BP	(L-550 x B-108)	2650	5.87
73266-3-5-1P-BP	(T-3 x Chafa)	2650	5.87
73345-1-1-2P-BP	(NP-34 x GW-5/7)	2637	5.35
7499-B-7H-LB-BP	(P-3111 x G-130)	2625	4.87
7498-B-1H-LB-BP	(P-3111 x BG-1)	2617	4.55
74100-B-3H-LB-BP	(H-208 x P-3111)	2617	4.55
74140-B-2P-LB-BP	(Radhey x G-130)	2608	4.19
73129-7-1-2P-BP	(JG-62 x Radhey)	2607	4.16
74213-B-2P-LB-BP	(F-378 x E-100)	2604	4.04
7369-1-2-1P-BP	(L-550 x USA-613)	2594	3.64
73129-16-4-1P-BP	(JG-62 x Radhey)	2592	3.56
74193-16-4-1P-BP	(K-468 x F-61)	2575	2.88
7445-B-4H-LB-BP	(T-3 x L-550) x (C-156 x F-404)	2568	2.60
73129-13-1-2P-BP	(JG-62 x Radhey)	2564	2.44
7475-B-5H-LB-BP	(No.56 x H-208) x T-3	2563	2.40
73301-4-3-2P-BP	(G-543 x Annigeri)	2556	2.12
73129-16-2-1P-BP	(JG-62 x Radhey)	2552	1.96
73167-10-2-1P-BP	(JG-62 x F-496)	2550	1.88
7394-11-1-1P-BP	(850-3/27 x N. 59)	2550	1.88
7369-5-2-1P-BP	(L-550 x USA-613)	2550	1.88
7497-B-6H-LB-BP	(JG-62 x P-3111)	2550	1.88
74274-B-4P-LB-BP	(850-3/27 x Chafa) x JG-62	2542	1.56
73185-2-3-1P-BP	(G-130 x Chafa)	2541	1.52
73156-9-1H-BP	(JG-62 x BR-70)	2524	0.84

Contd... Table 14

Pedigree	Cross	Yield	% increase over highest JG-62 yield
73129-1-3-2P-BP	(JG-62 x Radhey)	2521	0.72
73136-31-2-1P-BP	(JG-62 x BEG-482)	2508	0.20
73129-7-1-1P-BP	(JG-62 x Radhey)	2507	0.16
73136-3-1-1P-BP	(JG-62 x BEG-482)	2505	0.08
Check	JG-62	2503	

Table 15. Mean yield in kg/ha of the progenies exceeding highest yield of the check at Hissar

Pedigree	Cross	Yield	% increase over highest G-130 yield
73185-2-4-1H-BH	(G-130 x Chafa)	4083	4.82
73185-7-2H-BH	(G-130 x Chafa)	4052	4.03
7332-12-1-1H-BH	(H-208 x F-370)	4031	3.49
7333-15-2-1H-BH	(H-208 x F-496)	4021	3.23
73264-1-1-1H-BH	(Ahd-52 x 850-3/27)	4005	2.82
73185-1-4-1H-BH	(G-130 x Chafa)	3979	2.16
7332-12-3-1H-BH	(H-208 x F-370)	3968	1.87
73185-7-2-1H-BH	(G-130 x Chafa)	3968	1.87
739-6-3-1H-BH	(H-208 x Pant-110)	3963	1.75
7339-1-1-1H-BH	(H-208 x E-100)	3937	1.08
73187-1-2-1H-BH	(G-130 x JG-24)	3916	0.54
7370-15-2-1H-BH	(H-208 x BG-1)	3906	0.30
7313-2-3-1H-BH	(H-208 x Chafa)	3896	0.03
7320-11-2-1H-BH	(H-208 x RS-11)	3896	0.03
7337-12-4-2H-BH	(H-208 x F-370)	3896	0.03
Check	G-130	3895	

F_6 PROGENIES

The F_6 seed produced from a limited number of F_5 progenies in the Lahaul valley during 1976 were grown at Hyderabad and Hissar in the 1976-77 season. In view of the poor growth in Lahaul valley, it was not possible to select individual plants and the material was advanced by bulk method. Wherever enough seed was produced by a progeny, seed was provided for both locations, but by and large it was sent to either Hyderabad or Hissar. At both locations each progeny was grown in two replicates. Wherever seed quantity was not sufficient it was grown only in the high fertility field. The planting was done as in F_5 generation. At Hyderabad 869 and at Hissar 1003 F_6 progenies were grown.

The evaluation of F_6 progenies was done in the same way as that of F_5. Seven progenies were rated 2 and 63 progenies were placed in category 3 at Hyderabad. At Hissar 3 and 222 were classified in category 2 and 3, respectively. The remaining progenies at each location were rated in categories 4 and 5.

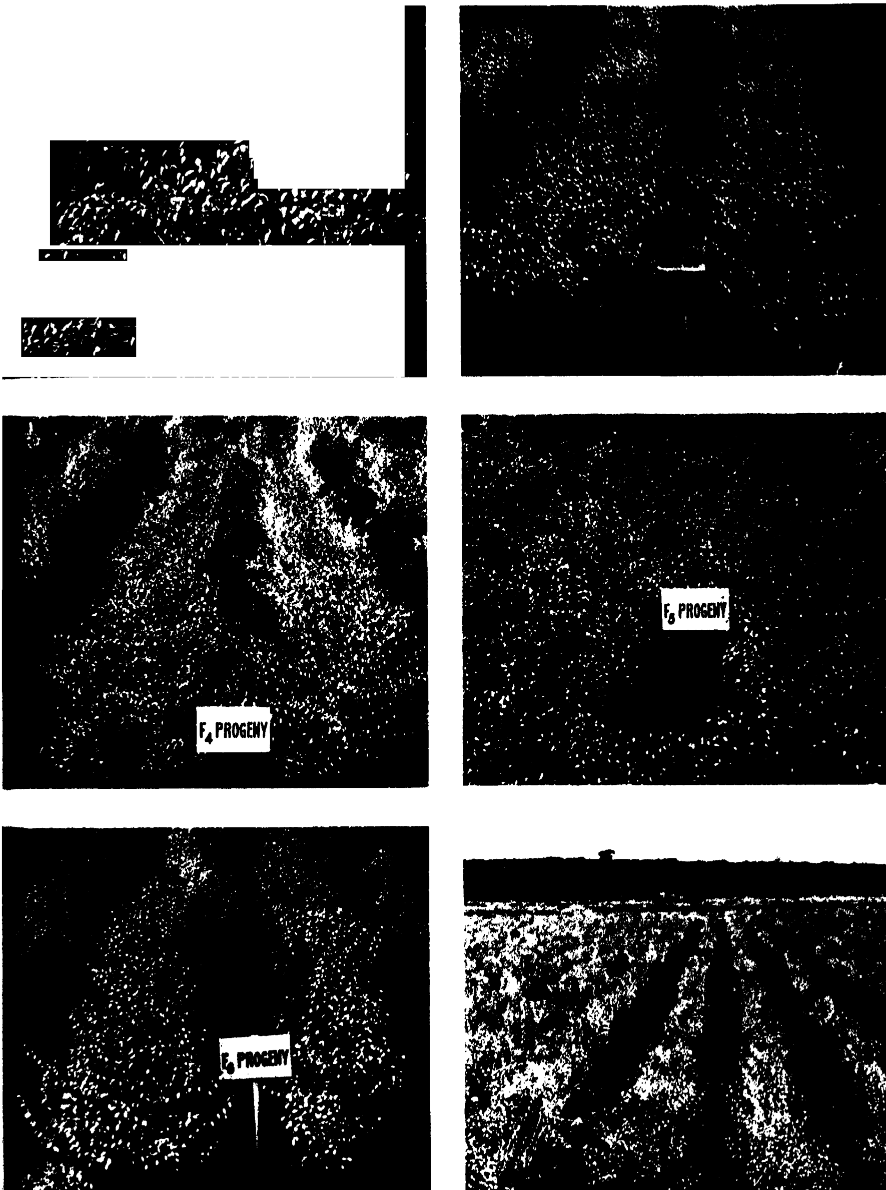
A few promising and uniform progenies were bulked, which will be described in a subsequent section. Of the non-uniform but very promising lines, individual plant selections were made for advancing the material to F_7. Thirteen and 302 plants were selected at Hyderabad and Hissar, respectively.

BULKING OF PROGENIES

The 1976-77 season was the first time when we had our material in F_5 and F_6 generations. We decided to bulk a few superior yielding and agronomically uniform progenies. We adopted two procedures for bulking; one based on performance in multilocation tests and the other based on performance of F_5/F_6 progenies at Hyderabad and Hissar.

Bulking based on multilocation tests

We prepared International Chickpea Screening Nurseries (ICSN) consisting of early maturing F_5 bulks (ICSN-A) and



F_2 THRU F_6 GENERATIONS AND AN ELITE BULKED LINE late maturing F_5 bulks (ICSN-B). Cultivar JG-62 was used as a check in ICSN-A, and G-130 in ICSN-B. Although these nurseries were sent to 38 locations in 10 countries, we received results from only 11 locations for ICSN-A and from 13 locations for ICSN-B trials in India by May, 1977.

We had furnished enough seed of each entry to be planted in an unreplicated trial. We considered each location as a replicate and analysed the results received. In the early group one line, and in the late group 4 lines yielded significantly higher than the check when averaged over all locations. These 5 entries have been designated as ICCC-1 thru 5. A few important characters of each of them are presented in Table 16. These lines will be offered for testing in the All India Coordinated Trial.

Besides these 5 entries, there were a large number of F_5 bulks which performed exceedingly well at one or more locations outyielding the standard check by a margin of 40 to 171%. All the bulks which were entered in ICSN-A or B were multiplied and purified at Hyderabad and Hissar, respectively. Consequently 25 bulks from Hyderabad and 28 bulks from Hissar were chosen for furnishing to the cooperators again for their evaluation. Their yield performance in multilocation tests is given in Table 17.

Bulking based on performance of F_5/F_6 progenies at Hyderabad and Hissar

Once we completed the first round of evaluation of progenies in F_5/F_6 generations we had a final look at those progenies which were rated 1 or 2 to evaluate uniformity and seed color. We picked up some lines and rogued out any suspected off-type plant. On completion of this procedure we harvested these lines and estimated their yield. These yield estimates were compared with the nearest check and any progeny exceeding the nearest check was bulked. Forty-one and 39 lines were bulked at Hyderabad and Hissar, respectively. Out of these, 65 were from F_5 and 15 from the F_6 generation. Their yield performance, per cent increase over nearest check, and agronomic characters are given in Table 18. These bulks will be furnished to our cooperators during the 1977-78 season.

Table 16. Morphological and seed characteristics of ICCC-1 recorded at Hyderabad and ICCC-2 thru 5 recorded at Hissar under space planting during 1976-77

Cultivar	DF	Pl. Ht. (cm)	Pl. Sp. (cm)	Gr. Ha.	Pr. Br.	Sr. Br.	Tr. Br.	Pods/ Plant	Seeds/ pod	DM	100-seed Wt.	Seed Color
ICCC-1	51	30	45	SS	2.5	2.6	Present	140	1.10	110	18.6	YB
ICCC-2	89	71	47	SS	2.8	10.0	15.8	225	1.67	173	12.3	B
ICCC-3	63	63	39	SS	4.0	11.0	14.8	294	1.34	173	13.7	YB
ICCC-4	52	76	48	SS	4.0	10.6	15.8	213	1.46	171	15.4	B
ICCC-5	65	65	44	SS	4.0	12.0	18.6	243	1.60	171	11.6	YB

DF = Days to flower, Pl.Ht. = Plant height, Pl.Sp. = Plant spread, Gr.Ha. = Growth Habit, Pr.Br. = Primary Branches, Sr.Br. = Secondary Branches, Tr.Br. = Tertiary Branches, DM = Days to maturity

SS = Semi-spreading; Y = Yellow, B = Brown

Pedigrees of ICCC-1 thru 5 are 7310-26-2-B-BP (H-208 x T-3), 7332-7-2-B-BH (H-208 x F-370), 73111-8-3-B-BH (850-3/27 x H-208), 7310-3-2-B-BH (H-208 x T-3), and 73219-2-1-B-BH (F-404 x H-223).

Table 17. Yield performance of F5 bulks in multilocation tests

	Pedigree	Cross	Range	Yield	% increase over check (JG-62)	Remark (Rank)
			Bulks from Hyderabad			
1.	7310-26-2-B-BP	(H-208 x T-3)	471-5000	2082	48.4	1 at Raichur and 3 at Rahuri and Badnapur
2.	7343-14-3-B-BP	(H-208 x USA-613)	305-5600	1743	24.2	1 at Hissar, 3 at Jabalpur and Bhubaneshwar
3.	7310-8-2-B-BP	(H-208 x T-3)	307-4400	1703	21.4	3 at Gulbarga, 4 at Raichur
4.	73129-16-1-B-BP	(JG-62 x Radhey)	561-3367	1634	16.5	1 at Gulbarga and 3 at Coimbatore
5.	7389-20-3-B-BP	(850-3/27 x F-378)	144-4878	1661	18.4	4 at Badnapur and Hissar
6.	7394-14-2-B-BP	(850-3/27 x N.59)	436-3850	1620	15.5	4 at Nayagarh
7.	739-3-4-B-BP	(H-208 x Pant-110)	222-2500	852	39.3	--
8.	73105-7-1-B-BP	(850-3/27 x B-108)	278-3650	1573	12.1	--
9.	73167-5-3-B-BP	(JG-62 x F-496)	88-4485	1541	9.8	1 at Akola
10.	73152-3-3-B-BP	(JG-62 x USA-613)	417-3200	1502	7.1	1 at Bhubaneshwar and 5 at Rahuri
11.	7389-18-3-B-BP	(850-3/27 x F-378)	196-4050	1455	3.7	1 at Badnapur and 5 at Raichur
12.	7389-32-2-B-BP	(850-3/27 x F-378)	467-3345	1405	0.1	1 at Hyderabad
13.	7341-12-1-B-BP	(H-208 x N.59)	333-3200	1503	7.1	1 at Jabalpur
14.	73111-8-2-B-BP	(850-3/27 x H-208)	420-3900	1389	1.0	1 at Nayagarh
15.	73217-2-2-B-BP	(F-404 x Ceylon-2)	600-2845	1251	10.8	2 at Gulbarga
16.	737-14-2-B-BP	(H-208 x BG-1)	111-3767	1131	19.4	--
17.	7310-3-1-B-BP	(H-208 x T-3)	333-3845	1551	10.6	2 at Bhubaneshwar
18.	73128-1-1-B-BP	(JG-62 x F-378)	250-3400	1455	3.7	1 at Rahuri, 3 at Hyderabad and 5 at Akola
19.	7341-8-1-B-BP	(H-208 x N.59)	195-3189	1146	18.3	--
20.	73213-9-3-B-BP	(GW-5/7 x H-223)	200-4378	1290	- 8	--
21.	739-6-1-B-BP	(H-208 x Pant-110)	333-4167	1205	-14	--

Contd... Table 17

	Pedigree	Cross	Range	Yield	% increase over check (JG-62)	Remark (Rank)
22.	7341-12-2-B-BP	(H-208 x N.59)	389-3200	1503	7	1 at Jabalpur
23.	73129-16-2-B-BP	(JG-62 x Radhey)	389-3800	1666	19	4 at Gulbarga
24.	7389-18-5-B-BP	(850-3/27 x F-378)	222-3822	1628	16	--
25.	73307-8-1-B-BP	(K-468 x F-378)	367-4167	1585	13	4 at Bhubaneshwar
	JG-62		403-3311	1403	0	--
					(G-130)	
		Bulks from Hissar				
26.	73307-8-1-B-BH	(K-468 x F-378)	466-4178	1793	- 0.6	4 at Berhampore
27.	7380-1-1-B-BH	(L-550 x F-496)	242-5667	1979	9.7	1 at Durgapura and 2 at HAU-Hissar B
28.	7380-1-4-B-BH	(L-550 x F-496)	375-6200	1949	8.0	1 at HAU-Hissar B and 2 at HAU-ICRISAT A and Varanasi
29.	7310-22-1-B-BH	(H-208 x T-3)	539-4333	1893	4.9	1 at Gurdaspur
30.	7357-22-3-B-BH	(L-550 x K-468)	225-5022	1780	- 1.3	1 at HAU-ICRISAT A
31.	73111-8-1-B-BH	(850-3/27 x H-208)	222-5133	2103	16.6	2 at New Delhi and 4 at Kanpur
32.	73126-6-2-B-BH	(850-3/27 x E-100)	571-4533	1789	- 0.8	--
33.	73167-5-3-B-BH	(JG-62 x F-496)	344-4467	1771	- 1.8	1 at Ranchi
34.	7310-26-2-B-BH	(H-208 x T-3)	483-4867	2042	13.2	2 at Berhampore and 5 at Hyderabad and Pantnagar
35.	7342-14-3-B-BH	(H-208 x USA-613)	389-4333	2090	15.9	1 at Berhampore, 2 at Ludhiana and 4 at Jabalpur
36.	7310-3-1-B-BH	(H-208 x T-3)	611-4133	1963	8.8	4 at Gurdaspur and Varanasi and 5 at Durgapura & Kanpur
37.	73111-7-2-B-BH	(850-3/27 x H-208)	632-4189	2056	14.0	--
38.	7328-8-5-B-BH	(H-208 x CP-66)	417-4467	1768	- 2.0	1 at Kanpur and 5 at Jabalpur

Contd... Table 17

	Pedigree	Cross	Range	Yield	% increase over check (G-130)	Remark (Rank)
39.	73252-11-2-B-BH	(RS-11 x C-214)	547-4400	1925	6.7	5 at Gurdaspur
40.	7341-12-1-B-BH	(H-208 x N.59)	333-3567	1597	-11.5	2 at Hyderabad and 4 at Durgapura
41.	7389-32-2-B-BH	(850-3/27 x F-378)	504-3600	1888	4.7	1 at Hyderabad
42.	7341-8-1-B-BH	(H-208 x N.59)	355-4667	1769	- 2.0	--
43.	73103-6-4-B-BH	(850-3/27 x Chafa)	300-5000	2105	16.7	--
44.	737-18-1-B-BH	(H-208 x BG-1)	435-4133	2086	15.6	2 at Kanpur and 5 at Jabalpur
45.	7389-18-6-B-BH	(850-3/27 x F-378)	432-5267	1945	7.8	1 at Jabalpur and 3 at Pantnagar
46.	731-8-3-B-BH	(H-208 x F-61)	451-4800	1831	1.5	5 at Berhampore
47.	7332-7-3-B-BH	(H-208 x F-370)	642-5667	2253	25	2 at HAU-Hissar, 3 at Jabalpur and Varanasi and 4 at ICRISAT-Hissar
48.	7332-7-2-B-BH	(H-208 x F-370)	275-5533	2141	19	3 at Durgapura and HAU-Hissar
49.	73111-8-3-B-BH	(850-3/27 x H-208)	556-4467	2140	19	3 at IARI-New Delhi
50.	73111-8-4-B-BH	(850-3/27 x H-208)	608-4800	2084	16	1 at Varanasi, 3 at Ranchi
51.	7310-3-2-B-BH	(H-208 x T-3)	577-5133	2048	14	1 at Gurdaspur and 2 at Durgapura
52.	73167-13-3-B-BH	(JG-62 x F-496)	523-4133	1709	- 5	--
53.	73219-2-1-B-BH	(F-404 x H-223)	--	1283	-	Taken from Hissar Multiplication
	G-130		509-4000	1804	0	--

Table 18. Yield and some important characteristics recorded from space planted F_5 and F_6 bulked progenies during 1976-77

Pedigree	Cross	Pl Ht (cm)	Pl Sp (cm)	Gr Ha	Pr Br	Sr Br	Tr Br	Pod No.	Seeds/pod	Col	100-seed wt	Testa Str	Yield (kg/ha)	H.I. (%)	% increase over check
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hyderabad															
F_5 Generation															
1. 73129-16-1-1P-BP	(JG-62 x Radhey)	50	36	SE	3	8	P	336	1.00	YB	15.50	R	2908	56	12
2. 73170-6-3-2P-BP	(JG-62 x E-100)	43	30	SE	3	10	P	236	1.00	YB	17.21	R	3050	52	0.4
3. 73136-3-3-2P-BP	(JG-62 x BEG-482)	38	38	SS	3	9	P	223	1.11	YB	16.62	R	2967	53	16
4. 7394-18-2-1P-BP	(850-3/27 x N-59)	40	43	SS	3	11	P	286	1.04	YB	16.85	R	3148	57	52
5. 73141-3-2-1P-BP	(JG-62 x K-4)	45	35	SE	3	8	P	197	1.02	SB	17.53	T	2500	49	2
6. 73153-15-1-2P-BP	(JG-62 x GW-5/7)	41	36	SE	3	7	P	233	1.00	YB	19.11	R	2642	52	1
7. 73136-3-1-1P-BP	(JG-62 x BEG-482)	44	39	SS	4	11	P	260	1.04	YB	17.03	R	3118	54	17
8. 73136-31-2-1P-BP	(JG-62 x BEG-482)	43	42	SS	2	10	P	290	1.07	YB	14.21	R	3230	53	21
9. 73144-14-2-1P-BP	(JG-62 x B-108)	51	37	SE	4	9	P	418	1.00	Y	15.09	R	3122	52	17
10. 73167-11-1-1P-BP	(JG-62 x F-496)	50	36	SE	4	8	P	405	1.11	Y	13.02	R	2695	52	3
11. 73357-1-2-1P-BP	(P-502 x P-736)	33	54	SS	3	4	P	333	1.00	YB	13.75	T	2580	62	4
12. 7394-18-3-1P-BP	(850-3/27 x N-59)	49	37	SE	3	7	P	217	1.00	Y	23.75	R	2612	54	21
13. 7388-4-1-2P-BP	(850-3/27 x F-61)	49	29	SE	4	9	P	204	1.10	Y	19.28	T	2792	52	25
14. 73136-31-2-2P-BP	(JG-62 x BEG-482)	40	52	SP	3	5	P	298	1.02	YB	14.65	R	2687	56	- 9
15. 73154-12-1-1P-BP	(JG-62 x No. 42)	52	36	SE	3	8	P	264	1.00	OB	16.04	S	2575	50	38
16. 73211-2-2-1P-BP	(Ceylon-2 x GW-5/7)	43	30	SE	3	7	P	191	1.02	YB	23.47	R	3030	56	17
17. 7362-4-2-1P-BP	(L-550 x B-110)	50	40	SE	3	6	P	305	1.00	SB	16.17	R	3207	49	30
18. 7375-1-4-1P-BP	(L-550 x CP-66)	45	24	SE	3	6	P	227	1.14	YB	14.59	R	2777	56	- 3
19. 738-8-1-1P-BP	(H-208 x BEG-482)	39	39	SS	2	6	P	275	1.00	YB	14.92	R	2808	54	- 2
20. 73114-16-2-2P-BP	(850-3/27 x GW-5/7)	55	31	SE	3	8	P	167	1.00	RB	29.25	S	2538	49	17

Contd... Table 18

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21. 73136-31-4-1H-BP (JG-62 x BEG-482)	41	43	SS	3	9	P	209	1.16	YB	16.52	T	2500	54	16
22. 73167-8-1-1H-BP (JG-62 x F-496)	51	34	SE	3	7	P	308	1.21	YB	13.69	R	2908	50	111
23. 73187-3-3-3H-BP (G-130 x JG-24)	50	34	SE	4	10	P	242	1.22	Y	13.24	R	2395	44	25
24. 73271-1-2-1H-BP (JG-62 x C-156)	47	48	SS	4	8	P	330	1.00	YB	15.39	R	2942	54	1
25. 73304-8-1-1H-BP (Radhey x Bengal gram)	45	37	SE	4	9	P	212	1.24	YB	14.15	R	2673	51	44
26. 73301-17-3-2H-BP (G-543 x Annigeri)	52	35	SE	4	7	P	279	1.03	Y	11.86	R	2542	42	36
27. 7342-6-4-1H-BP (JG-221 x H-208)	23	50	SS	2	6	P	326	1.03	YB	17.65	R	2633	56	40
28. 74203-B-4P-LB-BP (N-59 x Pant-102)	46	44	SE	4	8	P	412		YB		R	3020	51	65
29. 74279-B-5P-LB-BP (850-3/27 x T-3) x P-4245-1	49	35	SE	5	9	P	467		YB		R	3278	39	42
30. 74280-2P-LB-BP (850-3/27 x B-110) x C-156	50	46	SS	4	8	P	271	1.27	YB	12.67	R	2800	55	44
31. 7472-B-5H-LB-BP (P-272 x (F-61 x L-550))	46	40	SE	5	9	P	427	1.05	Y	14.24	T	2933	52	51
32. 7472-B-11H-LB-BP (P-272 x (F-61 x L-550))	40	40	SE	4	7	P	335		YB		R	2820	53	45
4951 JG-62	37	37	SS	3	10	P	363	1.00	YB	16.91	R	2748	61	
F_6 Generation														
33. 73357-1-1-1P-LB-BP (P-502 x P-736)	32	57	SS	3	19	P	620	1.06	Y	13.84	T	1530		Not Recorded
34. 7352-15-3-1P-LB-BP (L-550 x BG-1)	36	53	SS	3	15	P	270	1.02	GrB	19.45	R	1540		
35. 7394-18-2-2P-LB-BP (850-3/27 x N-59)	41	59	SS	3	14	P	350	1.06	B	16.02	R	1585		
36. 73129-16-1-1P-LB-BP (JG-62 x Radhey)	47	35	SE	3	22	P	340	1.04	YB	14.20	T	1560		
37. 73103-10-2-1P-LB-BP (850-3/27 x Chafa)	45	33	SE	3	20	P	290	1.02	YB	17.06	S	1705		
38. 73211-2-3-1P-LB-BP (GW-5/7 x Ceylon-2)	42	36	SE	3	24	P	260	1.12	Y	16.10	R	1770		
39. 73357-1-1-2P-LB-BP (P-502 x P-736)	31	64	SP	3	24	P	327	1.07	Y	14.64	T	1705		
40. 73128-10-1-2P-LB-BP (JG-62 x F-378)	37	55	SS	3	19	P	369	1.05	YB	15.11	R	2210		
41. 73241-3-1-1P-LB-BP (Chafa x JGC-1)	45	39	SE	3	15	P	405	1.01	LB	17.58	R	1715		

Contd... Table 18

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							Hissar							
F_5 Generation														
1. 7313-2-3-1H-BH (H-208 x Chafa)	70	45		3	22		270	1.78	B			3833		19
2. 73190-1-2-1H-BH (F-378 x Chafa)	70	48		3	22		511	1.43	B			3895		175
3. 7332-11-4-2H-BH (H-208 x F-370)	73	57		3	29		305	1.62	B			4041		53
4. 7343-10-2-1H-BH (H-208 x USA-613)	74	47	d	3	37	d	431	1.67	YB	d	d	3874	d	9
5. 73167-1-1-2H-BH (JG-62 x F-496)	77	57		3	27		360	1.33	B			2979		46
6. 73308-1-1-1H-BH (F-378 x USA-613)	74	48	e	2	22	e	285	1.72	B	e	e	3729	e	31
7. 7333-12-3-1H-BH (H-208 x F-496)	70	48		3	30		285	1.81	B			2958		3
8. 73213-9-3-1H-BH (GW-5/7 x H-223)	78	52	d	3	18	d	238	1.52	B	d	d	3354	d	18
9. 73167-11-2-1P-BH (JG-62 x F-496)	73	44		3	19		240	1.63	B			3187		56
10. 73167-5-3-1P-BH (JG-62 x F-496)	70	43	r	2	19	r	261	1.66	YB	r	r	3149	r	26
11. 73367-11-4-1P-BH (JG-62 x H-208)	64	49	o	4	17	o	593	1.80	YB	o	o	3833	o	175
12. 7339-3-2-1P-BH (H-208 x E-100)	69	38		3	24		432	1.47	B			3354		45
13. 73151-2-2-2P-BH (JG-62 x F-370)	71	44	c	3	23	c	274	1.41	YB	c	c	3209	c	-21
14. 74167-1-1H-B-BH (F-404 x BEG-482)	71	56	e	3	29	e	301	1.38	B	e	e	3177	e	27
15. 7357-2-3-1H-BH (L-550 x K-468)	65	34		4	16		233	1.54	B			2937		91
16. 7320-11-2-1H-BH (H-208 x RS-11)	63	33	R	3	17	R	292	1.14	B	R	R	3895	R	67
17. 7325-11-2-1H-BH (H-208 x F-404)	69	29		2	17		300	1.44	B			2958		27
18. 7332-12-4-1H-BH (H-208 x F-370)	70	30		3	16		188	1.43	B			3208		42
19. 7333-10-3-1H-BH (H-208 x F-496)	74	40	.	4	16		303	1.61	YB			2910		29
20. 7339-3-3-1H-BH (H-208 x E-100)	62	30	t	3	15	t	361	1.63	B	t	t	3291	t	9
21. 73170-3-1-1H-BH (JG-62 x E-100)	73	61		3	16		581	1.13	B			3416		25
22. 73185-7-1-2H-BH (G-130 x Chafa)	76	55	o	3	19	o	352	1.41	YB	o	o	3624	o	33
23. 73187-3-2-1H-BH (G-130 x JG-24)	78	43		3	19		136	1.60	B			2437		77
24. 7320-11-1-1H-BH (H-208 x RS-11)	60	31		3	20		417	1.44	B			3636		57
25. 73304-10-4-2H-BH (Radhey x Bengal gram)	61	54	N	3	14	N	147	1.68	B	N	N	1083	N	-265

Contd... Table 18

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
26. 731-9-2-1H-BH (H-208 x F-61)	72	35		3	18		212	1.39	B			1666		-265
27. 73179-24-1-1H-BH (G-130 x P-5409)	70	44		3	13		168	1.24	B			1646		- 91
28. 7332-1-1-1H-BH (H-208 x F-370)	70	40	Recorded	3	17	Recorded	181	1.72	YB	Recorded	Recorded	3083	Recorded	36
29. 73162-2-2-1P-BH (JG-62 x F-370)	69	49		3	13		125	1.46	B			1458		1
30. 7328-8-4-1P-BH (H-208 x CP-66)	64	41		2	13		176	1.44	B			1625		59
31. 73170-54-1-1P-BH (JG-62 x E-100)	74	46		3	13		224	1.19	B			1250		38
32. 73170-6-3-2P-BH (JG-62 x E-100)	72	40		3	18		165	1.27	B			1458		32
33. 7369-4-2-B-BH (L-550 x USA-613)	61	31		3	14		176	1.28	SW			2021		80
F_6 Generation														
34. 73213-9-1-3H-B-BH (GW-5/7 x H-223)	67	40		2	10		218	1.50	B			3229		39
35. 73219-4-4-2H-B-BH (F-404 x H-223)	68	58		3	28		493	1.72	B			4187		2
36. 7332-7-1-1H-B-BH (H-208 x F-370)	65	44	Not	3	33	Not	444	1.67	B	Not	Not	4166	Not	13
37. 7333-10-1-1H-B-BH (H-208 x F-496)	63	38		4	22		354	1.53	B			3822		4
38. 73304-14-2-1H-B-BH (Radhey x Bengal gram)	72	51		4	19		321	1.52	B			3968		60
39. 73162-2-2-2H-B-BH (JG-62 x F-370)	73	49		3	17		268	1.75	B			3541		- 17
4948 G-130	Not Recorded											2717		

Note: Yield in certain progenies is less than check because of damage caused by rats at Hyderabad and hailstorm at Hissar.

Pl Ht = Plant height; Pl Sp = Plant spread; Gr Ha = Growth habit; Pr., Sr., Tr. = Primary, Secondary, Tertiary; Br = Branches; Col = Color; Str = Striations; H.I. = Harvest index;

SE = Semi-erect; SP = Spreading; SS = Semi-spreading; P = Present;

Y = Yellow; B = Brown; O = Orange; Gr = Green;

R = Rough; S = Smooth; T = Tuberculated;

TRIALS

SMALL SCALE TRIAL OF BULKED LINES

Sixty F_5 bulked lines were tested at Hyderabad and Hissar with the aim of selecting a few promising ones to offer to our cooperators through international trials.

Materials and Methods

Sixty three entries including 60 F_5 bulks and 3 checks were planted in a randomized block design with three replications at Hyderabad and Hissar. The plot size was 3 m x 2 rows, spaced at 30 cm apart. Plant to plant spacing was 7 to 10 cm.

Results

The analysis of variance given in Table 19 indicates that the genotypes included in the trial were different. Although 5 bulks at Hyderabad and 6 bulks at Hissar gave higher yields than the local check, only one bulk, IC-73211-2-1-B (Ceylon-2 x GW-5/7) gave significantly higher yield than the check at Hyderabad.

Conclusion

The best bulked line will be furnished to the cooperators for their evaluation.

Table 19. ANOVA of small scale trial at Hyderabad and Hissar

Location	Source	d.f.	m.s.	F
Hyderabad	Replication	2	14215.45	3.92 *
	Genotypes	62	11587.37	3.20 **
	Error	124	3619.03	
Hissar	Replication	2	35140.89	4.21 *
	Genotypes	62	47396.71	5.67 **
	Error	124	8354.41	

* and ** Significance at 5% and 1% level, respectively.

ALL INDIA COORDINATED TRIALS

The All India Gram (Chickpea) Coordinated Varietal Trials are conducted at ICRISAT with the objective of evaluating lines developed at various institutions for their use in hybridization program. The other objective of conducting these trials is to compare the performance of material developed at ICRISAT with that produced by the research stations of the Indian National Program.

Two trials on gram; Gram Initial Evaluation Trial (GIET) and Gram Coordinated Varietal Trial (GCVT) were conducted during 1974-75, 1975-76 and 1976-77. Since the chickpea improvement program at ICRISAT was initiated only in the 1973-74 crop season, we had no entries available for contributing to any of these trials.

Materials and Methods

Twenty four entries for GIET and 15 for GCVT were tested in randomised complete block design (RCBD) with four replications during 1975-76. The GIET for 1976-77 had 36 entries and GCVT had 15. The designs in both the cases were RCBD with four replications.

Results

Although we conducted these two trials during 1974-75 also yield data could not be recorded for that crop season.

Strains B-110 (2485 kg/ha), Annigeri-1 (2443 kg/ha) and BG-204 (2100 kg/ha) were the top yielding entries in that order in the GIET (Table 20) and Annigeri-1 (2581 kg/ha), Radhey (2497 kg/ha) and Gram 9-3 (2426 kg/ha) in the GCVT (PZ) conducted during 1975-76 (Table 21).

In 1976-77 crop season the differences due to strains both for GIET and GCVT (PZ) were highly significant. The first three ranks in GIET were held by Annigeri (3052 kg/ha), RG-2 (2704 kg/ha), and BGS-384 (2664 kg/ha) (Table 22) and in GCVT Annigeri (2677 kg/ha), 850-3/27 (2469 kg/ha) and BDN-9-3 (2440 kg/ha) were the three highest yielding lines (Table 23).

Conclusion

The highest yielding line under Hyderabad conditions is Annigeri. Therefore, this line is being used as one of the checks in all our experiments.

Table 20. Yield data for Gram Initial Evaluation Trial, Rabi 1975-76

S.No.	Entry	Yield kg/ha	Rank
1	H-208	1829	11
2	BG-201	1273	23
3	BG-202	1456	20
4	B-110	2485	1
5	FG-662	1753	14
6	FG-87	1279	22
7	GC-667	1608	17
8	GL-657	1818	12
9	Annigeri-1	2443	2
10	GL-655	1105	24
11	No. 37	1631	16
12	Pant G-113	1716	15
13	Pant G-114	1847	10
14	Pant G-115	1974	7
15	Pant G-116	2093	4
16	BG-204	2100	3
17	BG-205	1882	9
18	BG-206	1908	8
19	H-75-1	1537	19
20	CPS-1	2079	6
21	CPS-2	2089	5
22	KE-30	1565	18
23	KE-78	1415	21
24	F-404	1788	13

C.V. % 18.67

C.D. (0.05) 460

Note: The underlined entries are in top significant group.

Table 21. Yield data for Gram Coordinated Varietal Trial (PZ), Rabi 1975-76

S.No.	Entry	Yield kg/ha	Rank
1	H-208	1806	13
2	Pant-104	1935	10
3	Pant G-110	1994	9
4	JG-74	2138	6
5	K-295	-	-
6	Radhey	2497	2
7	JG-297	2104	7
8	Strain 76	2333	4
9	850-3/27	1880	11
10	JG-221	2050	8
11	JG-62	2248	5
12	Annigeri-1	2541	1
13	Gram 9-3	2426	3
14	BEG-482	1841	12
15	BG-203	1698	14

C.V. % 20.89

C.D. (0.05) 583

Note: The underlined entries are in top significant group.

Table 22. Yield data for Gram Initial Evaluation Trial, Rabi 1976-77

S.No.	Entry	Yield kg/ha	Rank
1	H-208	1950	16
2	BG-201		
3	FG-662		
4	Annigeri	3052	1
5	GL-657	1367	38
6	H-75-1	1899	18
7	KE-30	1580	23
8	RG-1	2354	6
9	RG-2	2704	2
10	RGS-2	1655	21
11	GG-550	1483	28
12	GF-740	1527	26
13	F-187	1576	24
14	Pant G-121	999	32
15	Pant G-122	1427	29
16	BGS-19	1678	20
17	BGS-84	2294	8
18	BGS-142	1935	17
19	BGS-360	2345	7
20	BGS-384	2668	3
21	BGS-390	2058	13
22	BGS-398	2189	10
23	BG-207	2181	11
24	BG-208	1773	19
25	BG-209	-	-
26	BG-210	1516	27
27	BG-211	1567	25
28	BG-212	2243	9
29	Sel 114-24	2595	5
30	Sel 93-15	-	-
31	JG-1253	2165	12
32	JG-1254	1973	15
33	B-110	2630	4
34	BEG-482	1645	22
35	JG-62 (Local-1)	1190	31
36	L-550 (Local-2)	2041	14

C.V. % 19

C.D. (0.05) 509.84

Note: The underlined entries are in top significant group.

Table 23. Yield data for Gram Coordinated Varietal Trial (PZ), Rabi 1976-77

S.No.	Entry	Yield kg/ha	Rank
1	JG-74	<u>2324</u>	4
2	K-295	-	-
3	JG-897	2129	7
4	Strain 76	2022	9
5	850-3/27	<u>2469</u>	2
6	JG-221	2115	8
7	G-62-404	691	14
8	Annigeri	<u>2677</u>	1
9	BDN-9-3	<u>2440</u>	3
10	CPS-1	2148	5
11	CPS-2	973	13
12	Pant-114	1732	10
13	BG-204	1092	11
14	B-110	2145	6
15	BG-214	1041	12

C.V. % 21
C.D. (0.05) 358.46

Note: The underlined entries are in top significant group.

EVALUATION OF METHODS AND PRACTICES BEING ADOPTED

Effectiveness of Visual Selection for Yield

We have been raising several thousand F_3 thru F_6 progenies each year both at Hyderabad and Hissar. Precise yield estimate and visual scoring are used by the breeders for making selections. The former requires precise estimate of yield for which replicated yield trials are required. This necessitates more land and financial resources. Consequently, most breeders prefer to evaluate their material visually. In our program we have been evaluating our material visually and whatever lines were bulked or advanced were rated visually.

We were interested to know whether the progenies to which we allotted promising ranks actually outyielded the discard group. We estimated yield of F_4 progenies during 1975-76 and F_5 progenies during 1976-77, in addition to visual evaluation. A random sample of 100 progenies from each of promising and discard groups was drawn from 1975-76 and 1976-77 data and their average yield was computed (Table 24).

It can be seen that the average yield per plot (g) for 1975-76 was 1284 and 807 for the 'promising' and the 'discard' groups, respectively, with the 'promising' group outyielding the 'discard' group by 59 per cent. Similar results were obtained during 1976-77 where the selected group exceeded the rejected group by 35 per cent. This shows that our criteria for visual selection, in general, identified the yielding ability of progenies properly.

We also examined the visual scores of the top yielding 50 progenies in F_4 and F_5 generations. There we found that most of the progenies had a rating of 1 to 3, but there were a few progenies which had a rating of 4 or even 5 which were in the top 5 per cent for yield. This indicated that in general visual selection was effective, but we were not always correct in evaluating the material. In order to overcome this problem, we wish to use visual rating along with yield estimates on material in F_5 and later generations. For earlier generations we shall continue evaluating the material visually.

Table 24. Average yield (g) of promising and discard group of plants

	Year					
	F_4 1975/76			F_5 1976/77		
	Hyderabad	Hissar	Average	Hyderabad	Hissar	Average
Promising Ranks 1, 2 & 3	1270	1299	1284	1564	1467	1515
Discard Ranks 4 & 5	784	829	807	1099	1147	1123
% Increase of Promising over Discard			59			35

Note: 1. Averages are based on 100 progenies in each group.

2. Plot size was 4 m x 1.5 m at Hyderabad and 4 m x 1.2 m at Hissar.

Screening of Advanced Generations under High and Low Fertility Conditions

A major breakthrough in yields of cereals has been achieved by developing cultivars responsive to high doses of fertilizer. To screen for responsive genotypes in chickpeas, we grew advanced generation material both under high (60 kg P_2O_5/ha) and low (30 kg P_2O_5/ha) fertility conditions. Since chickpeas have been reported to respond to phosphate fertilizer in poor soils, this element was chosen to test at two levels.

All of the F_4 progenies (approximately 4000) during 1975-76 and F_5 progenies (about 3100) during 1976-77 were grown under high and low fertility both at Hyderabad and Hissar. At Hissar the performance of the material was poor in the F_4 generation during 1975-76 owing to soil salinity. At Hyderabad the F_5 generation was affected due to poor stand. Hence, these results were discarded.

To estimate correlation 410 progenies were sampled from Hyderabad in 1975-76. A sample of 5 progenies was taken after every 50 progenies. The average yield of all the progenies under high and low fertility conditions was 1450 and 1399 kg/ha, respectively. The correlation coefficient between high and low fertility was positive and significant (0.62). The results suggest that there was no response to additional phosphate.

At Hissar in 1976-77 310 progenies were chosen in the same manner as at Hyderabad to determine the correlation coefficient between yields in high and low fertility conditions. The mean yields in high and low fertility conditions were 1986 and 2063 kg/ha respectively. Again, the correlation was 0.55, which was positive and significant. These results were in agreement with those at Hyderabad during the previous year.

We concluded that the chickpea crop did not respond to different levels of phosphate fertilizer. Our results are similar to those found in physiology and agronomy experiments at ICRISAT where trials were conducted with pure lines. In view of the results obtained, the use of two levels of phosphate will be discontinued. Some more basic research is needed to determine if response could be obtained with different quantities or methods of application of fertilizer.

Usefulness of Raising Material in Segregating Generations at South and North Indian Sites

The breeding work in chickpea was started at Hyderabad during 1973-74, which was extended to Hissar from 1975-76. Hyderabad is located 17°32' N, 78°16' E and 542 m altitude and Hissar is situated at 29°10' N, 75°44' E and 221 m altitude. Hyderabad has a very mild winter and the crop usually takes 110 days to mature. On the other hand Hissar has a severe winter and the crop takes 160 days to mature. The soil at Hyderabad is medium to deep black soil, whereas at Hissar it is alluvial soil with sandy loam texture. On the whole the Hissar site is well suited for chickpea cultivation, whereas the Hyderabad site appears to be on the fringes of chickpea cultivation in the Indian sub-continent.

We make individual plant selections in the material at Hissar and Hyderabad and grow the progenies in succeeding generations at both the sites. So far our practice has been to grow all progenies at both sites. Since the two locations differ widely, it was thought necessary to evaluate the usefulness of this practice. At the end of two seasons we have made a critical analysis of the available data.

We analysed four types of crosses, 1) early x early - selection made at Hyderabad, 2) early x late - selection made at Hyderabad, 3) early x late - selection made at Hissar, and 4) late x late - selection made at Hissar. The plants selected in the F_4 generation were grown as F_5 progeny rows at Hyderabad and Hissar.

In the early x early crosses selections made at Hyderabad performed well at Hyderabad giving a mean yield of 2007 kg/ha, whereas at Hissar the mean yield was only 1370 kg/ha. As could be seen from Table 25, an early x early cross produced segregants that were adapted to Hyderabad. In the progenies selected at Hissar from the late x late cross, the yield levels were 1225 and 2996 kg/ha at Hyderabad and Hissar, respectively. This indicated that a late x late cross was generally well adapted at Hissar, although it can occasionally produce a few transgressive segregants suited for Hyderabad conditions.

In the early x late cross (progenies selected at Hyderabad) the progenies performed well at Hyderabad (range of yields 1305-2541), whereas at Hissar some progenies produced miserably low to fairly high yields (range 232-3552). In

Table 25. Performance of different crosses and their selections at Hyderabad and Hissar, 1976-77

Cross	Progeny Selected at	Hyderabad Mean (Range)	Hissar Mean (Range)
Early x Early	Hyderabad	2007 (1527-2418)	1370 (521-3208)
Early x Late	Hyderabad	2018 (1305-2541)	2033 (232-3552)
Early x Late	Hissar	1658 (1231-2313)	2698 (1958-3896)
Late x Late	Hissar	1225 (665-2289)	2996 (1609-3760)

comparison the progenies selected at Hissar were moderately adapted at Hyderabad also, their yield ranging from 1231 to 2313 kg/ha.

In another study we analysed three cross combinations: (i) crosses with a late parent (H-208), (ii) crosses with a medium duration parent (850-3/27), and (iii) crosses with an early parent (JG-62). Selections made at both places were grown at both Hyderabad and Hissar, and their yield figures were used for analysis (Table 26).

The highest yielding progeny at Hissar came from a cross with H-208 (selected at Hissar in F_4 stage), whereas the highest yielding progeny at Hyderabad was obtained from a cross with JG-62 (selected at F_4 stage at Hyderabad).

The comparison of cross means at both locations revealed that selections made at Hissar yielded significantly lower when grown at Hyderabad than when grown at Hissar. But there was no significant difference between cross means for Hyderabad and Hissar for the selections made at Hyderabad.

It appears that maturity of genotypes alone cannot fully explain adaptation of these selections to contrasting environments. A comparison of the range of yields revealed that at Hyderabad the lowest yielder among Hissar selections was significantly lower than the lowest yielder of Hyderabad selections in all paired crosses. Similarly at Hyderabad the highest yielder among the Hissar selections was significantly lower than the highest yielder of Hyderabad selections

Table 26. Cross Performance - means and ranges (kg/ha) of F_5 progenies grown at Hyderabad and Hissar during 1976-77

Cross	Hyderabad Mean (Range)	Hissar Mean (Range)	Cross Mean
H-208 x ... (Hyderabad Selections)	1816 (1300-2391)	2051 (854-3801)	1934
H-208 x ... (Hissar Selections)	1264 (850-1726)	3307 (2198-3937)	2286
850-3/27 x ... (Hyderabad Selections)	1564 (835-1918)	1710 (645-3828)	1637
850-3/27 x ... (Hissar Selections)	1574 (532-2157)	2663 (1536-3708)	2119
JG-62 x ... (Hyderabad Selections)	1851 (1470-2458)	1933 (865-3218)	1892
JG-62 x ... (Hissar Selections)	1357 (939-1942)	2548 (1531-3156)	1953

STANDARD ERROR:

For Cross Means (e.g. 1934 vs 2286)	± 242
For Cross Means at one location (e.g. 1264 vs 1816)	± 342
For Cross Means at both locations (e.g. 1816 vs 2051)	± 741
For F_5 Progenies within a cross at each location (e.g. 1300 vs 2391)	± 318
For F_5 Progenies in any cross or location (e.g. 850 vs 1300)	± 184

CV % = 22.9

Note: Each cross has 20 entries having half-sib relationships with each other. "H-208 (Hyderabad Selections)" has 20 entries selected as F_4 single plants at Hyderabad in the 1975-76 season; etc. There were two replications at each location.

YIELD OF STANDARD CHECKS (Kg/ha)	MEANS OF 12 PLOTS CONTIGUOUS WITH ABOVE Hyderabad	Hissar
G-130 (North Indian cultivar)	1444	2681
JG-62 (South Indian cultivar)	1506	1440

At Hissar, however, the lowest yielders of Hyderabad selections are significantly lower than the lowest yielders of Hissar selections but there was no significant difference between the highest progeny yields of paired crosses. This could indicate a temperature effect on selections for yield. Selection at Hissar would be for long duration and tolerance to low temperature and hence they may yield well at Hyderabad in a favorable season. In contrast, selection at Hyderabad would be for short duration only, and when these genotypes were grown at Hissar there would be marked differential response among them for low temperatures and this might explain why some were very low yielders but others yielded well.

To test this hypothesis, we chose 50 high yielders from Hyderabad and from Hissar, and then looked to see where the selections were made in the previous generation. In the case of F_4 progenies at Hyderabad 34 came from Hissar selections and 16 from Hyderabad selections (Table 27). At Hissar 41 of them were Hissar selections and only 9 from Hyderabad selections. In F_5 progenies the trend in Hissar was the same (47 from Hissar and 3 from Hyderabad). At Hyderabad, 38 progenies were from Hyderabad selections and 12 from Hissar selections. When we considered the top 10 high yielders, all top yielders at Hissar were from selections made at Hissar, whereas at Hyderabad 2 of these were from Hissar selections. Table 27 shows the performance at both locations of the 50 high yielding F_4 and F_5 lines at each location.

We raised all F_2 populations at Hyderabad and Hissar for the past two years. This practice appears to be satisfactory. Selections at Hissar were mostly made from the late maturing crosses as against Hyderabad where early maturing plants were selected from mostly early x early or early x late crosses. Occasionally we observed that a few selections at Hyderabad were made from crosses involving only late parents and the reverse was true for Hissar site. We shall continue this practice for at least two more seasons before critically examining four years' data to arrive at a final decision on the merit of the system.

All plant selections made at Hyderabad and Hissar in F_2 populations were grown as F_3 progenies at both locations in the past two years. We consider this practice to be useful, since the possibility of finding widely adapted types may be greater in earlier generations. We plan to follow this practice for at least two more years.

Table 27. Comparison of F_4 and F_5 progeny performance at Hyderabad and Hissar, 1976-77

Parameter	50 Top yielders at Hyderabad	50 Top yielders at Hissar	No.
	F_4 PROGENIES		
Hyderabad			
Mean (Range)	2018.37 (1883-2417)	1155.26 (133-2292)	50
Av. yield of 'P' Selections	2029.21 (1883-2309)	885.00 (133-1757)	16
Av. yield of 'H' Selections	2068.21 (1900-2417)	1214.51 (138-2292)	34
Hissar			
Mean (Range)	2752.92 (542-4208)	3987.26 (3729-4981)	50
Av. yield of 'P' Selections	1960.00 (542-3604)	3852.33 (3749-3978)	9
Av. yield of 'H' Selections	3130.47 (979-4208)	4015.36 (3729-4981)	41
	F_5 PROGENIES		
Hyderabad			
Overall Mean (Range)	2590.30 (2425-3037)	1362.12 (578-2297)	50
Av. yield of 'P' Selections	2584.50 (2525-3037)	1980.00 (1489-2297)	38
Av. yield of 'H' Selections	2608.67 (2442-2783)	1322.68 (578-2110)	12
Hissar			
Overall Mean (Range)	1921.84 (656-3385)	3853.22 (3708-4083)	50
Av. yield of 'P' Selections	1713.68 (656-3187)	3835.00 (3802-3875)	3
Av. yield of 'H' Selections	2581.00 (1927-3385)	3854.38 (3708-4083)	47

N.B. 'P' Selections = Selections made at Hyderabad (Patancheru)
'H' Selections = Selections made at Hissar

Based on our observations from F_2 thru F_5 generations being grown at Hyderabad and Hissar the following conclusions can be tentatively drawn:

1. It is desirable to grow all of the F_2 and F_3 generations at both sites at least until more experience has been gained.

2. The usefulness of growing entire material from F_4 onwards at both the locations appears doubtful. It appears that local adaptation plays a major role in later generations. In F_4 and F_5 the Hissar selections are doing better at Hissar site and Hyderabad selections at Hyderabad site.

3. High yielders at Hissar site were from early x late and late x late crosses, whereas high yielders at Hyderabad originated from early x early, early x late, and mid-late x early crosses.

Observations on Introgression of "Yield Genes" from Kabuli to Desi Types and Vice-Versa

Like 'flint' and 'dent' types in maize and 'kafir' and 'milo' in sorghum, the 'desi' and 'kabuli' are two distinct types in chickpeas. It is believed that from the center of origin in Turkey, Afghanistan, and the Caucasus region of USSR, kabuli types migrated towards West Asia and Southern Europe, and desi type towards East Asia. Their cultivation remained separated for centuries. There is evidence of the kabuli type being introduced into the Indian sub-continent around 1750. These two types of chickpeas not only differ for seed characters but also for plant morphological characters and agronomic requirements. We believe that these two types possess some "yield genes" uncommon to each other and upon introgression they may produce transgressive segregates for high yield.

In the past three years we have been making single and multiple crosses involving at least one desi and/or kabuli parent. The proportion of desi and kabuli types in various crossing schemes varied from 25 to 75 per cent. Besides, we had some crosses with 100 per cent desi or kabuli parentage.

The crosses involving desi and kabuli types in different proportions were available in F_2 populations and F_3 and F_4 progenies during 1976-77. These were evaluated in different categories which were finally clubbed into promising and discard groups. The selections for 1975-76 and 1976-77 for Hyderabad and Hissar were pooled for F_2, F_3, and F_4 generations separately and their percentages were worked out.

The data (Tables 28, 29 and 30) over two locations and two years for the three generations indicated that while a higher percentage of 100% desi crosses were selected in F_2, in F_3 and F_4 the percentage of kabuli containing progenies selected compared favorably with 100% desi. Our observations indicate the kabuli x kabuli crosses are not promising, and it may be important to introduce desi genes for kabuli improvement. On the other hand the need for kabuli genes in desi material appears to be less. However we plan to continue to introgress genes in both directions.

Table 28. Number of F_2 populations involving various proportions of desi (D) and kabuli (K) genes, evaluated as promising and discard

% desi & kabuli genes	No. of populations									
	Hyderabad				Hissar				Total	
	1975/76		1976/77		1975/76		1976/77			
	PR	DIS	PR	DIS	PR	DIS	PR	DIS	PR	DIS
					SINGLE CROSSES					
100 D	27	196	49	117	52	118	46	135	250(31)	566(69)
50D + 50K	15	169	65	146	3	124	50	160	133(18)	599(82)
100 K	0	26	13	20	0	16	6	26	19(18)	88(82)
					THREEWAY CROSSES					
100 D	22	63	11	26	43	38	21	20	97(40)	147(60)
75D + 25K	3	6	10	38	2	7	13	19	28(29)	70(71)
50D + 50K	6	16	7	26	4	20	22	22	39(32)	84(68)
25D + 75K	0	5	4	28	1	4	8	10	13(22)	47(78)

N.B. Figures in parentheses are percentages.

PR = Promising; DIS = Discard.

Table 29. Number of F_3 progenies involving various proportions of desi (D) and kabuli (K) genes, evaluated as promising and discard

% desi & kabuli genes	No. of progenies									
	Hyderabad				Hissar				Total	
	1975/76		1976/77		1975/76		1976/77			
	PR	DIS	PR	DIS	PR	DIS	PR	DIS	PR	DIS
					SINGLE CROSSES					
100 D	26	70	52	742	29	87	101	233	208(16)	1132(84)
50D + 50K	2	11	30	224	2	19	34	118	68(15)	372(85)
100 K	4	3	0	1	0	0	0	0	4(50)	4(50)
					THREEWAY CROSSES					
100 D	21	20	57	926	9	32	58	227	145(11)	1205(89)
75D + 25K	5	4	10	125	2	5	9	49	26(12)	183(88)
50D + 50K	4	0	1	28	1	2	5	25	11(17)	55(83)
25D + 75K	1	3	21	279	1	6	22	153	45(10)	441(90)

N.B. PR = Promising; DIS = Discard

Figures in parentheses are percentages.

Table 30. Number of F_4 progenies involving various proportions of desi (D) and kabuli (K) genes, evaluated as promising and discard

% desi & kabuli genes	No. of progenies									
	Hyderabad				Hissar				Total	
	1975/76		1976/77		1975/76		1976/77			
	PR	DIS	PR	DIS	PR	DIS	PR	DIS	PR	DIS
					SINGLE CROSSES					
100 D	660	2415	71	851	601	1798	95	288	1427(21)	5352(79)
50D + 50K	159	640	15	97	182	425	7	21	363(23)	1183(77)
100 K	2	50	1	5	15	63	2	1	20(14)	119(86)
					THREEWAY CROSSES					
100 D			59	597			39	204	98(11)	801(89)
75D + 25K			15	94			12	40	27(16)	134(84)
50D + 50K			7	64			7	37	14(12)	101(88)
25D + 75K			6	67			10	17	16(16)	84(84)

N.B. PR = Promising; DIS = Discard

Figures in parentheses are percentages.

PROJECT 2 : BREEDING 'KABULI' TYPE CULTIVARS WITH HIGH YIELD AND STABILITY OF PERFORMANCE

OBJECTIVES :

i. To breed high yielding Kabuli cultivars with stability of performance

ii. To contribute early and advanced breeding lines and bulks to Kabuli chickpea producing countries for strengthening regional and national programs

PROCEDURES AND RESULTS

The breeding methodology and technique for cultivar development for 'kabuli' type is the same as for 'desi' type. However, there are some minor differences which require special attention. Kabuli types are mainly grown as a summer crop in West Asia, North Africa, and South Europe. In these regions, day length and diurnal temperature variations are different than for the winter planted crop in the Indian sub-continent. We have, however, some evidence that breeding material developed at Hissar may be suitable for West Asia.

As regards performance of kabuli types in the Indian sub-continent, it has been observed that these are more demanding in their cultivation requirements. This type is better suited to the areas having a longer growing season with some irrigation and protection from pests. Even so, yields are normally lower than for 'desi' types. These factors contribute to a very low hectareage of kabuli in this sub-continent.

CROSSING BLOCK

The crossing block entries for 'kabuli' type were assembled with the same consideration for 'desi' type. Though numerous kabuli strains are available in the germplasm collection, there appears to be a dearth of good ones. We, however, included 90 strains in our crossing block for 1976-77. They originated from 22 countries (Table 31). Special characteristics of all the 90 strains

Table 31. Geographic distribution of Kabuli strains used in 1976-77 crossing block at ICRISAT

Country/ Institute	No. of strains	Country/ Institute	No. of strains
ICRISAT	4	Morocco	1
India	20	Sudan	1
Iran	18	Afghanistan	3
USSR	6	Algeria	2
Ethiopia	1	Tunisia	2
Greece	1	USA	2
Egypt	3	Turkey	3
Pakistan	5	Israel	3
Lebanon	4	Mexico	2
Jordan	1	Peru	1
Iraq	2	Cyprus	1
Spain	2	Unknown	2

including those 16 which were used most extensively are shown in table 32.

The past four years' experience has shown that cultivar L-550 is a good combiner, is a high yielder, and has wide adaptation. However, this cultivar has comparatively small seed size (22 g/100 seed) and is susceptible to *Fusarium* wilt and *Ascochyta* blight. It has been utilized extensively in crosses with a view to eliminate these defects. In the 1976-77 season, we also crossed a few advanced breeding lines derived from crosses with L-550.

Table 32. List of kabuli cultivars used in the crossing program during rabi 1976-77

Sl No	Pedigree	ICC. No.	Origin	Seed color	Special characteristic
1	Angostura	7344	Mexico	S.White	Large seed size
2	Ayelet	8639	Israel	S.White	Blight resistant
3	Baroda Dhakri local	5704	Gujrat	S.White	High pod number, small seed size
4	Bet degan 302	7351	Israel	S.White	Blight resistant
5	Culia cancito	7346	Mexico	S.White	Large seed size
6	*C-104	4928	Punjab	S.White	Large seed size
7	Frontier-1	5164	Pakistan	S.White	Good bearing, dull color
8	*Giza	7773	Egypt	S.White	High yield under irrigation
9	GL-622	5244	Punjab	S.White	Promising culture
10	GL-629	5250	Punjab	S.White	Large seed size
11	GL-630	5251	Punjab	S.White	Promising culture
12	GL-651	5270	Punjab	S.White	Promising culture
13	Hyb-16-3	8284	U.P.	S.White	Promising culture in ICCT
14	Jam	7510	Iran	S.White	Released cultivar
15	JM-460/A-64-7-A	8444	Tunisia	S.White	Mid-late, semi-erect
16	JM-466	8446	Ethiopia	S.White	Good yielding capacity
17	JM-482-PP	8465	Pakistan	S.White	Promising culture at Hissar site
18	JM-484	8467	Pakistan	S.White	-do-
19	*K-4	4962	U.P.	S.White	High yield and wide adaptation
20	K-1189	8923	USSR	S.White	Tall, erect, good fruiting, good plant type
21	*K-1480	8926	USSR	S.White	Tall, erect, good podding
22	*K-56567	8929	USSR	S.White	Very good podding, tall, erect, good plant type
23	Kourosh	7512	Iran	S.White	Released variety
24	*L-532	4971	Punjab	S.White	Large seed size
25	L-534	4972	Punjab	S.White	Large seed size

contd.... Table 32

Sl No	Pedigree	ICC. No.	Origin	Seed color	Special characteristic
26	*L-550	4973	Punjab	S. White	High harvest index, high yield and wide adaptation
27	*Lebanese local	8273	Lebanon	S. White	High yielding local cultivar
28	Lebanese local peduncle mutant		Lebanon	S. White	Pods exposed above leaves
29	No.501	4983	Punjab	S. White	Good plant type
30	NEC-10	7709	Jordan	S. White	High yield
31	NEC-30	6165	Iraq	S. White	Good local type (Hawtin's observation)
32	NEC-34	7710	Iraq	S. White	Promising culture
33	NEC-62	6194	Spain	S. White	Vigorous, large pods, late
34	NEC-79	6211	Spain	S. White	Large seed size, many pods
35	NEC-108	7716	Greece	S. White	Erect, extra tall
36	*NEC-139	7721	USSR	S. White	Extra tall
37	NEC-140	7722	USSR	S. White	Extra tall
38	*NEC-141	6262	USSR	S. White	Tallest among Russian types
39	NEC-143	7723	Sudan	S. White	Good plant type
40	NEC-175	6283	Peru	S. White	Erect type
41	NEC-197	6249	Pakistan	S. White	Promising culture
42	NEC-571	9056	Iran	S. White	Mid-late, good podding
43	NEC-643	6567	Afghanistan	S. White	Good line from PYT, ALAD, Lebanon
44	NEC-657	9075	Unknown	Yellow	Promising culture from Hissar site
45	NEC-701	9080	Unknown	Yellow	-do-
46	NEC-1572	7774	Egypt	S. White	Erect,tall, small seeded
47	NEC-1604	7775	Egypt	S. White	Promising culture
48	NEC-1607	7776	Lebanon	S. White	Promising culture
49	NEC-1614	7241	Lebanon	S. White	Good line in PYT,ALAD
50	NEC-1640	7267	Algeria	S. White	Best line in PYT,ALAD

contd.... Table 32

Sl No	Pedigree	ICC. No.	Origin	Seed color	Special characteristic
51	NEC-1646	7778	Algeria	S. White	Good plant type
52	NEC-1660	7287	Tunisia	S. White	Erect and tall
53	NEC-1713	7794	Iran	S. White	Erect
54	NEC-2174	8043	Iran	S. White	Promising culture from Hissar site
55	NEC-2296	8149	Iran	S. White	" " "
56	NEC-2427	8260	Turkey	S. White	Promising variety
57	NEC-2436	9511	Turkey		Late, good podding
58	NEC-2561	8716	Afghanistan	S. White	Promising culture from Hissar site
59	NEC-2692	8842	"	S. White	-do-
60	*OFRA	8638	Israel	S. White	Blight resistant
61	L-550 x G-130	7347-6-4	ICRISAT	S. White	Top yielder kabuli type
62	L-550 x K-4	7358-7-2	"	S. White	" " "
63	L-550 x K-4	7358-8-2	"	S. White	" " "
64	L-550 x CP-66	7376-15-2	"	S. White	" " "
65	P-100-1	123	U.P.	S. White	High pod number (Pulse germplasm)
66	P-736-2	929	India	S. White	Small seed size among kabuli types
67	P-1054	1152	U.P.	S. White	Round seeds
68	P-1071	1159	India	S. White	Promising culture
69	P-1213-2	1350	U.P.	S. White	Good podding, cream pod color
70	P-1216-2	1355	U.P.	S. White	Promising culture
71	P-2215-1	2437	Iran	S. White	Excellent podding
72	P-2219	2438	Iran	S. White	L-550 habit,excellent podding
73	P-2236	2452	Iran	S. White	Typical desi growth habit, med.maturity, excellent podding.
74	P-2242	2456	Iran	S. White	Very late, good podding
75	P-2386-1	2508	Iran	S. White	High number of pods

contd.... Table 32

Sl No.	Pedigree	ICC. No.	Origin	Seed color	Special characteristic
76	P-2566	2569	Iran	S. White	Promising culture
77	P-2571	2570	Iran	S. White	Good plant type
78	*P-2591	2584	Iran	S. White	Large seed size, high number of pods
79	P-2614	2600	Iran	S. White	More pods and secondary branches
80	P-2718-1	2407	Iran	S. White	Typical desi growth habit, medium maturity, excellent podding.
81	P-2943	2769	Iran	S. White	More branches and more pods
82	P-3896	3282	Iran	S. White	Good podding capacity
83	P-5462	4454	Cyprus	S. White	Good bearing
84	*P-9623	4854	USA	S. White	Large seed size
85	*P-9800	4987	Turkey	S. White	Medium tall, semi-erect, bold pods
86	Rabat	4993	Morocco	S. White	Good table type
87	Shahkot-5-1	10606	Pakistan	S. White	Good plant type, good podding
88	1252	5614	Punjab	S. White	Good podding, comparatively tall
89	251783	7323	USA	S. White	Erect and late

N.B : Most of the special characteristics were reported from the originating centres.

* Strains used most extensively every year since 1973-74

CROSSES MADE

The criteria for the choice of parents for making crosses of kabuli type chickpeas are the same as those for desi type (CP-brd-1). There is, however, one departure. We believe that though desi types could be improved by crossing among themselves, yield improvement in kabuli type will require some input from desi type. Therefore, while making crosses we usually incorporate genes from desi types in various proportions (25 to 50%)

as: Kabuli x desi and (kabuli x desi) x kabuli and only a few crosses are made involving 100% kabuli parents.

During 1976-77, 75 crosses involving only kabuli parents and 760 crosses involving kabuli and desi parents were made. The transfer of "yield genes" from desi to kabuli types poses a serious problem because many characters in kabuli type are governed by recessive genes. As a result, a large number of segregants in early segregating generations are of undesirable type. To overcome this difficulty, we make a large number of crosses. Nearly half of the 7000 crosses made since inception of the program involve kabuli types.

F_1 GENERATION

We grew 407 single crosses and 75 multiple crosses involving kabuli type strains during 1976 off-season at the Lahaul valley. Due to unfavorable weather in the valley, we could produce F_2 seeds from only 40 per cent of the crosses.

In addition to F_1's raised in off-season, 51 F_1's involving kabuli x kabuli strains and 342 involving desi x kabuli strains were grown in 1976-77 season at Hyderabad. A few two-way crosses were utilized for making multiple crosses. The F_2 seeds were produced and were saved for planting next generation.

F_2 POPULATIONS

Method of planting, and evaluation of material was same as explained for F_2 generation of desi type (CP-brd-1).

Five hundred and sixty F_2 populations of desi x kabuli crosses and 33 of kabuli x kabuli crosses were grown at Hyderabad. Of these, 243 were single, 120 were three-way, 141 were double, and 89 were composite crosses. At Hissar 455 populations were grown, which consisted of 240 single crosses, 78 three-way crosses, 86 double crosses, and 51 composite crosses.

Twenty populations were rated as very promising, 117 as promising, and the remaining 456 as discard at Hyderabad. At Hissar, 19 populations were classified as very promising, 93 as promising and 344 were put in discard category (Table 33).

Table 33. Number of F_2 populations scored in various categories in different years

Year	Hyderabad				Hissar			
	Total	VP	P	D	Total	VP	P	D
1974-75	72	7	16	49	-	-	-	-
1975-76	388	14	45	329	335	12	32	291
1976-77	593	20	117	456	456	19	93	344

The total number of populations and their evaluation since 1974-75 are given in table 33. A total of 935 and 1823 plants were selected at Hyderabad and Hissar respectively during 1976-77.

As described for project 1, all plants in the very promising F_2 populations were bulk harvested for supplying to cooperators as early generation segregating material. Nineteen populations from Hyderabad and 14 from Hissar were retained for this purpose. The details are given in table 34.

Table 34. F_3 bulks of kabuli x desi and kabuli x kabuli crosses selected for supplying to cooperators during 1977-78.

Sl.No.	Pedigree	Cross
	<u>Hyderabad</u>	
1	74826-BP	NEC-143 x C-214
2	74828-BP	NEC-249 x NEC-143
3	741225-BP	L-532 x P-472
4	741363-BP	Giza x T-103
5	741471-BP	P-2591 x P-3090

contd.... table 34

Sl.No.	Pedigree	Cross
6	741507-BP	P-2591 x P-436
7	7414-BP	T-103 x JM-530
8	75112-BP	Pant-104 x NEC-142
9	75157-BP	JG-62 x L-550
10	75239-BP	(Ceylon-2 x G-130) x (NEC-1077 x P-3090)
11	75979-BP	P-9800 x P-2252
12	75275-BP	(NEC-143 x L-550) x (V-4 x P-472)
13	751779-BP	GW-5/7 x (NEC-108 x Giza)
14	751795-BP	NEC-1566 x (JG-109 x P-2939-2)
15	752118-BP	F_2 (NEC-249 x NEC-10)-3 X F_2 (P-502 x P-1243)-3
16	752186-BP	F_2 (NEC-249 x P-4306)-2 x F_2 (NEC-143 x P-99)-2
17	752267-BP	F_3 (850-3/27 x GW-5/7) x P-458 x F_3 (L-550 x Guamuchil)
18	74977-BP	P-9800 x GL-651
19	751269-BP	L-550 x Ofra
	Hissar	
1	751663-BH	L-550 x P-3642-1
2	751665-BH	L-550 x IC-2667
3	751448-BH	L-550 x P-1613
4	751514-BH	P-431 x L-534
5	751546-BH	F-61 x GL-629
6	751685-BH	L-550 x (NEC-143 x C-214)
7	751922-BH	(BG-1 x P-502) x (G-130 x Ayelet)
8	752559-BH	F_3 (L-345 x K-468) x F_3 K-4 x (L-550 x H-355)
9	741297-BH	JG-39 x L-550
10	741319-BH	JG-39 x C-375
11	75406-BH	L-550 (C-214 x NEC-108)
12	75417-BH	L-532 (NEC-143 x P-2994)
13	75433-BH	P-388 (K-4 x P-99)
14	75358-BH	(C-214 x K-4) x (K-468 x P-514)

F_3 PROGENIES

The method of planting and evaluating these F_3 progenies was the same as in Project 1.

At Hyderabad 2522 progenies were grown during this season. This consisted of 255 progenies from single, 465 from three-way, 980 from double and 822 from composite crosses. At Hissar 2630 F_3 progenies were grown during 1976-77 season. Of these 294 originated from single, 448 from three-way, 326 from double and 1562 from composite crosses. The total number of F_3 progenies grown from 1975 onwards is given in table 35.

The visual rating at Hyderabad was: 15 progenies rated as 2,202 as 3, and the remaining 2305 as 4 and 5. The scoring of progenies at Hissar was; 4 progenies as 1, 46 as 2, 1137 as 3, and the remaining as 4 and 5.

A total of 511 plants, including 243 from Hyderabad and 268 from Hissar, were selected from the promising progenies.

Table 35. The number of F_3 progenies grown up to 1976-77 season

Year/Season	Hyderabad	Hissar	Off-season
1975/off-season	--	--	1212
1975-76/rabi	48 (B)*;85	61(B)*; 89	--
1976/off-season	--	--	615
1976-77/rabi	2522	2630	--

(B)* denotes F_3 modified bulk populations

F_4 PROGENIES

The F_4 generation was treated the same way as the F_3 generation. Forty plants of each progeny were grown in two rows 4 m long both at Hyderabad and Hissar. The cultivar L-550 was used as the standard check for kabuli type, but two desi types, JG-62 and G-130, were also included for comparison. The crop condition in Hissar was in general satisfactory, whereas it was variable at Hyderabad.

All plants selected in the previous generation at either site were grown at both the locations. A total of 331 progenies were grown during 1976-77.

The F_4 generation was visually scored on a 1 to 5 scale. The characters which were taken into consideration, while evaluating the lines, were the same as those in case of desi type, except that special attention was paid to the seed color and size.

Very few progenies were rated in 1-3 categories and most of those were placed in the last two. Besides visual scoring, actual yields were also estimated. The progenies exceeding the nearest check and those higher than the highest check yield are shown in table 36. Though 28 and 14 progeny lines exceeded the nearest check at Hyderabad and Hissar respectively only one and two lines yielded higher than the highest check yield. Even there the yield differences were marginal. The picture which has emerged so far from breeding kabuli cultivars is not very encouraging. This calls for more concerted effort to generate higher yielding material than L-550.

The individual plant selections were made in the progenies placed in categories 1 to 3. A total of 43 plants were selected at both the locations.

Table 36. Comparison of F_4 kabuli progenies with best check (L-550) during 1976-77.

Progenies yielding	Hyderabad (no.)	Hissar (no.)
More than the nearest check	28	14
Higher than the highest check yield	1	2

F_5 PROGENIES

The F_5 generation for kabuli types was handled in the same fashion as described in Project 1 for desi type. The method of raising the material at Hyderabad and Hissar was the same as for Project 1. During 1976-77 we raised 663 and 825 progenies under high and low fertility conditions respectively, at Hyderabad. At the Hissar site, the number was 752 and 718 in high and low fertility conditions, respectively. The cultivar L-550 was used as a standard check for comparison. Two desi checks, JG-62 and G-130, were also included to judge the performance of kabuli types in relation to desi types.

The same procedure for evaluating the progenies and selecting individual plants from the chosen progenies were adopted as in the case of desi types. Besides visual scoring, actual yield measurements were also taken. The number of progenies exceeding the nearest kabuli check and those higher than the highest check yield are shown in table 37. As many as 53 and 56 progenies outyielded the nearest kabuli check, but only 3 and 5 progenies outyielded the highest yield of the check at Hyderabad and Hissar respectively.

Table 37. Comparison of F_5 progenies with best check (L 550) during 1976-77

Progenies yielding	Hyderabad (no.)	Hissar (no.)
More than the nearest check	53	56
Higher than the highest check yield	3	5

The yield performance of progenies which have outyielded the nearest kabuli check at Hyderabad and Hissar are shown in tables 38 and 39. It can be seen that the highest yielding progeny 7376-15-1-2P-BP (L 550 x SP 405) yielded 2742 kg/ha giving an increase of 108 per cent over the nearest check at Hyderabad. The highest yielding F_5 progeny 7387-3-1H-BH (L 550 x E 100) produced 3416 kg/ha yield which exceeded the nearest check by a margin of 95 per cent at Hissar.

A total of 155 plants including 44 from Hissar and 111 from Hyderabad were finally chosen from categories 1 to 3. A few uniform and high yielding progenies were bulked. The details for these bulked lines will be given in a subsequent section.

In general, the progress in breeding for kabuli type to date is not so impressive as in breeding for desi type. It was partly because the same amount of effort was not devoted to this project as for desi type in the beginning of the program. In later years equal emphasis has been laid on both the projects, yet the progress is not on par with the one for desi. The varietal improvement program for kabuli types may get impetus, once the program is initiated in the Middle East in collaboration with ICARDA.

Table 38. Mean yield of the progenies exceeding the nearest kabuli check at Hyderabad

Pedigree	Cross	Yield kg/ha	% increase over the nearest check
7376-15-1-2P-BP	(L 550 x SP 405)	2742	108.2
7360-1-4-1H-BP	(L 550 x Annigeri)	2667	109.34
7385-10-1-2H-BP	(L 550 x L 2)	2663	132.58
7357-22-1-1H-BP	(L 550 x K 468)	2533	98.82
7358-4-3-1H-BP	(L 550 x K 4)	2358	17.26
73235-5-1-1P-BP	(F-378 x Rabat)	2293	48.03
7385-17-2-1H-BP	(L 550 x L 2)	2258	97.20
7366-17-2-1H-BP	(L 550 x RS 11)	2227	74.80
7353-2-3-2P-BP	(L 550 x BEG 482)	2183	45.53
73356-3-2-1P-BP	(L 550 x T 3)	2133	52.25
7366-17-5-1H-BP	(L 550 x RS 11)	2104	19.34
7385-10-2-1P-BP	(L 550 x L 2)	2103	12.34
7358-25-3-1H-BP	(L 550 x K 4)	2100	4.43
7385-8-2-1P-BP	(L 550 x L 2)	2070	10.58
7385-17-2-2H-BP	(L 550 x L 2)	2067	80.52
7369-2-1-1P-BP	(L 550 x USA 613)	2047	9.35
7366-17-3-1H-BP	(L 550 x RS 11)	2033	59.58
7344-19-3-2P-BP	(F 61 x L 550)	1987	6.14
7353-6-1-1P-BP	(L 550 x BEG 482)	1891	1.01
7376-12-1-1H-BP	(L 550 x SP 405)	1867	89.74
7338-2-3-3H-BP	(H 208 x C 104)	1808	25.52
7385-8-1-1P-BP	(L 550 x L 2)	1798	28.34
7325-11-2-2H-BP	(H 208 x F 404)	1779	0.91
7357-12-3-2H-BP	(L 550 x K 468)	1723	75.10
7385-1-1-1H-BP	(L 550 x L 2)	1723	50.48
7338-1-2-2H-BP	(H 208 x C 104)	1722	75.00
7358-25-2-2H-BP	(L 550 x K 4)	1650	44.10
73242-17-2-1P-BP	(K 4 x L 144)	1635	1.68
7357-22-1-1P-BP	(L 550 x K 468)	1619	10.89
7353-6-2-2H-BP	(K 550 x BEG 482)	1546	57.11
7347-6-4-1H-BP	(L 550 x G 130)	1527	55.18
7387-3-1-1H-BP	(L 550 x E 100)	1500	31.00
73344-4-2-1P-BP	(NP 34 x P 3896)	1500	7.07
73356-3-3-1P-BP	(L 550 x T 3)	1487	6.14
7353-6-1-1H-BP	(L 550 x BEG 482)	1485	16.56

contd.... Table 38

Pedigree	Cross	Yield kg/ha	% increase over the nearest check
7385-12-1-1H-BP	(L 550 x L 2)	1441	25.85
7351-15-3-1H-BP	(L 550 x H 355)	1433	45.63
7376-9-3-1H-BP	(L 550 x SP 405)	1367	38.92
7353-6-2-2H-BP	(L 550 x BEG 482)	1334	35.56
73242-17-2-2H-BP	(K 4 x L 144)	1322	15.46
7338-2-4-1H-BP	(H 208 x C 104)	1304	32.52
7367-14-1-2H-BP	(L 550 x P 1786)	1280	30.08
7358-7-3-1H-BP	(L 550 x K 4)	1273	11.18
7357-6-1-1H-BP	(L 550 x K 468)	1268	28.86
7366-17-5-2H-BP	(L 550 x RS 11)	1250	27.03
7358-9-2-1H-BP	(L 550 x K 4)	1207	5.41
7366-17-5-1H-BP	(L 550 x RS 11)	1196	21.54
7387-12-1-1H-BP	(L 550 x E 100)	1148	0.3
7320-9-2-2P-BP	(H 208 x RS 11)	1106	18.54
7338-2-3-1H-BP	(H 208 x C 104)	1089	10.67
73242-17-2-1H-BP	(K 4 x L 144)	1063	20.11
7357-3-2-1H-BP	(L 550 x K 468)	991	0.71
7387-12-1-1H-BP	(L 550 x E-100)	984	11.19

Table 39. Mean yield of the progenies exceeding the nearest kabuli check (L 550) at Hissar

Pedigree	Cross	Yield kg/ha	% increase over the nearest check
7387-3-1-1H-BH	(L 550 x E 100)	3416	95.20
7385-10-1-1H-BH	(L 550 x L 2)	3052	16.05
7387-3-3-2H-BH	(L 550 x E 100)	3010	14.52
7387-3-1-2H-BH	(L 550 x E 100)	2974	13.08
7376-15-1-2P-BH	(L 550 x SP 405)	2938	13.83
73242-17-2-2H-BH	(K 4 x L 144)	2870	9.13
7387-12-1-2H-BH	(L 550 x E 100)	2854	8.52
7385-7-2-2H-BH	(L 550 x L 2)	2817	7.11
7354-3-1-1H-BH	(L 550 x Pant 110)	2802	2.67
7378-15-4-1P-BH	(L 550 x H 223)	2792	86.76

contd.... Table 39

Pedigree	Cross	Yield kg/ha	% increase over the nearest check
7376-15-1-1P-BH	(L 550 x SP 405)	2786	7.94
7366-17-5-2H-BH	(L 550 x RS 11)	2765	29.51
7387-12-1-1H-BH	(L 550 x E 100)	2760	4.94
7378-16-5-2H-BH	(L 550 x H 223)	2750	6.8
7344-19-3-1H-BH	(L 550 x F 61)	2724	55.66
7338-2-3-1H-BH	(H 208 x C 104)	2667	48.83
7344-19-3-2P-BH	(F 61 x L 550)	2656	48.63
7366-17-5-1H-BH	(L 550 x RS 11)	2614	22.44
7385-1-2-1P-BH	(L 550 x L 2)	2583	72.76
7357-10-3-2H-BH	(L 550 x K 468)	2573	20.52
7366-17-2-1H-BH	(L 550 x RS 11)	2500	42.86
7338-2-3-2H-BH	(H 208 x C 104)	2484	41.94
72235-5-2-1P-BH	(F 378 x Rabat)	2479	69.68
7385-10-2-1P-BH	(L 550 x L 2)	2479	23.94
7347-6-4-1H-BH	(L 550 x G 130)	2458	37.17
7385-8-1-1P-BH	(L 550 x L 2)	2385	59.53
7357-3-2-1H-BH	(L 550 x K 468)	2370	11.01
7338-1-3-1H-BH	(H 208 x C 104)	2354	31.36
7385-8-2-1P-BH	(L 550 x L 2)	2302	53.98
7366-17-5-1H-BH	(L 550 x RS 11)	2302	31.54
7376-12-1-2H-BH	(L 550 x SP 405)	2302	7.82
7385-10-1-1P-BH	(L 550 x L 2)	2297	14.85
73242-17-2-1P-BH	(K 4 x L 144)	2276	6.06
7338-3-2-1H-BH	(H 208 x C 104)	2245	28.29
7367-15-3-1P-BH	(L 550 x P 1786)	2240	49.83
73235-5-1-1P-BH	(F 378 x Rabat)	2219	51.88
7385-17-2-1P-BH	(L 550 x L 2)	2219	48.43
7353-6-2-2H-BH	(L 550 x BEG 482)	2198	22.66
7376-12-1-1H-BH	(L 550 x SP 405)	2198	2.93
7312-4-1H-BH	(H 208 x K 4)	2182	24.69
7385-8-1-1P-BH	(L 550 x L 2)	2083	4.15
7370-8-3-1P-BH	(L 550 x GW 5/7)	2068	1.27
7358-6-2-1H-BH	(K 4 x L 550)	2042	16.69
73235-5-2-1P-BH	(F 378 x Rabat)	2026	5.41
7385-8-2-1P-BH	(L 550 x L 2)	2010	0.5
7366-17-3-1H-BH	(L 550 x RS 11)	1969	12.51
7353-6-2-3H-BH	(L 550 x BEG 482)	1922	7.25
7353-3-2-2P-BH	(L 550 x BEG 482)	1890	81.38
7351-16-3-1H-BH	(L 550 x H 355)	1885	5.19
7353-3-2-1P-BH	(L 550 x BEG 482)	1875	1.41

contd.... Table 39

Pedigree	Cross	Yield kg/ha	% increase over the nearest check
73242-17-2-1H-BH	(K 4 x L 144)	1865	6.57
7373-3-5-1P-BH	(L 550 x BR 70)	1854	24.01
7369-2-1-2P-BH	(L 550 x USA 613)	1828	23.51
7375-1-3-2P-BH	(L 550 x CP 66)	1656	11.89
7353-2-3-3P-BH	(L 550 x BEG 482)	1651	58.45
7366-17-1-1P-BH	(L 550 x RS 11)	1636	8.27

F_6 PROGENIES

The material for this project was advanced in the similar manner as that for 'desi'type. It was divided between Hyderabad and Hissar and sown in high and low fertility as for Project 1. At Hyderabad and Hissar 96 and 135 progenies, respectively, were grown during this season.

The evaluation of F_6 progenies was done the same way as that of F_5 progenies. Four progenies were rated in category 3 at Hyderabad, whereas at Hissar 2 progenies were rated 2 and 31 rated 3.

None of the kabuli progenies in F_6 merited bulking However, there were some lines which were good but were segregating. From such progeny rows individual plants were selected for further evaluation in F_7 generation. In total 45 plants, including 4 from Hyderabad and 41 from Hissar were selected.

BULKING OF PROGENIES

The 1976-77 season was the first time when we had our material in F_5 and F_6 generations. As in case of desi types we decided to bulk a few superior yielding and agronomically uniform progenies. We adopted similar procedures for bulking as described in Project 1.

Bulking based on multilocation tests

We composed an International Chickpea Screening Nursery comprising 25 kabuli F_5 bulks and L 550 as a check which we designated as ICSN-C. Though these nurseries were sent to 7 locations in 4 countries we received results from 2 locations in India by May, 1977. There were a few entries which performed well at one or more locations exceeding the standard check by a reasonable margin. All the bulks which were included in ICSN-C were also multiplied and purified at Hyderabad and Hissar. Consequently, 19 bulks were chosen for furnishing to the cooperators again for evaluation. Their yield performance in multilocation tests is given in Table 40.

Table 40. Mean yield and range of F_5 kabuli bulk entries during 1976-77

Pedigree	Cross	Mean yield kg/ha	Range	Remarks
7358-4-3-B-BH	(L 550 x K 4)	2184	1678 - 2689	
7369-3-1-1P-BH	(L 550 x USA 613)	Not recorded		
7385-1-1-B-BP	(L 550 x L 2)	2744	1965 - 3522	3 at Hyderabad
7385-10-2-BH-BP	(L 550 x L 2)	3049	1530 - 4567	1 at Hissar
7344-19-2-BH-BP	(F 61 x L 550)	2194	1454 - 2933	
7358-7-1-BH-BP	(L 550 x K 4)	1877	1165 - 2589	
7346-9-2-BH-BP	(L 550 x Radhey)	1928	1367 - 2489	
7387-3-3-BH-BP	(L 550 x E 100)	2598	1028 - 4167	4 at Hissar
7384-12-3-BH-BP	(L 550 x Pant 104)	2386	760 - 4011	5 at Hissar
7358-7-3-BH-BP	(L 550 x K 4)	2641	1348 - 3933	
7385-17-3-BH-BP	(L 550 x L 2)	2463	1381 - 3543	
7358-6-2-BH-BP	(L 550 x K 4)	2475	1238 - 3711	
7375-15-1-BP-BP	(L 550 x CP 66)	Not recorded		
7358-11-3-B-BP	(L 550 x K 4)	2283	1721 - 2844	5 at Hyderabad
7358-3-2-BP-BP	(L 550 x K 4)	2504	1374 - 3633	

contd.... Table 40

Pedigree	Cross	Mean yield kg/ha	Range	Remarks
7347-6-4-B-BH	(L 550 x G 130)	2756	1645 - 3867	
7358-8-2-B-BH	(L 550 x K 4)	2877	1410 - 4344	Ranked 2 at Hissar
7385-17-2-B-BH	(L 550 x L 2)	2989	2033 - 3944	1 at Hyderabad
7357-12-3-B-BH	(L 550 x K 468)	2334	-	Taken from Hissar multiplication
L 550		2831	2017 - 3645	2 at Hyderabad

Bulking based on performance of F_5/F_6 progenies at Hyderabad and Hissar

Based on superior yield performance and agronomic uniformity, we bulked 10 progenies. Their yield performance along with per cent increase over nearest check is given in table 41. These bulks will be furnished to our cooperators during the 1977-78 season.

Table 41. Plant characteristics (average) of entries in F_5 (kabuli) generation grown during 1976-77

S. No.	Pedigree	Cross	Pl Ht (cm)	Pl Sp (cm)	Gr Ha	Pr Br	Sr Br	Tr Br	Pod No.	Seeds/pod	Col	100-seed wt	Testa str	Yield (kg/ha)	H.I. (%)	Pl St	% increase over check
1.	7369-5-3-1P-BP	(L-550 x USA-613)	50	33	SE	4	8	P	227	1.00	SB	20.87	T	3273	51	34	30.0
2.	73235-5-2-1P-BP	(F-378 x Rabat)	42	40	SE	4	9	P	223	1.00	SW	21.50	S	2183	50	34	-16.0
3.	73242-17-2-1H-BP	(K-4 x L-144)	51	34	SE	3	6	P	180	1.00	SW	24.75	S	2117	52	24	-15.9
4.	73242-17-2-2H-BP	(K-4 x L-144)	53	25	SE	3	8	P	229	1.00	SW	24.20	S	2423	49	30	30.5
5.	73235-5-1-1P-BP	(F-378 x Rabat)	46	39	SE	4	8	P	241	1.00	SW	21.54	S	3158	54	35	21.5
6.	7378-16-5-2H-BP	(L-550 x H-223)	43	41	SE	3	6	P	232	1.03	SW	22.13	S	2800	55	29	7.5
7.	7376-15-2-1H-BP	(L-550 x SP-405)	43	37	SE	3	7	P	234	1.14	SW	16.88	S	2688	56	32	3.2
8.	7387-8-3-1P-BP	(L-550 x E-100)	44	42	SE	2	8	P	299	1.03	SW	20.97	S	2987	58	29	6.0
9.	7338-3-2-2H-BP	(H-208 x C-104)							Not	Recorded							
10.	7366-17-5-1H-BP	(L-550 x RS-11)							Not	Recorded							

N.B. Details of abbreviations already mentioned under Project 1.

PROJECT 3 : BREEDING FOR DISEASE RESISTANCE

OBJECTIVE : i. To develop cultivars resistant to wilt and other diseases

ii. To maintain yield and stability of performance within the new disease resistant cultivars

PROCEDURES AND RESULTS

Chickpeas are subject to a number of diseases out of which *Fusarium* wilt, root rots, and *Ascochyta* blight are the most important ones. The extent of damage due to these diseases varies but it could be complete in certain fields/ areas.

In other varietal improvement projects, we are relying heavily on the pedigree method of breeding. In this project, besides the pedigree method, we propose to utilize the backcross method, partial or complete, for developing high yielding and disease-resistant cultivars.

Until now a paucity of basic information on these diseases prevented us from initiating systematic work on breeding for disease resistance in this crop. The complex nature of wilt disease has been attributed to different causes. The pulse pathology group of ICRISAT has established that wilt complex in chickpea can be attributed to several organisms; *Fusarium oxysporum* (wilt), *Rhizoctonia bataticola* (root rot), *Sclerotium rolfsii* (collar rot), *Rhizoctonia solani* (root rot), a sterile fungus, *Fusarium solani* and *Operculella padwickii* (foot rot). The vascular wilt caused by *F. oxysporum f.* sp. *ciceri* is the most important. The pathology group has standardized diagnostic characteristics of these diseases. They have also developed laboratory screening techniques for wilt and blight.

The pulse pathology group and we have observed that if chickpea is grown in a particular field for three seasons under Hyderabad conditions, the field is likely to develop into a sick-plot. This, therefore, appears to be a good method of creating a sick plot. However, a significant implication of this for prevention of wilt is to suggest farmers not to grow chickpeas in the same field year after year. This should also be true for the breeding material which does not involve wilt resistant parents.

A wilt sick plot in B-5 field has been developed by growing chickpeas for the three consecutive years and dumping stubble of wilted plants in that plot. This can be utilized for screening breeding material from the next season. The pathology group has developed a multiple disease sick plot, in BT-6 field which has pathogens for several diseases.

Inheritance studies

Resistance to wilt in chickpeas has been reported to be recessive. To investigate this we sent 10 seeds each of five F_1's (crosses) involving the wilt susceptible cultivar JG 62 with lines reported resistant (by previous workers) to the pulse pathology section for testing. The five crosses were with NEC 802, Annigeri, 850-3/27, H 355 and CPS 1. Two laboratory tests run by the pathologists included JG 62, other parents and the F_1's. The F_1's and JG 62 completely wilted within 21 days whereas the other parents, Annigeri, 850-3/27, H 355, NEC 802 and CPS 1, were resistant. In these crosses resistance to wilt was recessive. The number of genes involved will be studied in segregating generations.

Breeding populations

In the past we made crosses with parents claimed to be resistant to Fusarium wilt and Ascochyta blight diseases in the hope of finding resistance in the segregates. In the absence of screening facilities the material was advanced without any conscious selection pressure for diseases. Now that the wilt-sick plot is available we have the following number of populations/lines in various generations which involve one or more parents resistant to wilt available for screening:

F_2	:	109 populations
F_3	:	317 progeny lines
F_4	:	417 progeny lines

Some progeny lines and promising advanced generation bulked lines also are derivatives of one or more wilt resistant parents. The total number of lines of F_5, F_6 and F_7 generations available with us are:

F_5	:	750 progeny lines
F_6	:	1173 progeny lines
F_7	:	280 progeny lines

Similarly 43 F_2 populations, 129 F_3, 125 F_4 and 129 F_5 progeny lines were derived from one or more Ascochyta blight tolerant lines.

PROJECT 6 : BREEDING FOR HIGHER PROTEIN CONTENT AND GOOD AMINO ACID PROFILES PER UNIT AREA PER DAY.

OBJECTIVES : To develop chickpea cultivars high in protein quantity and quality with high yield and stability

PROCEDURES AND RESULTS

Variation for protein content

Legumes in general have a higher protein content than cereals. There is considerable variation for protein content among legume species and within a species. To determine the range of protein content in chickpeas, the seeds of a number of lines grown in the crossing block were analyzed for protein content. A few high and low protein lines were analyzed the following year also. The range for these lines was from 13.9 to 28.6 per cent (Table 42.)

Table 42. Variation for protein content among chickpea cultivars

ICRISAT No.	Cultivar	Origin	Protein %	
			1975-76*	1976-77**
9252	NEC 1696	Iran	28.2	25.9
7920	NEC 2205	Iran	14.3	17.9
4464	P 5482	Iran	13.75	17.4
344	P 257	India	26.00	19.4
2271	P 1872-1	Iran	13.87	19.0
5464	T 3	India	13.50	13.9
7448	NEC 1831	India	28.40	24.7
8446	JM 466	Ethiopia	25.00	18.2
1110	P 993	Pakistan	23.26	17.4
8274	Annigeri	India	14.1	13.9
6067	JG 39	India	18.76	16.3
6804	NEC 969	Iran	26.1	20.6
804	P 636	India	30.9	25.6
8397	T-1-A	India	28.6	28.6

CONTD.... Table 42

ICRISAT No.	Cultivar	Origin	Protein %**	
			1975-76*	1976-77*
1166	P-1092	India	24.50	17.9
		Range	13.5 - 30.9	13.9 - 28.6

* Mikrokjeldahl analyses. The analyses for all lines were not done at the same time.

** Average of three determinations performed by Technicon Auto Analyser on whole seed samples

Studies on protein content of kabuli and desi cultivars

We were interested in knowing whether desi and kabuli type cultivars differed in protein content. The seed harvested from the 1974-75 crossing block entries was analyzed for protein content by the quality laboratory. There were 264 desi and 86 kabuli type cultivars. The ranges and means obtained from these data (Table 43) show that there is no difference between desi and kabuli types in mean protein content.

Table 43. Ranges and means for protein content of desi and kabuli cultivars

Type	No.of cvs.analysed	Range (%)	Mean (%)
Desi	264	14.5 - 25.2	18.5
Kabuli	86	13.9 - 26.2	18.2

Relationship of seed size and protein content

With a view to ascertain whether large and small seed size cultivars differed in protein content, a random sample of 25 cultivars having more than 25 g/100 seed and another of lines having less than 15 g/100 seed were analyzed for protein content. The average protein content for the large seeded group was 18.4% and for the small seeded one was 18.2%. This indicates that seed size may not affect the protein content in chickpea.

These results were corroborated with the finding that small or large seeds of the cultivar T-3 (grown in similar environments) contained almost equal per cent of protein. In this comparison seed size within a genotype had no effect.

Protein content and genotype x environment interaction

A study to investigate the environmental effect on protein content in chickpeas was undertaken during 1975-76. The protein content of 49 chickpea cultivars grown in four replications at each of the following four locations, Hyderabad (Patancheru), Hissar, Pantnagar, and Jabalpur was determined and studied (Table 44).

Table 44. Average protein content of cultivars grown at different locations

Cultivar	Patancheru	Hissar	Pantnagar	Jabalpur	Average
T-3	16.08	17.75	20.93	20.25	18.75
C 214	19.30	17.70	23.40	20.85	20.31
Annigeri	16.20	17.05	20.70	19.33	18.32
H 208	18.63	18.75	21.68	21.05	20.03
L 532	17.90	18.30	21.93	21.40	19.88
K 4	19.68	16.30	21.85	20.68	19.63
P 324	19.53	18.08	22.98	21.38	20.49
P 3090	20.95	17.88	23.53	22.85	21.30
P 2559	19.48	18.35	24.03	22.63	21.12
Radhey	19.20	17.58	21.03	20.65	19.62

contd... Table 44

Cultivar	Patancheru	Hissar	Pantnagar	Jabalpur	Average
P 127	20.10	18.75	22.08	21.53	20.62
No.501	20.78	18.95	21.90	22.33	20.99
P 514	21.13	18.40	-	21.68	20.40
L 550	18.88	18.83	21.60	20.28	19.90
BG-1	18.13	18.80	21.65	20.25	19.71
G 130	18.73	19.18	21.85	21.23	20.25
Rabat	20.88	18.65	22.23	21.45	20.80
C 104	20.10	18.58	22.58	22.83	21.02
P 3284	18.10	17.18	22.28	21.03	19.65
P 1243	19.15	19.13	22.80	21.45	20.63
P 896	21.20	17.93	22.53	22.40	21.02
P 2883	18.43	17.43	22.58	21.00	19.86
USA 613	20.55	18.43	22.80	21.68	20.87
P 182	20.80	18.75	23.55	21.80	21.23
L 534	19.60	17.90	21.43	23.03	20.49
Pant 102	18.05	18.93	21.60	20.90	19.87
C 235	20.80	17.98	23.33	21.83	20.99
JG 62	19.18	17.83	21.65	21.00	19.92
NEC 240	19.13	18.20	23.60	22.43	20.84
Bengal gram	19.80	18.80	23.25	22.10	20.99
V 4	19.55	16.65	20.53	20.15	19.22
P 1137	19.00	18.65	21.70	21.18	20.13
P 4235	20.05	18.95	23.68	21.05	20.93
P 3552	20.85	17.93	22.85	22.10	20.93
850-3/27	20.33	17.83	21.65	21.78	20.40
P 436	20.18	16.98	23.18	20.80	20.29
L. Local	22.08	19.10	23.38	21.13	21.42
K 468	19.18	18.48	21.90	22.03	20.40
B 110	18.68	16.10	21.25	20.43	19.12
F 378	19.70	18.08	23.20	22.15	20.78
NEC 249	19.58	19.38	23.63	23.05	21.41
P 2974	17.38	17.65	21.30	20.05	19.10
NP-50	18.75	18.50	21.60	20.93	19.95
B 108	20.45	17.70	22.23	21.38	20.44
P 946	18.53	18.20	22.35	21.60	20.17
P 4765	20.20	18.28	23.00	21.10	20.65

contd.... Table 44

Cultivar	Patencheru	Hissar	Pantnagar	Jabalpur	Average
P-3394-3	21.08	17.53	-	21.80	20.14
NEC 1572	18.50	17.53	24.43	21.43	20.47
P 481	18.75	17.90	21.63	21.23	19.88
Average	19.45	18.12	22.39	21.40	-

The analyses of variance for individual locations (Table 45) showed that cultivars differed for protein content at each one of these locations. The pooled analyses (Table 44) of these data showed that location effect was significant, i.e. at some locations cultivars in general showed a higher protein content than at others. The average protein per cent for 49 cultivars was the highest at Pantnagar (22.39) followed by Jabalpur (21.40), Hyderabad (19.45) and Hissar (18.12)(Table 44).

Table 45. Mean squares for protein content of cultivars grown at different locations

Source	d.f	Mean square			
		Patancheru	Hissar	Pantnagar	Jabalpur
Replications	3	44.57	58.24	10.00	7.76
Cultivars	48	6.11**	2.18**	3.52**	2.70**
Error	144	1.51	1.82	1.01	1.01

** Significant at .01 probability

The cultivar x location (C x L) interaction was non-significant (Table 46), indicating that location effect on protein content was linear. However, the significance of cultivars changed from highly significant when analysed for individual locations to significant in the combined analyses for all the four locations. This shows that there was some C x L interaction. However, if the C x L interaction is of low magnitude (as in this study) and these results are repeatable the implications are important to breeders. Protein analysis for chickpeas grown over these locations may not be needed as ranking of the lines grown at one location would more or less hold true for others as well.

Table 46. Mean squares for genotype x environment interaction for protein content (Pooled data)

Source	d.f.	Mean squares
Location	3	180.78**
Cultivars	48	1.96*
Location x Cultivars	144	0.56
Error (s^2)	576	1.34
Pooled error	-	1.18

* Significant at .05 probability

** Significant at .01 probability

PROJECT 7 : BREEDING FOR NEW PLANT TYPE

OBJECTIVES :
i. Breeding for mid-tall, compact, and high yielding cultivars
ii. Developing cultivars suitable for mechanical harvest
iii. Searching for new concepts of plant type with higher yield potential

PROCEDURES AND RESULTS

In wheat, rice, and sorghum higher yields have been achieved by breeding dwarf plant types which are responsive to fertilizer and irrigation and do not lodge. In contrast in soybeans, broadbeans, and peas higher yields have been recorded from mid-tall plant type. Indian chickpeas have a short bushy plant type. A mid-tall to tall plant type can be one possibility for higher productivity because of increased pod bearing nodes.

In the germplasm several tall cultivars are available. These are extremely late in maturity, have fewer branches, and produce only 20-25 pods as against 200-250 in the bushy cultivars when space-planted. Moreover, at Hyderabad, maturity is usually forced and many pods are either partially filled or unfilled. The plants are compact with few secondary branches which grow almost vertically. In contrast the bushy cultivars are short-statured, and produce more secondary and tertiary branches that grow semi-vertically.

The tall cultivars from USSR and other countries were received during 1974-75 season. Very few crosses were made during that season at Hyderabad. Most of these cultivars were grown in summer off-season nursery at the Lahaul Valley, and about 100 crosses were made. All the F_1's were grown at Hyderabad during <u>rabi</u> 1975-76. Fifteen F_2 populations of these tall crosses were grown in the 1976 off-season nursery at the Lahaul Valley. These crosses were:

ICRI 752	NEC 140 x NEC 141
ICRI 7512	Annigeri x K 1480

ICRI 7516	NEC 240 x NEC 139
ICRI 7522	850-3/27 x NEC 108
ICRI 7567	JG-62 x K 1258
ICRI 7568	NEC 143 x K 56567
ICRI 7570	G 130 x K 1189
ICRI 7573	F 378 x K 1184
ICRI 7581	K 4 x K 56567
ICRI 7582	H 208 x K 1258
ICRI 7588	NEC 249 x K 1481
ICRI 7595	NEC 143 x K 1286
ICRI 75107	Pant 102 x K 1189
ICRI 75123	P 2426-1 x K 1170
ICRI 75133	NEC 240 x K 1258

Out of these, the ten most promising F_2's were chosen. From each of these F_2's, approximately twenty-five tall plants were selected. Many promising plants in dwarf background were also selected.

All selections were grown as F_3 progeny rows along with some of the parents during rabi 1976-77 at Hyderabad. Our major concern about these progenies was their maturity. Many of the tall selections flowered earlier than their late parents, and matured normally. They produced more pods per plant than their shy bearing tall parents. Yield estimate of the progenies and parents was made to have an idea of the comparative productivity of tall progenies. The yield estimates of the 10 top yielding F_3 progenies and 6 parents given in Table 47 indicate that the per plot yield of a few of these F_3 progenies was more than that of their parents.

During the year 1976-77 a total of 459 crosses were made for this project. These included 142 single crosses and 317 multiple crosses. For the first time the F_3 derivatives from tall x bushy crosses were backcrossed to bushy type to improve podding ability and maturity.

Two hundred twenty F_2 populations were grown both at Hyderabad and Hissar. A total of 517 individual plants were selected.

Out of the 547 F_3 progeny rows grown, 313 plants were selected for advancement to F_4.

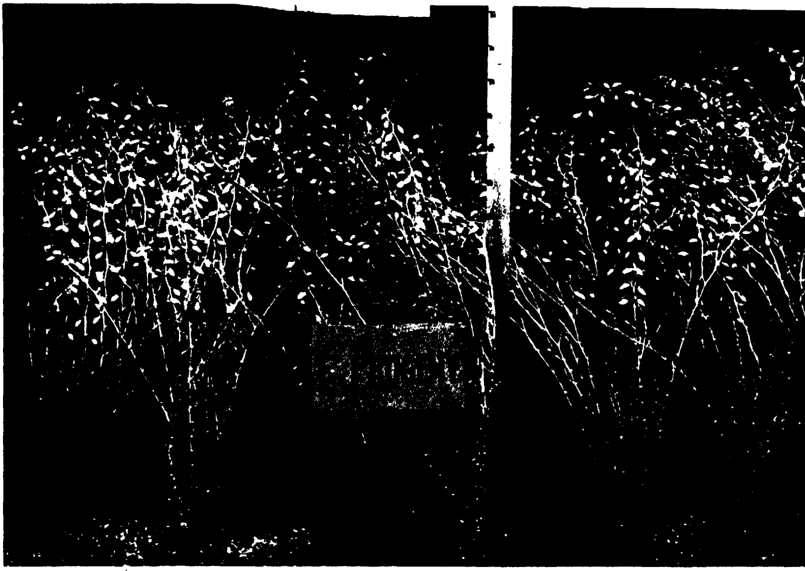
Since the derivatives of tall x bushy crosses are weak stemmed and brittle, attempts will be made to eliminate this deficiency. Crosses will also be made to diversify the genetic base and make them adapted for long duration regions (northern latitudes). These lines will also be tested for their reaction to diseases.

Table 47. Comparative performance of normal and tall cultivars and their F_3 progenies during 1976-77 at Hyderabad

Cultivar/progeny	Height (cm)	Maturity	Yield/plot (g)
Dwarf parent			
Annigeri	30 - 35	E	995
G 130	35 - 40	L	889
K 4	35 - 40	ML	985
Tall parent			
K 1170	65 - 70	VL	78
K 1184	65 - 70	VL	187
K 1481	65 - 70	VL	280
F_3 progeny			
H 208 x K 1258 (-37)	54	M	1293
K 4 x K 56567 (-18)	60	M	1179
F 378 x K 1184 (-28)	60	M	1123
H 208 x K 1258 (-34)	55	M	1099
Annigeri x K 1480 (-35)	51	M	1056
NEC 143 x K 56567 (-54)	61	M	1054
NEC 249 x K 1481 (-40)	53	M	1026
H 208 x K 1258 (-31)	61	M	1009
Annigeri x K 1480 (-28)	59	M	1007
F 378 x K 1184 (-64)	68	M	995

E = Early, L = Late, VL = Very late, M = Medium, ML = Mid-late

F_3 DERIVATIVE FROM A TALL AND CONVENTIONAL TYPE



CONVENTIONAL (FOREGROUND) AND TALL TYPE CHICKPEAS

PROJECT 8 : EVALUATION OF RECURRENT SELECTION AS A BREEDING PROCEDURE

OBJECTIVES :

i. To examine the feasibility of utilizing Jensen's diallel selective mating system for the production of high yielding cultivars

ii. To create "diverse" and "dynamic gene pools" for issue to cooperating countries

PROCEDURES AND RESULTS

Chickpea, being a self-pollinated crop, has limited scope for genetic recombination and breaking up of close linkage groups. A diallel selective mating system (Jensen 1970)*, provides for the use of broad based germplasm, simultaneous input of parents, creation of persistent gene pools, breakage of linkage blocks, freeing of genetic variability, and general fostering of genetic recombination.

The work completed in the past three years is described briefly :

1974-75 : Eleven cultivars were selected for making the first diallel cross. Selection of parents was on the basis of diversity for plant height, growth habit, maturity, seed size, yielding ability, and geographical origin (from different countries). In India they represented southern and northern chickpea growing areas. Both desi and kabuli types were included in the study. Origin and other characteristics of these eleven parents are given in table 48. These parents were crossed in all combinations (55 crosses).

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* Jensen, N.F. 1970. A diallel selective mating system for cereal breeding. Crop Sci. 10:629-35.

TABLE 48. Origin and characteristics of cultivars involved in the Jensen's selective mating system

S.No.	Cultivar	Origin	Kabuli/ Desi	Special characteristic(s)
1	NEC 141	USSR	K	Erect, tall, and late
2	JG 62	India	D	Early, double podded, high yielder
3	NEC 108	Greece	K	Erect, mid-tall
4	C 214	India	D	Late, high yielder
5	P 2974	Iran	D	High yield, wide adaptation
6	L 550	India	K	High yield, wide adaptation
7	NEC 1572	Egypt	K	High yield under irrigated conditions
8	NEC 139	USSR	K	Erect, tall, late
9	P 36	India	D	Early
10	Ofra	Israel	K	Blight tolerance
11	Lebanese local	Lebanon	K	Large seed size

1975-76 (II Year) : All the F_1's were grown during the 1975-76 season and were evaluated at the flowering stage. Seven F_1's were selected (mostly on the basis of vigour and diversity of parents involved), and a 7 x 7 F_1 diallel was attempted. The selected F_1's were: 1) JG 62 x NEC 139; 2) JG 62 x NEC 1572; 3) JG 62 x L 550; 4) NEC 139 x Ofra; 5) NEC 1572 x P 36; 6) NEC 1572 x Ofra, and 7) NEC 1572 x NEC 139. Since most of the crosses could not be completed in the rabi season these were continued during the 1976 off-season summer nursery at the Lahaul Valley. The F1 diallel thus has 6 parents originating from 4 countries.

1976-77 (III Year) : The 21 double crosses (of F_1 diallel) and the F_2's of single crosses were grown during this season. Selective mating was initiated in the double-cross F_1's. Eight plants were selected from each of the best 10 double crosses and were crossed randomly within each cross to give

40 combinations. Of these 40, we got sufficient seed from only 32 crosses (intra-population crosses). Fifty plants were selected from the whole population, and 25 inter-population crosses were attempted, out of which sufficient seed was obtained in 21 crosses.

From the single-cross F_2 populations, 47 individual plants were selected for advancing through pedigree method.

PROJECT 9 : COMPARISON OF BREEDING METHODS

OBJECTIVES : To generate information on suitable breeding methods for developing high yielding chickpea cultivars. Information so gathered will be of use to us and other chickpea breeders of the world.

Under this project three experiments have been designed with the objective of:

i. Testing the validity of selecting 'kabuli' and 'desi' types in West and East Asia.

ii. Testing the efficacy of the pedigree method of selection (PMS), single seed descent (SSD), and bulk method of selection (BMS).

iii. Testing the validity of rejecting crosses on F_1 performance.

i. TESTING THE VALIDITY OF SELECTING KABULI AND DESI TYPES IN WEST ASIA AND EAST ASIA

Background information

Chickpeas appear to have originated in Western Asia, and recent work of Ladizinsky and Adler (1976)* suggest that Cicer reticulatum is the progenitor of C. arietinum. Within the cultivated species there are two main types of practical importance: desi and kabuli. Kabulis seem to be better adapted to spring planting and desis are grown predominantly as a winter crop. The kabuli and desi types have most probably been geographically separated for thousands of years which may account for this divergence.

In order to make a significant breakthrough in yield, we should attempt to introduce new genes into locally adapted cultivars. If there has been a long time separation of desi

* Ladizinsky, G. and A. Adler (1976). Euphytica, 25:211-217

and kabuli types,it is probable that the genetic divergence between these is appreciable and crosses between the two groups could give rise to cultivars with higher yield potential.

Observation during off-season advance: Lebanon 1975

At the time of maturity it was apparent that F_2 segregating populations of crosses involving Indian desi x Indian desi parentage were showing little phenotypic variability. In F_2 populations of kabuli x desi crosses, and to a lesser extent in Indian desi x Iranian desi crosses, there were phenotypic differences among plants, and individual plant selections could be made.

From these observations (on 178 single and 92 multiple crosses) it was hypothesised that adaptability is important in chickpeas and that the kabuli types are more adapted to West Asia and the desi types (excepting Iranian desis) to East Asia. Conceptually, this would be the case if long time separation of these major types had occurred. If this were true then it would be more likely, for instance, that a superior cultivar for East Asia would be produced by a (Kabuli x Desi) x Desi backcross and for West Asia by a (Kabuli x Desi) x Kabuli backcross. This was exemplified in a spectacular fashion in Lebanon by two reciprocal backcrosses involving the cultivar F-378 (an Indian desi) and Rabat (a Moroccan kabuli). The two populations, about 800 spaced plants for each, were grown contiguously.

The F_2 of (F-378 x Rabat) x Rabat was producing divergent segregants and it was easy to select the best phenotypes. The F_2 of (F-378 x Rabat) x F-378 showed no remarkable divergences of plant type in the Lebanese environment. All plants within these two backcrosses were harvested and individual plant seed weight recorded. Results are given in table 49.

From each backcross we selected 15 high yielding, 15 low yielding and 15 random sample F_2 plants and grew them as F_3 progeny rows in Hyderabad during 1975-76 rabi season. Results are presented in tables 50 and 51. The F_3 yields of the 3 F_2 groups were essentially the same. The F_3 of the backcross to F-378 has produced a higher mean yield than the backcross to Rabat and the possibilities of selecting higher

Table 49. Production of divergent segregants by backcrosses of F-378 and Rabat strains of chickpea (F_2 generation : Lebanon 1975)

Cross/parent	% frequency : gm. classes				Mean seed wt. gms/plant
	0-40	40-80	80-120	120-140	
(F-378 x Rabat) x Rabat	43.4	46.6	9.7	0.3	46.3
(F-378 x Rabat) x F-378	79.7	19.7	0.6		32.8
F-378	90.0	10.0			22.4
Lebanese local*	85.0	15.0			25.5

* N.B. Rabat not grown. Lebanese local is a kabuli type

Table 50. Production of divergent segregants by backcrosses of F-378 and Rabat strains of chickpea (F_3 generation : India 1975-76)

C r o s s	% frequency: gm classes			Mean seed wt. gms/plant
	0-40	40-80	80-120	
(F-378 x Rabat) x Rabat	95.9	3.6	-	22.4
(F-378 x Rabat) x F-378	72.7	27.0	0.3	31.7

Table 51. Selected segregants from backcrosses of F-378 and Rabat strains of chickpea

Cross	Mean seed wt. gm/plant		Correlation
	Lebanon (F_2)	India (F_3)	F_2/F_3
(F-378 x Rabat) x Rabat			
High yielding segregants	90.7	21.7	+ 0.25
Random segregants	46.4	22.2	+ 0.18
Low yielding segregants	10.4	23.4	- 0.47*
Cross mean	49.8	22.4	- 0.10
(F-378 x Rabat) x F-378			
High yielding segregants	73.3	30.6	+ 0.37
Random segregants	33.0	32.9	0.00
Low yielding segregants	3.4	31.6	- 0.52*
Cross mean	36.5	31.7	- 0.31

* Denotes significance at $P < .05$

yielding plants are greater in the former cross at Hyderabad.

From each of these lines two best (high yielding) plants were selected (at Hyderabad) to be grown as progeny rows next generation. All these lines were also bulked to be advanced as bulk.

At Hyderabad the response of F_4 progenies was similar to that of last year i.e., the backcross to F-378 prognies had higher mean (in high, random, and low categories), and were producing higher yielding progenies also. The backcross to Rabat progenies were normally low yielding (Fig. 2 and 3).

At Hissar the response of selected plants was different. Here, the backcross to Rabat progenies were definitely superior to the backcross to F-378 progenies Although we could not collect the yield data, we had earlier scored each progeny on a 1 to 5 scale. Based on the scoring results it can be seen that many of the backcross to F-378 progenies were scored 4 or 5, and many of the backcross to Rabat progenies were scored 1 or 2 (Fig. 2 and 3).

This reversal of trend at Hissar could be explained by considering two factors: (1) Hissar environment may be closer to Lebanese environment (latitude-wise) and hence the kabuli types may be doing better there. However, Rabat itself was not performing well. (2) Since the selection in F_3 generation was made at Hyderabad, the progenies may not be doing well at Hissar. From the studies we made earlier on the F_4/F_5 progenies grown at Hyderabad and Hissar, it was clear that selections made at Hyderabad were not doing well at Hissar, and vice-versa.

It is intended to carry on this project for one more year.

ii. TESTING THE EFFICACY OF THE PEDIGREE METHOD OF SELECTION (PMS), SINGLE SEED DESCENT (SSD), AND BULK METHOD OF SELECTION (BMS)

Plant breeders are in continuous search for more efficient methods of selection after hybridization for advancement of their breeding material. Of late three methods, pedigree method of selection (PMS), bulk method of selection (BMS), and single seed descent method (SSD), have been used more extensively by breeders working on self-pollinated crops. Apart from these, the backcross method of breeding is also used but only in special situations. The efficacy of the three methods of selection has been worked out in many crops. Such information is lacking in chickpea. Thus a study has been designed to determine the efficiency of these three methods in chickpea.

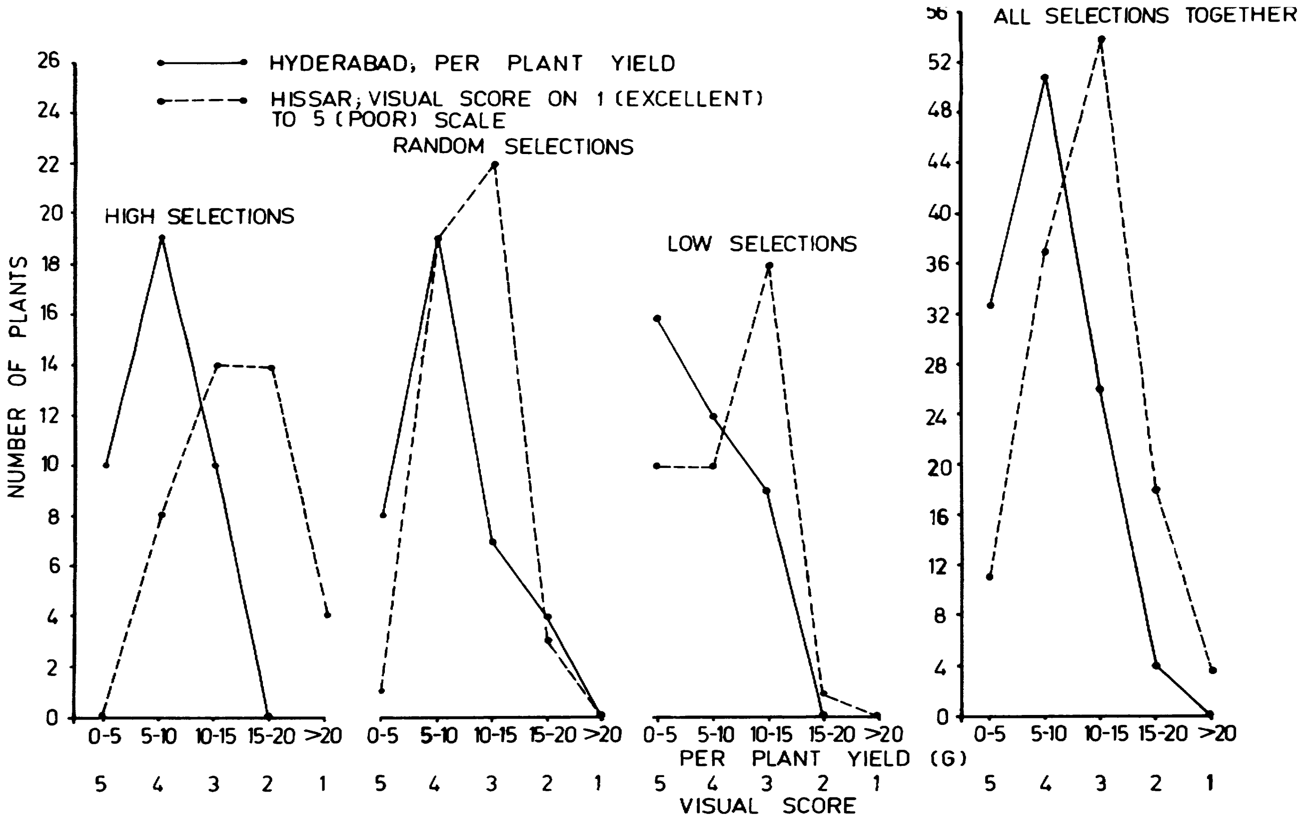

FIG. 2 : PERFORMANCE OF F_4 PROGENIES OF (RABAT X F-378) X RABAT AT HYDERABAD AND HISSAR, 1976-'77.

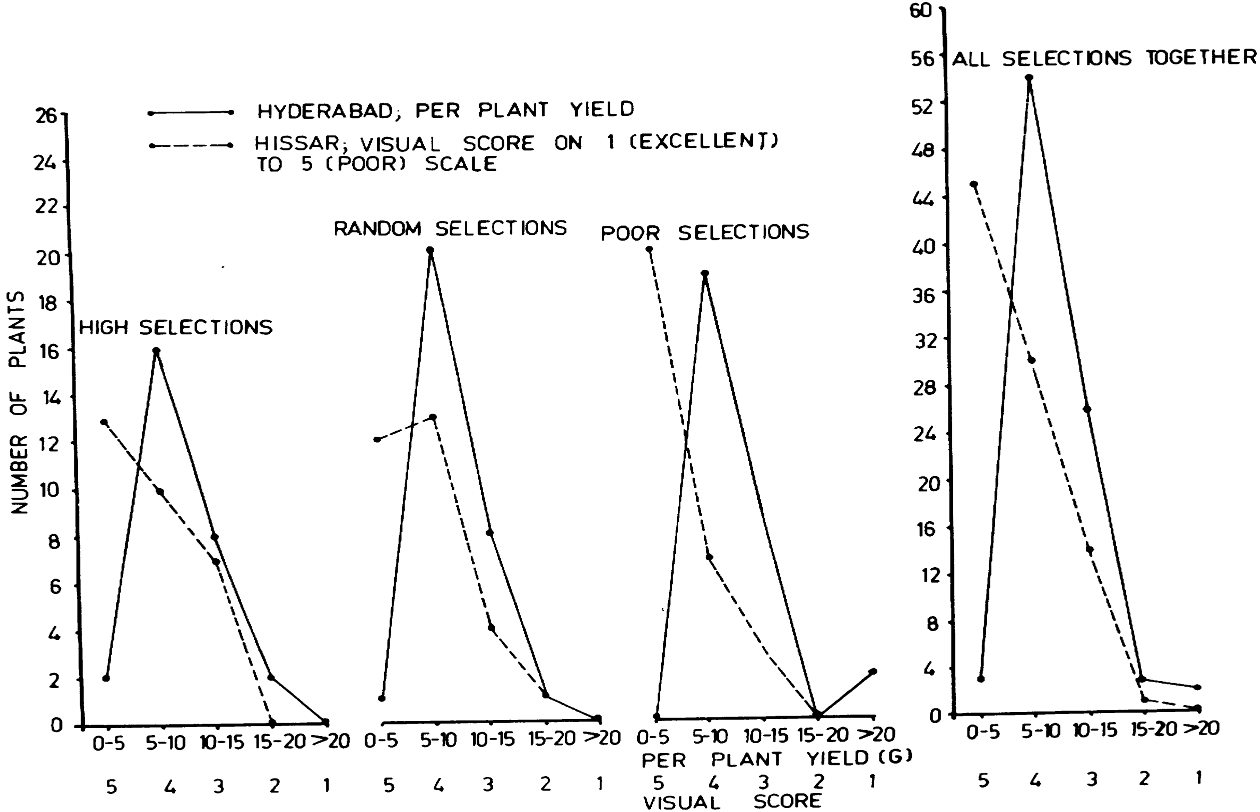

FIG. 3 : PERFORMANCE OF F_4 PROGENIES OF (RABAT X F-378) X F-378 AT HYDERABAD AND HISSAR 1976-'77

Progress to date

To accomplish this study, we selected 3 single crosses, 1 three-way cross, 1 four-way cross, and 1 composite cross. We chose these combinations carefully and made crosses during 1974-75. These crosses were:

1. F-61 x Chafa
2. T-3 x G-130
3. JG-39 x Chafa
4. P-1245-1 x (P-502 x P-9623)
5. (L 550 x WFWG-III) x (F-240 x P-3090)
6. F_2 (NEC-240 x NEC-10)-1 x F_2 (P-502 x P-1243)-1

Their F_1's were grown and F_2 seeds produced during 1975-76. During 1976-77, 500 plants of each single cross and 1500 plants of each multiple cross were grown. The spacing of 75 cm between rows and 20 cm within rows was maintained.

From each population 25 plants were visually selected on the basis of morphological, seed, and yield characters as we commonly practice for individual plant selection in the F_2 population. These plants were selected to be advanced by PMS. For following the SSD we collected one pod from each plant including those plants which were selected for PMS. At the end of the season we harvested the entire material in bulk and mixed the surplus seed of individual plants selected for PMS. This bulked seed formed the part of the seed to be advanced by BMS.

It is proposed to advance the material upto F_4 generation. F_5 progenies will be planted in a replicated test and detailed observation on yield and other characters will be recorded for comparison of the methods.

iii. TESTING THE VALIDITY OF REJECTING CROSSES ON F_1 PERFORMANCE

One of the strategies which we have adopted for varietal improvement program is to produce a large number of crosses and to grow a large number of F_2 populations. Until recently we have been raising F_2 from all F_1's, but we have observed that over 50 per cent of the F_2 populations are rejected without making any plant selections. We have also noticed that most F_2 populations rejected were from poor performing F_1s. This indicated that the poor performing F_1s could be rejected with little risk of losing good material. In order to test this hypothesis, we propose to estimate the yield of F_1's, selecting some crosses giving significantly high heterosis over mid-parent, average heterosis and poor or negative heterosis and to grow them in F_2 thru F_5 generations to evaluate their potential.

Materials and Methods

During 1974-75 we carefully chose 7 tester lines, T-3, F 61, P 502, Ceylon 2, P 648, P 861, and JG 39. These seven tester parents were crossed with 31 lines. We grew 217 F_1 crosses along with their parents in 3 replications during 1975-76. The results of the analysis of variance showed significant mean sum of the squares for hybrids, testers and line x tester (Table 52).

We studied heterosis over mid-parent. Based on the expression of heterosis and mean yield we classified all the crosses in three groups: high, medium, and low. From each of these three categories we selected 5 crosses as shown below.

High	Medium	Low
1. JG -39 x P-436	P-861 x T-103	JG-39 x P 3172
2. P-502 x BG-1	P-502 x P-514	Ceylon-2 x NEC 835
3. T-3 x L-532	P-861 x Pant-104	JG-39 x Pant 102
4. T-3 x P-4357	T-3 x T-103	P-648 x G-543
5. T-3 x NEC-721	P-648 x P-1243	Ceylon-2 x P-662

During 1976-77 we space planted 1000 F_2 plants of each of these 15 crosses along with the two best performing parents included in the top cross study, and two standard checks.

We evaluated the yield of each F_2 and parent plant and at the same time selected 100 plants from each population. The variance for yield of each population was estimated from these 100 selected plants.

Table 52. Analysis of variance for yield in 31 x 7 top cross study

Source	d.f.	M.S.
Replications	2	957.02
Hybrids	216	110.61*
Testers	6	884.54*
Lines	30	112.94
Line x Tester	180	84.41*
Error	432	55.80

* Significant at P = 0.05

Results and discussion

The mean yield of all the crosses along with heterosis over mid-parent are shown in table 53. It can be seen from this table that the per plant F_1 yield varied from 19.5 to 50.0 gm as against the parental mean of 15.0 to 39.0 gm per plant. Heterosis over mid-parent for yield in F_1's ranged from -38.8 to +85.4 per cent.

The data pertaining to yield per plant, heterosis (%) in F_1 and the mean yield per plant and variance of F_2 population of all the 15 crosses have been tabulated in table 54. This table reveals that the yields in the high group ranged from 24.7 to 35.5 kg per plot with 29.4 kg as yield of the group. The yields in medium group ranged from 24.4 to 36.4 kg with group average of 32.1 kg. The yields in low group varied from 19.8 to 24.3 kg/plot with mean of the group being 22.9 kg.

A clear trend is apparent in the results. The highest yielding F_2's (Nos. 1,6,7 & 9) are in the high and medium groups of F_1's. However both of these groups contain populations (Nos. 3 and 10) only slightly different from most of the F_2's in the low group.

When selecting F_2's for further advancement, yield and variance both are considered. The overall variance of high and medium group were generally higher than the low group (table 54). However, one cross in low group had very high variance.

Conclusions

The results obtained so far indicate that low yielding crosses in F_1 probably can be rejected. This is in confirmity with our visual scoring of F_2's. However, conclusive results can only be obtained by collecting data in advanced generations. This experiment will continue for one or two seasons more to observe their performance in F_3 and F_4 before concluding this project.

Table 53. Heterosis (%) over mid-parent for yield/plant in 32 x 7 top cross study

Line \ Tester	Parental yield	Ceylon-2	P-502	F-61	P-648	T-3	JG-39	P-861
		22.33	30.00	22.67	21.33	30.67	22.00	32.33
Jam	22.00	24.00 (8.27)	42.13 (62.03)	28.53 (27.73)	24.00 (10.77)	26.66 (1.23)	27.33 (24.22)	28.33 (4.28)
Pyrouz	32.36	29.55 (8.06)	31.33 (0.48)	28.33 (2.96)	20.08 (-25.2)	27.00 (-14.32)	24.00 (-11.69)	29.66 (-8.3)
P-2940	21.25	29.36 (34.74)	34.00 (32.68)	29.00 (32.05)	32.66 (53.40)	34.30 (32.12)	24.00 (10.98)	25.00 (-6.68)
Pant-102	22.33	26.00 (16.43)	28.33 (8.27)	25.00 (11.11)	27.00 (23.68)	42.66 (60.98)	20.33 (-8.27)	27.66 (1.2)
V-4	20.80	32.66 (51.44)	27.44 (8.03)	35.13 (61.62)	28.91 (37.24)	34.66 (34.68)	25.66 (19.9)	23.00 (-13.41)
F-240	29.33	21.66 (-16.14)	27.00 (-8.98)	23.66 (9.0)	35.80 (41.33)	36.33 (21.1)	29.00 (12.99)	26.33 (-14.59)
P-1243	23.67	38.66 (68.08)	39.00 (45.11)	27.33 (17.95)	34.46 (53.15)	39.00 (43.54)	31.66 (38.64)	37.50 (33.92)
P-514	25.33	33.66 (41.25)	34.66 (25.30)	26.33 (9.7)	29.33 (25.71)	44.16 (57.71)	27.93 (18.02)	27.44 (-4.82)
P-10	30.67	31.20 (17.73)	34.00 (12.08)	34.00 (27.48)	31.83 (22.42)	27.33 (-10.89)	36.33 (37.95)	39.00 (23.80)
NEC-721	20.50	25.33 (18.28)	32.16 (27.36)	35.20 (63.07)	24.44 (16.85)	42.66 (66.73)	23.33 (9.78)	33.25 (25.87)
L-432	29.00	26.33 (2.59)	30.58 (3.66)	21.66 (-16.16)	24.66 (-2.0)	33.50 (12.28)	31.00 (21.56)	28.66 (-6.53)

Contd...Table 53

Line \ Tester	Parental yield	Ceylon-2	P-502	F-61	P-648	T-3	JG-39	P-861
		22.33	30.00	22.67	21.33	30.67	22.00	32.33
P-662	23.00	21.33 (-5.89)	27.08 (2.18)	24.00 (5.1)	28.33 (27.81)	44.41 (65.49)	26.66 (18.48)	31.33 (13.24)
P-436	35.33	35.33 (22.54)	20.00 (-38.77)	33.26 (14.68)	27.33 (-3.52)	36.93 (11.90)	50.00 (74.42)	33.66 (-0.5)
P-6218	16.00	28.33 (47.82)	29.33 (27.52)	25.00 (29.29)	27.66 (48.19)	36.33 (55.68)	28.00 (47.36)	24.33 (0.68)
T-103	26.66	39.33 (60.56)	28.00 (-1.16)	39.33 (59.45)	33.46 (39.44)	34.53 (20.46)	36.33 (49.32)	34.66 (17.51)
P-4235	26.42	29.00 (18.97)	29.00 (2.8)	29.00 (18.15)	29.00 (21.46)	38.50 (34.87)	27.66 (14.25)	26.13 (-11.04)
No. 296	24.00	28.66 (23.72)	31.00 (14.81)	29.33 (25.69)	23.66 (4.39)	38.41 (40.51)	29.33 (27.52)	26.33 (-6.51)
BG-1	39.00	41.33 (34.77)	44.33 (28.49)	31.33 (1.6)	26.33 (-12.71)	37.33 (7.16)	33.33 (9.27)	33.33 (-6.54)
BR-70	25.00	26.33 (11.26)	31.00 (12.72)	27.00 (13.27)	33.08 (42.80)	23.46 (-15.71)	22.66 (-3.57)	38.00 (32.56)
Chafa	26.00	25.33 (4.82)	29.33 (4.75)	34.00 (39.71)	30.00 (26.76)	40.33 (42.33)	24.00 (0)	35.81 (22.78)
G-130	18.46	28.33 (38.90)	33.33 (37.55)	29.16 (41.79)	31.61 (58.88)	33.66 (37.02)	23.00 (13.69)	33.33 (31.24)
G-543	22.00	21.66 (-2.27)	37.00 (42.30)	23.00 (2.97)	20.66 (-4.63)	36.33 (37.95)	22.00 (0)	32.53 (19.74)
L-532	19.17	22.25 (7.22)	41.20 (67.58)	33.13 (58.36)	27.16 (34.12)	43.88 (76.08)	26.08 (26.69)	32.33 (25.55)

Contd... Table 53

Line / Tester	Parental yield	Ceylon-2	P-502	F-61	P-648	T-3	JG-39	P-861
		22.33	30.00	22.67	21.33	30.67	22.00	32.33
No. 501	22.16	28.41 (27.71)	34.33 (31.63)	23.66 (5.55)	27.00 (20.45)	38.66 (46.35)	21.33 (-3.39)	28.73 (5.45)
P-272	30.67	32.66 (23.24)	36.00 (18.67)	36.66 (37.45)	34.13 (31.26)	31.66 (3.22)	37.33 (41.75)	30.66 (-2.66)
P-3172	22.10	28.16 (26.76)	37.00 (42.03)	33.00 (47.42)	35.00 (61.17)	25.00 (-5.24)	19.00 (-13.83)	28.33 (4.09)
P-4357	35.00	35.00 (22.10)	31.83 (02.06)	26.33 (-8.68)	24.00 (-14.78)	43.33 (31.96)	30.00 (5.26)	31.00 (-7.91)
Pant-104	27.00	21.33 (-13.52)	25.00 (-12.28)	24.66 (-0.70)	31.33 (29.65)	34.00 (17.91)	30.00 (22.44)	34.66 (16.83)
L-534	24.17	28.00 (20.43)	36.33 (34.13)	30.00 (28.09)	20.00 (-12.08)	37.41 (36.43)	35.33 (53.04)	31.33 (10.90)
NEC-835	22.33	19.50 (-12.67)	27.33 (4.45)	25.33 (12.57)	29.11 (33.34)	32.00 (20.75)	27.33 (23.30)	38.66 (4.145)
NEC-1077	16.67	21.66 (11.07)	39.00 (67.13)	29.23 (49.11)	24.00 (26.31)	40.83 (72.49)	32.36 (67.36)	36.66 (49.63)

Note: 1. Figures in parentheses are heterosis (%) over mid-parent.

2. Cross combinations with figures underlined were picked up for this study.

Table 54. Mean yield and heterosis in F_1 and plot yield and variance in F_2 populations

Sl No	Pedigree		F_1		F_2	
			Mean yield gm/plant	Heterosis (%)	Yield kg/plot	Variance
	HIGH					
1	741475	JG-39 x P-436	50.00	74.42	35.5	237
2	741143	P-502 x BG-1	44.52	28.49	29.8	265
3	741286	T-3 x L-532	43.88	76.08	24.7	339
4	741289	T-3 x P-4357	43.33	31.96	27.8	270
5	741273	T-3 x NEC-721	42.66	66.73	29.4	181
	MEDIUM					
6	741337	P-861 x T-103	34.66	17.51	36.0	240
7	741135	P-502 x P-514	34.66	25.30	36.4	271
8	741153	P-861 x Pant-104	34.66	16.83	28.9	242
9	741275	T-3 x T-103	34.53	20.46	33.9	211
10	741234	P-648 x P-1243	34.46	53.15	25.4	156
	LOW					
11	741314	JG-39 x P-3172	19.00	-13.83	24.2	170
12	741126	Ceylon-2 x NEC-835	14.50	-12.67	14.8	166
13	741298	JG-39 x Pant-102	20.33	- 8.27	22.9	180
14	741331	P-648 x G-543	20.66	- 4.63	24.3	162
15	741381	Ceylon-2 x P-662	21.33	- 5.89	23.5	327
	Parents	BG-1	39.00	-	29.79	116
		P-436	35.33	-	40.64	307
	Checks	Annigeri	-	-	34.67	236
		JG-62	-	-	33.41	294

PROJECT 10 : PLOT TECHNIQUE INVESTIGATION

OBJECTIVE :

In order to assure the most efficient use of staff, land, and financial resources, we decided to investigate the most efficient minimum plot size giving an acceptable level of precision in yield tests. With this objective in mind, an experiment was designed to estimate the optimum plot size.

Materials and Methods

Four genotypes, H-208 and Pant-102 (desi, semi-spreading), L-550 (kabuli, semi-spreading) and NEC-1646 (kabuli, semi-erect); two row lengths, 6m and 3m; three row numbers, 1, 2 and 3; and two environments, Hyderabad and Hissar, were chosen for this investigation. The normal row spacing of 30 cm was used. The experiment was planted in a split-split-plot design with 4 replications. This experiment was conducted for two years during 1975-76 and 1976-77. Row lengths were the main plots, number of rows sub plots, and genotypes sub-sub plots in 1975-76. For the 1976-77 experiment genotypes were the main plots, row length sub plots, and number of rows sub-sub plots.

The coefficient of variation (cv) for the various plot sizes was taken as a measure of acceptable precision.

Results and Discussion

The analyses of variances for both years and locations (Table 55) showed significant yield differences for main plots, sub plots and sub-sub plots. The coefficients of variation for different plot sizes and different years are given in Table 56.

The coefficient of variation was maximum for 3m x 1 row plot, the smallest plot size, while it was minimum for 6m x 3 row, the largest plot size in the experiment, in both years at both locations. There was a progressive reduction in cv as plot size increased (Figure 4). Thus, the precision of the

Table 55. ANOVA for experiment conducted at Hyderabad and Hissar during 1975-76 and 1976-77

Source	1975-76 d.f.	1975-76 Mean square Hyderabad	1975-76 Mean square Hissar	1976-77 d.f.	1976-77 Mean square Hyderabad	1976-77 Mean square Hissar
Replications	3	57820	239420	3	29024	18932
Mean plots	1	977075*	2231075*	3	152242*	3093665*
Error	3	2782	59108	9	15896	18178
Sub plots	2	1404706*	1501863*	1	1788696*	4441901*
Main plots x sub-plots	2	124424*	146875	3	29086*	230731*
Error	12	20528	65886	12	7398	28646
Sub-sub plots	3	379355*	339938*	2	118913*	4950959*
Main plots x sub-sub plots	3	23195	56051*	6	8845	315901*
Sub-sub plots x sub plots	6	61606*	14265	2	102555*	380269*
Main plots x sub plots x sub-sub plots	6	55411*	7865	6	11013	91911
Error	54	15547	9521	48	7309	41551

	1975-76	1976-77
Main plot	Row length	Genotypes
Sub plot	Number of rows	Row length
Sub-sub plot	Genotypes	Number of rows

Table 56. Coefficients of variation (%) for different plot sizes in different years

Row length	3 m				6 m			
No. of	Hyderabad		Hissar		Hyderabad		Hissar	
rows	1975-76	1976-77	1975-76	1976-77	1975-76	1976-77	1975-76	1976-77
1 row	61.84	55.63	62.07	66.69	45.29	27.71	28.89	35.03
2 row	39.35	33.51	30.40	32.53	23.72	15.87	16.06	21.21
3 row	25.18	20.11	21.40	22.93	15.25	10.61	10.78	12.99

experiment increased with increase in plot size, reaching a respectable level only at the maximum plot size.

It was observed that as the plot size went on decreasing the corresponding per unit yield generally increased (Table 57). This suggests that with smaller plot size the yield gets inflated and becomes unrealistic.

Table 57. Yield (g) of different plot sizes in the two years over both the locations

Plot size	1975-76		1976-77	
	Hyderabad	Hissar	Hyderabad	Hissar
3 m 1 row	201.6	157.2	153.7	305.6
3 m 2 row	316.8	320.9	255.1	626.6
3 m 3 row	495.0	455.9	425.2	889.1
6 m 1 row	275.3	336.9	308.5	581.9
6 m 2 row	525.6	607.2	538.5	961.2
6 m 3 row	817.8	904.7	805.7	1568.1

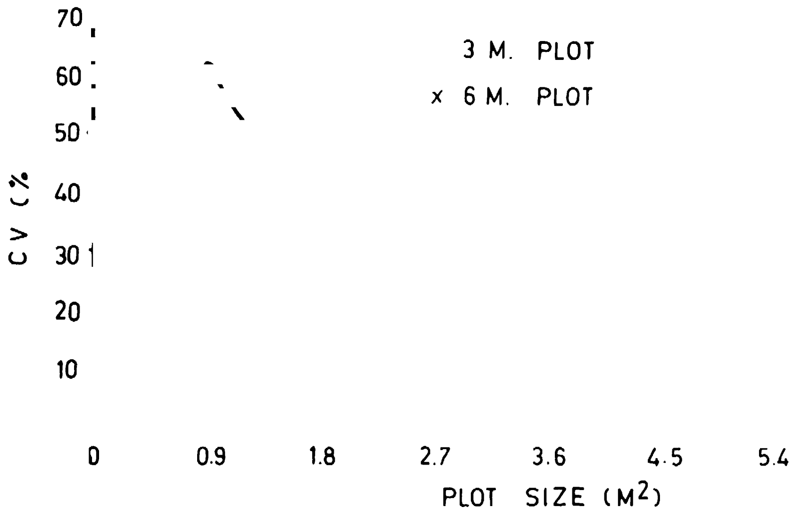

FIG. 4 : RELATIONSHIP OF C.V. (%) TO PLOT SIZE (M^2) IN AVERAGE DATA FOR TWO YEARS.

Conclusion

It is concluded that with the increase in plot size, corresponding efficiency of the experiment also increased. The plot size, 6m x 3 row, appeared to be acceptable. Considering the effect of plot area and lack of effect of plot shape, it would be worthwhile to investigate the effect of plot size and shape in a uniformity trial.

PROJECT 11 : INTERNATIONAL COOPERATION

INTERNATIONAL NURSERIES AND TRIALS

We assembled and distributed international chickpea cooperative trials and nurseries with the following objectives:

1. To make available elite genotypes developed by the chickpea breeders of the world to all cooperating scientists with a view to:

   (a) provide an opportunity to breeders in chickpea growing countries to test material over a range of environments,

   (b) identify superior genotypes at a particular location/region,

   (c) recognise widely adapted genotypes over a range of environments.

2. To identify genotypes for use in national breeding programs.

3. To supply early and advanced segregating populations to supplement national and regional programs.

To achieve the objectives set forth for the international cooperative activities, the following trials and nurseries were included in the first and second international nurseries.

First International Nursery (1975-76)

1. International Chickpea Cooperative Trial (ICCT)
   (49 entries of released cvs and germplasm lines)

2. International Chickpea Observational Nursery (ICON)
   (200 entries included in our crossing block)

3. F_3 bulks
   (selected crosses as requested by breeders)

Second International Nursery (1976-77)

1. International Chickpea Cooperative Trial-Desi (ICCT-D) (49 entries of released desi cultivars and germplasm lines)

2. International Chickpea Cooperative Trial-Kabuli (ICCT-K) (25 entries of released kabuli cultivars and germplasm lines)

3. International Chickpea Screening Nursery-A set (100 short duration F_5 generation desi bulks)

4. International Chickpea Screening Nursery-B set (100 long duration F_5 generation desi bulks)

5. International Chickpea Screening Nursery-C set (25 F_5 generation kabuli bulks)

6. International Chickpea Observational Nursery (ICON) (100 entries included in our crossing block for 1976-77)

7. F_3 bulks (25 promising early generation bulks)

Materials listed above were sent to 46 cooperators in 25 countries during 1975-76 (Table 58) and to 67 cooperators in 28 countries during 1976-77 (Table 59).

We have received results of first international nurseries/trials from India, Pakistan, Bangladesh, Ethiopia, Sudan, United Arab Republic, Chile, Thailand, Turkey, Iran and Mexico. Our cooperators from India, Pakistan, Nepal, Bangladesh, Thailand, Sudan, Chile, Iran, Syria, and Turkey have sent the results of the second international trials/nurseries. The trial in the Philippines failed. The results from other countries are still awaited. These results will be compiled separately and circulated when received.

TRAINING

One of our important objectives is to provide training for scientific staff from chickpea growing areas of the world. From October 1976 until the end of April, 1977 Getahum Terefe, Taye Walde Marian (Ethiopia), and Abdalla

Table 58. International Trials and Nurseries for winter (1975-76) and summer (1976) plantings

Country	No. of locations	Sets of seed material sent			
		ICCT		ICON	F_3 bulks
		K	D		
		Winter Planting			
India	5	5		3	3
Pakistan	4	4		2	3
Nepal	1	1		1	-
Bangladesh	3	2		1	1
Burma	2	2		1	-
Thailand	3	2		2	-
Philippines	2	1		2	-
Ethiopia	2	2		1	1
Sudan	1	1		1	-
Y.A.R.	1	1		-	-
Mexico	2	2		1	1
Chile	2	2		1	1
Peru	1	1		-	-
		Summer Planting			
Afghanistan	1	1	1	1	-
Iraq	1	1	1	1	-
Iran	2	2	2	1	1
Jordan	1	1	-	1	1
Syria	2	2	-	2	-
Lebanon	1	1	-	-	-
Turkey	3	3	-	2	3
Spain	1	1	-	-	1
Greece	1	-	-	-	1
Tunisia	2	2	-	2	1
Morocco	1	1	-	1	-
Tanzania	1	1	1	1	-
Total (25)	46	47		28	18

Table 59. International Trials and Nurseries for winter (1976-77) and summer (1977) plantings

Country	No. of locations	Sets of seed material sent: ICCT-D	ICCT-K	ICSN A set	ICSN B set	ICSN C set	ICON	F_3 bulks
				Winter Planting				
India	23	10	4	12	13	2	8	15
Pakistan	4	4	4	-	4	-	2	2
Nepal	1	1	1	-	1	-	-	-
Bangladesh	3	2	2	2	-	-	3	1
Burma	2	1	1	1	-	-	1	2
Ceylon	2	2	-	-	-	-	-	-
Thailand	3	2	1	-	-	-	2	-
Philippines	2	1	1	-	-	-	2	-
Ethiopia	2	2	2	1	-	-	1	1
Sudan	1	-	1	-	-	1	1	1
Y.A.R.	1	1	1	-	-	-	-	-
Mexico	2	2	2	-	1	-	1	1
Chile	2	-	2	-	-	1	1	1
Peru	1	-	1	-	-	1	1	1
Argentina	1	-	1	-	-			
				Summer Planting				
Afghanistan	1	1	1	-	-		1	-
Iraq	1	1	1	-	-		1	-
Iran	2	2	1	-	-		1	1
Jordan	1	-	1	-	-		1	1
Syria	1	-	1	-	-			
Lebanon	1	-	1	-	-			
Turkey	2	-	2	-	-		2	2
Spain	1	-	1	-	-		-	1
Greece	1	-	-	-	-		-	1
Tunisia	2	-	1	-	-		2	1
Morocco	1	-	-	-	-		1	-
Libya	2	-	1	-	-		2	-
Tanzania	1	1	1	-	-		1	-
Total (28)	67	33	36	16	19	5	35	32

Fageer Ahmed (Sudan) joined us as our first trainees. They were involved in planting of the breeding material, making crosses, collecting data, analysing and writing reports (one experiment each), learning techniques for evaluating progenies/populations and selecting individual plants. They had an opportunity to visit and work at Hissar, and were taken on trips to various agricultural universities and institutions within India to see chickpea research.

Within ICRISAT, they spent some time in plant pathology, entomology, microbiology, physiology, germplasm, biochemistry, computer center, agronomy, and farming systems. They also had a chance to aquaint themselves with the breeding work in pigeonpea, sorghum, millet, and groundnut.

Though their training was predominantly practical, they were also given some lectures on the theoretical basis of crop improvement. At the end of their stay, they were given an examination which they cleared satisfactorily. It is expected that such persons on return to their country's program may prove useful.

VISITS

We received a large number of distinguished visitors from various countries including Australia, Bangladesh, Burma, India, Israel, Nepal, Pakistan, Sri Lanka, Syria, Thailand, and United Kingdom during 1976-77. Such visits are valuable in exchange of ideas and materials, besides establishing personal contact.

Dr. A.K. Auckland visited Nepal and Pakistan, and had an opportunity to see their programs and our international nurseries. Dr. K.B. Singh went to Thailand, Philippines, and Australia during February, 1977. While he was impressed with the progress and dimensions of the program in Australia, he felt that climatic conditions of Thailand and Philippines were not favorable for the chickpea crop.

Drs. A.K. Auckland, K.B. Singh, C.L.L. Gowda, S.C. Sethi, and Mr. Onkar Singh visited a large number of experiment stations in the states of Karnataka, Maharashtra, Rajasthan, Punjab, Haryana, New Delhi, Uttar Pradesh, West Bengal, Assam, Orissa, and Andhra Pradesh. These visits proved useful in acquainting us with the performance of our material in different places as well as with the local research programs.

WORKSHOP AND CONFERENCES ATTENTED

Drs. A.K. Auckland and K.B. Singh participated in the All India Rabi Pulses Workshop held at Varanasi during the first week of October 1976. This workshop gave clearance to ICRISAT to conduct international trials at various experiment stations within India.

Dr. K.B. Singh went to Canberra, Australia to participate in the Third Congress of SABRAO There he presented a paper on "International Chickpea Breeding at ICRISAT".

ANNUAL CHICKPEA BREEDERS' MEET

The third Annual Chickpea Breeders' Meet was held on February 24-25, 1977 at Hyderabad. Twenty-nine breeders from India and one from Israel participated. The meet was opened with the presentation of work on chickpea breeding. This was followed by field visits to breeding, physiology, entomology, pathology, microbiology, and germplasm. In the afternoon the progress of work on plant pathology, physiology, entomology, microbiology, germplasm and quality were explained by the concerned scientists. On the second day the visiting breeders made selections of material in breeding and germplasm plots. The selected materials were supplied to them after harvest (Table 60). In the afternoon there was a group discussion on the problems and prospects of chickpea improvement and organization and strengthening of international nurseries.

Table 60. Seed supplied to Indian Breeders selected by them in 1977

State	Name of breeder	Number of entries supplied from					
		CB	F_2	F_3	F_4	F_5	F_6
Andhra Pradesh	Dr. C. Sreeramulu		6		6	30	
Bihar	Dr. S.K. Chowdhury	45	11				
Gujarat	Dr. R.M. Shah					20	
Haryana	Dr. S. Lal	30	151		45	75	
Himachal Pradesh	Dr. V.P. Gupta	56	11				
Karnataka	Mr. D.K. Tirumalachar					15	
	Mr. T. Madhava Rao		8	8		5	
	Dr. K.G. Shambulingappa	70	8				
Madhya Pradesh	Dr. Laxman Singh	67	3				
Maharashtra	Dr. B.T. Khadilkar	9	32		5		
	Dr. D.P. Gavankar	11	31	2	5	18	
	Mr. R.B. Deshmukh	7	15		6	30	
Orissa	Dr. B.N. Samolo					28	
Punjab	Dr. T.S. Sandhu	92		31		78	
Tamil Nadu	Prof. R.S. Annappan	225	56		11	15	25
Uttar Pradesh	Dr. B.P. Pandya		4		7	11	
	Dr. S. Venkateswarlu	15		18		140	58
	Dr. J.S. Sindhu	64	16	78	42	90	
		691	356	137	127	555	83

Total = 1949

CHICKPEA BREEDERS MEET AT ICRISAT

ICRISAT CHICKPEA TRAINEES EXAMINING
CROP AT IARI

PROJECT 12 : GENETIC STUDY OF QUALITATIVE AND QUANTITATIVE CHARACTERS

OBJECTIVES :

i. To collect information on mode of inheritance of qualitative and quantitative characters of interest.

ii. To work out correlation and path coefficients between yield and other characters for computing selection indices.

Preliminary investigation on inheritance of plant height

We have a project which deals with the development of tall, erect, and compact plant type. The objective of this project is to develop cultivars suited for mechanical harvest and if possible, for higher yield. Although there are a few reports in literature on the inheritance of plant height, earlier studies were conducted with traditional plant type, where differences in plant height were small. We have in our collection some cultivars which are twice as tall as the traditional ones. Therefore, a study to collect information on the mode of inheritance of height in these was initiated.

Materials and Methods

The parents chosen for this study were: JG-62 (normal statured cultivar), NEC-141 and NEC-139 (tall cultivars). Two crosses, JG-62 x NEC-141 and JG-62 x NEC-139, were made in the 1975 off-season nursery. The F_1's were backcrossed to both parents to produce BC_1 and BC_2 seeds in 1975-76. Two parents, P_1 and P_2, and their F_1, F_2, BC_1 and BC_2 for both the crosses were planted in 1976-77 in rows 3m long and 75 cm apart, accommodating 15 plants at 20 cm apart. A randomized block design with 3 replications was used. Data on plant height (cm) were recorded when plants attained full growth

Analysis of variance for all generations was done for each cross separately. Separate analyses for each population were performed to determine within plot variances. Heritability in the narrow sense was estimated following Warner's (1952) approach. The A, B, C scaling tests of Mather (1949) and joint scaling test of Cavalli referred by Mather and Jinks (1971) were also used to test for epistasis. Generation means were analysed using the method of Hayman (1958) to fit a 6-parameter model for determining gene action.

Results and Discussion

The information regarding means and variances is given in Table 61. The six generations differed significantly from each other in both the crosses (Table 62). The F_1-MP deviations were positive for both crosses, which suggested that tallness is partially dominant over dwarfness. Heritability in the narrow sense was 64 per cent in JG-62 x NEC-139 and 43 per cent in JG-62 x NEC-141.

The B and C scaling tests (Table 63) were significant while the A test was non-significant. However, each one of the above scaling tests has its own limitation because it uses only a few generations. Thus their validity can be doubtful. On the other hand, the joint scaling test is more powerful because it uses information from all six generations. The joint scaling test (Table 63) revealed that the scale used for the cross JG-62 x NEC-139 was adequate, while it was not so for JG-62 x NEC-141. Despite this no attempt was made to transform the data because the idea was to detect epistasis. It seems likely that the probability value even in the first cross (0.5) was not high enough to disprove the presence of epistasis. We conclude that the 3-parameter model (m, a, d) was not sufficient to explain the whole variation in the two crosses.

The 6-parameter model of Hayman (1958) was used. The data in Table 64 shows that all the gene effects, additive, dominance, and their first order interactions, were significant for both the crosses. There was an indication of duplicate epistasis as indicated by significant and positive d and significant and negative dd values.

Warner, J.N. (1952) Agron. J., 44:427-430
Mather, K (1949) Biometrical Genetics (Ist edn), Methuen, London
Mather, K, and J.L. Jinks (1971) Biometrical Genetics. The study of continuous variation. Cornell University Press, Ithaca, New York
Hayman, B.I. (1952) Heredity, 12:371-390

Table 61. Generation means, variance, (F_1-MP) deviations and narrow sense heritability for plant height (cm)

Generation	Cross	
	JG-62 x NEC-139	JG-62 x NEC-141
$\bar{P}_1$	38.24	38.30
$\bar{P}_2$	73.78	66.78
$\bar{F}_1$	57.19	55.67
$\bar{F}_2$	47.32	46.48
$\bar{B}_1$	50.07	46.00
$\bar{B}_2$	71.00	65.93
F_1-MP	1.18	3.13
h^2 (ns) %	64.02	42.87

Table 62. Analysis of variance for generation means for plant height for two crosses

Source	d.f.	Cross	
		JG-62 x NEC-139	JG-62 x NEC-141
Replications	2	22.32	22.82
Generations	5	586.70**	315.91**
Error	10	9.11	7.02

** Significant at 1% level

Table 63. A, B, C and joint scaling tests for two crosses for plant height

Cross	Scaling Test				
	A	B	C	Joint	
				X^2	P
JG-62 x NEC-139	NS	S	S	2.24	0.5
JG-62 x NEC-141	NS	S	S	6.09	0.2

Table 64. Gene effects for plant height using Hayman's (1958) model

Gene effect	Cross	
	JG-62 x NEC-139	JG-62 x NEC-141
m	47.32 ± 2.38	46.48 ± 0.01
a	20.93 ± 1.48	19.93 ± 1.63
d	54.04 ± 10.19	41.04 ± 4.47
aa	42.96 ± 9.99	37.94 ± 3.49
ad	9.10 ± 2.03	5.69 ± 2.18
dd	-68.60 + 11.94	-45.38 + 8.76

Conclusion

The inheritance of plant height in chickpea was studied in two crosses, which differed widely in their tallness. The difference between F_1 and mid-parent was positive indicating partial dominance for this character. The heritability estimate in narrow sense was comparatively high. Duplicate epistasis was indicated. In view of the small number of plants for backcrosses, it would be worthwhile repeating the experiment to confirm the findings of this study.

DIALLEL ANALYSIS

The success of any breeding project depends upon the choice of parents for hybridization. The approach of choosing parents only on the basis of proven performance and adaptation does not necessarily lead to fruitful results. The ability of the parents to combine well depends upon the complex interaction among genes which cannot be judged by mere yield performance. It becomes imperative in such cases to estimate the combining ability of different parents. Griffing (1956) provided a detailed examination of the concept of combining ability in relation to a diallel crossing system. Such analyses have been reported by various scientists using only a limited number of chickpea cultivars. The present study was undertaken on an 18 x 18 diallel cross to obtain estimates of general and specific combining ability variances and effects.

Materials and Methods

Eighteen homozygous lines of chickpea were selected for the present investigation. A brief description of these parental lines is given in Table 65.

All possible crosses (excluding reciprocals) were attempted during 1974-75. The resultant 153 F_1's along with their 18 parents were grown in a randomized block design with two replications during 1975-76. The progenies were grown in single rows 3m long, 75 cm apart with plant to plant spacing of 20 cm.

Griffing, B., (1956). A generalised treatment of the use of diallel crosses in quantitative inheritance, Heredity, 10, 31-50

Table 65. Origin, seed color, type, and special characteristics of the parental lines

Cultivar	Origin	Kabuli/ Desi	Seed color	Special characteristic(s)
NEC-143	Sudan	Kabuli	S.White	Good plant type, upright habit
NEC-240	USSR	Desi	Y.Brown	Many pods per plant
NEC-1572	Egypt	Kabuli	S.White	Upright habit, small seed
Kaka	Iran	Desi	Black	Released variety of Iran
P-99	India	Desi	Y.Brown	Multiseeded
WFWG-III	India	Desi	Brown	More pods, extremely tiny pods and seeds
F-378	India	Desi	Yellow	High yield and wide adaptation
H-208	India	Desi	Yellow	High harvest index, good yield
C-214	India	Desi	Yellow	Drought and frost tolerant
NEC-249	India	Desi	Brown	Upright habit, light pink flower
NEC-1639	Pakistan	Desi	Y.Brown	More pods per plant
NEC-1604	Egypt	Kabuli	S.White	Promising culture from Egypt
NEC-1646	Algeria	Kabuli	S.White	A good line from Algeria
NEC-34	Iraq	Kabuli	S.White	Good local type
NEC-1607	Lebanon	Kabuli	S.White	Promising line from Lebanon
NEC-10	Jordan	Kabuli	S.White	High yield
P-317	India	Desi	Dark brown	Multiseeded
P-2994	Iran	Desi	Brown	Double-podded

Observations were recorded on five random and competitive plants for days to flower, plant height, primary branches, secondary branches, days to maturity, number of pods/plant, number of seeds/pod, 100-seed weight, and yield.

Statistical analyses were run on means of the five plants. Model 1 and method 2 of Griffing (1956) was followed for diallel analysis.

Results and Discussion

The data on analysis of variance for all the characters is given in Table 66. The differences among the entries were significant for all except seeds/pod, primary branches, and secondary branches, and these characters were dropped from further analyses.

Analysis of variance for combining ability with respect to yield, number of pods, seed weight, days to flower, days to maturity and plant height are also presented in Table 66.

The analysis of variance for combining ability revealed that both general combining ability (g.c.a.) and specific combining ability (s.c.a.) variances were significant for all the characters. The variances due to g.c.a. were consistently larger than the corresponding variances due to s.c.a. The results suggest that a large proportion of total genetic variability associated with these characters was the result of additive gene action and therefore, selection for these would be effective.

General combining ability effects

The estimated g.c.a. effects of parents for different characters along with their standard errors are given in Table 67. The data indicate that there were 2 good combiners for yield, 10 for pod number, 5 each for seed-weight, early flowering and early maturity, and 4 for plant height.

Among the best combiners were, NEC-10 and P-317 for yield, WFWG-III and NEC-143 for pod number, and NEC-34 and NEC-1607 for 100-seed weight.

Table 66. Analysis of variance of the experiment and for combining ability

Source	d.f.	Mean squares due to Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
Replications	1	1194	33385	0.96	4.9	2.1	234
Entries	170	106*	3659*	71.25**	15.0*	13.5*	44*
Error	170	64	1500	2.12	5.7	4.6	15
gca	17	114.1**	8008.5**	321.6**	34.8**	35.3**	116.6**
sca	153	46.1*	1142.8**	3.9**	4.5*	3.6*	11.3*
Error	170	32.2	749.8	1.1	2.9	2.3	7.3
gca/sca ratio		2.47	7.01	83.52	7.71	9.87	10.28

* Significant at 5%

** Significant at 1%

Table 67. General combining ability effects and Means of the parents for different characters

Parent	Yield	Pod number	Seed weight	Days to flower	Days to maturity	Plant height
NEC-143	1.69 (32.75)	30.26* (200)	-2.87* (12.11)	-1.92* (50)	-1.62* (109)	0.01 (42.5)
NEC-240	-2.59* (21.08)	1.84 (131)	-1.63* (12.99)	0.88* (60)	0.90* (113)	-0.49 (41.0)
NEC-1572	0.56 (22.13)	8.74* (117)	-1.70* (11.95)	0.69 (54)	-0.07 (114)	3.91* (40.5)
Kaka	-3.63* (15.94)	-7.29* (91)	-3.18* (11.04)	0.93* (535)	1.20* (113)	3.41* (47.5)
P-99	2.37 (24.05)	11.89* (140)	-1.33* (14.73)	-1.82* (.51)	-1.88* (114)	0.16 (39.0)
WFWG-III	-0.40 (11.25)	30.59* (182)	-4.21* (4.90)	-1.77* (50)	-2.05* (110)	-4.14* (28.5)
F-378	-3.86* (14.19)	-3.04 (140)	-2.76* (12.34)	-0.49 (52)	0.76* (112)	-1.64* (34.0)
H-208	-0.25 (22.74)	5.29* (151)	-2.36* (12.41)	0.33 (53)	0.20 (111)	-1.11 (34.5)
C-214	-0.29 (23.04)	6.29* (114)	-2.05* (12.88)	1.41* (58)	1.42* (115)	-2.09* (34.5)
NEC-249	-1.57 (21.08)	6.46* (127)	-2.20* (14.41)	-1.99* (52)	-1.90* (110)	4.36* (16)
NEC-1639	-0.60 (18.41)	11.36* (137)	-2.22* (11.72)	2.25* (63)	1.23* (113)	-0.11 (38)
NEC-1604	-2.59* (18.11)	-34.54* (49)	3.02* (24.24)	0.61 (54)	0.73* (114)	2.21* (44)

* Significant at 5% level

Contd....Table 67

Parent	Yield	Pod number	Seed weight	Days to flower	Days to maturity	Plant height
NEC-1646	-1.07 (10.88)	-26.56* (34)	5.49* (30.55)	2.05* (65)	1.10* (116)	0.94 (44)
NEC-34	0.30 (28.17)	-32.41* (85)	8.29* (36.82)	-0.52 (55)	0.40 (114)	-0.81 (38)
NEC-1607	1.81 (31.79)	-27.69* (106)	6.66* (31.64)	-0.35 (52)	0.95* (113)	0.86 (37)
NEC-10	5.49* (43.11)	-13.71* (145)	6.59* (29.37)	0.13 (55)	0.70* (113)	-1.64* (36.5)
P-137	2.54* (27.63)	15.69* (157)	-2.33* (12.39)	-0.99* (50)	-2.48* (107)	-4.14* (29)
P-2994	1.01 (23.19)	16.86* (150)	-1.22* (12.56)	0.63 (56)	0.40 (114)	1.09 (40.5)
SE (gi)	1.23	2.09	0.22	0.37	0.32	0.58

Note: Figures in parentheses are parental means.

* Significant at 5% level

Good combiners for early flowering were NEC-249, NEC-143, P-99, WFWG-III, and P-317. Good combiners for early flowering and also for early maturity (though their order differed) were P-317, WFWG-III, NEC-249, P-99, and NEC-143. NEC-249, NEC-1572, and Kaka were comparatively tall parents and were also good combiners for tallness.

It would be worthwhile comparing combining ability values with the actual performance of the parents for different characters. While there was no close relationship between combining ability and per se performance for yield, there was a good agreement between the two for the number of pods and seed size. It means that for effecting improvement in pod number and seed size, parents with high mean values could be chosen, but this may not be true for yield. Further, there was a close association between combining ability and per se performance for early flowering, early maturity, and plant height. Thus, mean values of the parents are good indicators of combining ability for these traits.

Specific combining ability effects

The values for specific combining ability effects for all characters and crosses have been tabulated in Table 68. There were 7 cross combinations with significantly positive s.c.a. effects for yield, while 6 were significantly negative. Some of the top specific combinations were WFWG-III x NEC-1646, NEC-1646 x NEC-1607, H-208 x NEC-1646, and NEC-10 x P-2994. It is interesting that these crosses involved one parent which was a good combiner for pod number or seed weight or both. These are considered the two most potent components of yield. Eight crosses exhibited significant positive s.c.a. effects for pod number. The crosses, WFWG-III x NEC-1646, F-378 x NEC-1604, and NEC-1646 x NEC-1607, might be considered promising for making improvement for this character.

For seed weight there were 9 cross combinations that were superior due to significant positive s.c.a values. The combinations of most interest were: NEC-1604 x NEC-1607, NEC-1604 x NEC-34, and NEC-34 x NEC-1607. In these crosses both parents had large seed size. Though three of the crosses involving small x small seeded parents also possessed significant positive s.c.a. effects, the values were higher when one of the parents was large seeded and still higher when both were large seeded. So, for improving this character a large seeded line should be chosen as one of the parents.

Table 68. Specific combining ability effects

Cross	Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
NEC-143 x NEC-240	10.63	16.41	1.12	-2.11	1.86	0.54
" x NEC-1572	8.58	20.01	0.34	-0.66	-3.67*	2.14
" x Kaka	- 2.08	5.54	1.16	3.84*	-4.44*	-3.86
" x P-99	-12.59*	-64.13*	0.43	0.87	1.63	-6.11*
" x WFWG-III	4.88	16.66	1.55	-0.46	-4.19*	2.19
" x F-378	- 1.71	- 6.21	0.96	1.26	-0.52	2.69
" x H-208	- 1.40	50.96	1.00	-0.56	1.06	-4.83
" x C-214	7.79	44.96	0.79	0.36	1.33	-0.36
" x NEC-249	- 3.53	-43.21	1.65	2.26	1.56	1.19
" x NEC-1630	0.77	13.89	0.99	-1.48	1.03	3.67
" x NEC-1604	1.13	15.29	-4.30*	0.84	0.32	-1.66
" x NEC-1646	- 6.84	-58.68*	-0.12	-1.29	2.65	-3.88
" x NEC-34	7.34	28.16	-1.59	-1.21	-1.14	-1.13
" x NEC-1607	- 2.79	9.94	-3.44*	-0.59	-0.19	1.97
" x NEC-10	-11.55*	-38.53	-2.56*	1.14	1.05	0.19
" x P-317	- 2.39	-25.93	1.22	0.26	1.73	2.19
" x P-2994	0.48	24.89	-0.66	-1.36	-2.14	0.97
NEC-240 x NEC-1572	5.03	25.44	0.27	-2.46	-0.19	1.64
" x Kaka	4.54	35.46	0.87	0.54	0.03	2.14
" x P-99	- 5.88	-16.71	-0.40	-1.71	-1.39	-2.61
" x WFWG-III	- 7.30	-68.91*	-0.22	-2.26	-1.22	-0.81
" x F-378	1.54	0.21	0.12	0.46	-0.04	-1.31
" x H-208	1.37	28.39	-0.26	1.14	1.03	0.17
" x C-214	- 5.08	-17.11	-0.52	-1.44	-0.69	1.14
" x NEC-249	6.02	29.21	1.37	-0.54	-0.86	1.19
" x NEC-1639	- 1.33	-34.68	4.00*	-1.79	1.00	2.17
" x NEC-1604	- 1.23	39.21	-6.23*	1.86	-0.49	-3.16
" x NEC-1646	3.41	7.74	1.23	-3.09	-0.87	-0.38
" x NEC-34	- 0.34	7.09	0.53	-0.51	0.33	-0.13
" x NEC-1607	1.68	7.36	-0.58	-0.39	0.78	1.97
" x NEC-10	- 5.95	0.39	0.65	-0.66	0.53	3.19
" x P-317	- 8.23	-38.51	0.22	1.46	-0.29	-6.31*
" x P-2994	4.12	13.31	0.16	0.34	0.83	-2.53

Contd....Table 68

Cross	Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
NEC-1572 x Kaka	- 2.92	18.06	0.91	2.49	-0.49	-0.26
" x P-99	- 3.93	-30.11	0.55	7.73*	-0.92	-2.51
" x WFWG-III	- 4.02	-31.81	1.25	6.69*	0.26	-3.21
" x F-378	3.86	-12.18	1.02	-2.09	-0.56	1.29
" x H-208	- 1.17	-11.01	2.97*	-1.91	2.00	-0.73
" x C-214	1.47	40.99	-0.13	-0.49	0.78	-2.26
" x NEC-249	- 3.54	-17.68	-0.31	-0.59	1.10	5.79*
" x NEC-1639	- 2.46	- 9.08	-0.29	0.16	-0.52	-0.73
" x NEC-1604	2.13	6.31	-1.62	-2.69	1.48	2.44
" x NEC-1646	5.63	-33.66	0.75	-4.64*	-1.89	4.22*
" x NEC-34	8.82	28.19	-1.84	-2.06	-1.19	2.97
" x NEC-1607	5.61	26.46	-0.31	1.56	1.26	0.57
" x NEC-10	- 2.67	- 1.01	0.36	-7.13*	2.00	-2.71
" x P-317	8.15	6.09	-0.17	-0.88	-2.82*	5.79*
" x P-2994	- 5.82	-42.08	-0.25	-3.21*	-3.19*	1.06
Kaka x P-99	0.19	15.91	0.52	0.24	3.30*	-1.00
" x WFWG-III	5.47	17.21	0.81	-0.31	-0.18	3.29
" x F-378	8.97	47.84	1.27	-0.59	-0.34	4.29*
" x H-208	0.64	-19.98	0.38	-2.91	-1.27	4.27*
" x C-214	0.75	7.01	-0.54	-0.49	0.51	-3.76
" x NEC-249	- 2.46	-14.66	0.02	-1.59	-0.17	-3.71
" x NEC-1639	- 2.60	- 9.56	0.09	2.66	-0.29	-1.73
" x NEC-1604	- 3.18	-16.66	-2.70*	-1.69	2.21	-1.06
" x NEC-1646	0.91	6.36	-5.82*	3.36*	0.33	0.22
" x NEC-34	- 0.65	2.21	-0.32	-1.56	-1.47	-2.03
" x NEC-1607	- 2.07	-20.01	-0.09	-0.94	-0.52	-2.43
" x NEC-10	- 2.41	-26.98	1.67	0.79	1.23	-5.21*
" x P-317	6.22	42.11	0.61	-0.59	-0.93	7.79*
" x P-2994	- 2.08	-12.06	0.40	0.79	2.03	2.57
P-99 x WFWG-III	4.83	- 6.96	2.19*	-0.56	-0.44	3.54
" x F-378	- 2.71	- 4.83	-0.57	0.16	0.23	0.54
" x H-208	9.00	44.84	1.09	-1.16	-1.69	-0.48
" x C-214	9.21	58.34*	-0.21	-2.24	-3.92*	0.49
" x NEC-249	8.88	40.66	0.47	-0.84	1.41	0.54
" x NEC-1639	7.30	23.26	1.67	-2.09	-0.22	4.02
" x NEC-1604	- 7.84	-43.33	1.14	1.56	-3.72*	-2.31
" x NEC-34	6.35	13.54	-0.80	-1.31	2.11	-1.78

Contd....Table 68

Cross	Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
P-99 x NEC-1607	- 3.01	20.81	-8.33*	-1.19	-4.44*	-0.68
" x NEC-10	8.63	18.34	-0.17	0.46	-3.19*	12.04*
" x P-317	- 2.90	-20.56	0.48	0.16	0.98	1.04
" x P-2994	- 1.07	6.26	0.27	-0.46	0.11	-0.68
WFWG-III x F-378	3.23	11.96	0.84	-0.89	-2.59	0.84
" x H-208	- 0.05	-46.36	-0.28	-0.21	0.98	3.32
" x C-214	- 0.23	- 6.86	1.35	-2.29	-1.74	7.29*
" x NEC-249	- 1.37	-22.53	1.15	-2.89	-1.42	-0.16
" x NEC-1639	7.02	55.06*	0.47	1.86	2.96*	7.32*
" x NEC-1604	9.59	3.46	2.33	-1.99	4.46*	-7.01*
" x NEC-1646	20.91*	186.49*	-2.19*	-2.44	-0.92	1.26
" x NEC-34	7.67	17.84	-2.92*	1.64	-1.22	-4.98
" x NEC-1607	-16.14*	-71.89*	-0.96	2.76	3.73*	-5.35*
" x NEC-10	13.96*	26.14	1.20	-0.51	-3.52*	0.84
" x P-317	- 2.90	- 6.76	-0.27	0.61	0.16	-1.66
" x P2994	- 5.15	-24.43	1.29	-0.51	-0.72	0.62
F-378 x H-208	- 2.51	-15.73	0.04	-0.49	0.66	-3.68
" x C-214	- 3.39	-24.73	0.80	0.94	0.93	0.29
" x NEC-249	- 2.55	-37.41	-0.19	0.34	0.26	1.34
" x NEC-1639	- 4.09	-13.81	-0.25	-0.91	0.13	-1.18
" x NEC-1604	9.61	75.59*	-2.06*	0.23	1.13	-0.01
" x NEC-1646	- 7.02	-28.88	-4.21	-1.71	0.74	1.27
" x NEC-34	- 0.64	- 7.53	-0.92	1.36	1.46	-3.48
" x NEC-1607	3.68	5.24	-0.31	-1.01	-0.09	0.62
" x NEC-10	0.86	6.26	0.15	0.71	-0.34	0.84
" x P-317	6.90	14.36	0.72	1.84	0.33	2.34
" x P-2994	- 2.32	-12.31	-0.84	-0.29	0.96	-0.38
H-208 x C-214	2.84	-27.56	-0.69	3.11	1.01	-2.23
" x NEC-249	8.09	34.26	1.32	0.01	0.33	3.82
" x NEC-1639	- 2.22	12.86	0.02	0.76	-2.79	-1.71
" x NEC-1604	0.36	-21.73	-3.67*	3.41*	0.70	0.97
" x NEC-1646	18.22*	58.29*	-0.21	1.46	0.33	-1.76
" x NEC-34	- 3.43	-21.86	-1.90	-1.46	1.53	6.49*
" x NEC-1607	3.00	- 6.08	1.31	-1.84	-1.01	2.09
" x NEC-10	- 5.09	-23.56	0.92	0.39	0.23	-0.68
" x P-317	- 4.80	-15.96	-0.54	1.51	-1.09	3.31
" x P-2994	- 4.82	-10.63	1.08	-0.61	-0.47	-0.90

Contd....Table 68

Cross	Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
C-214 x NEC-249	- 1.23	-10.23	0.19	-0.56	-0.39	-0.71
" x NEC-1639	- 3 25	-14.63	0.20	0.19	0.48	0.77
" x NEC-1604	3.54	18.76	0.42	-0.66	-1.01	-4.06
" x NEC-1646	- 5.30	-28.21	-0.70	-2.11	-3.39*	-2.28
" x NEC-34	2.54	2.14	-0.41	-0.54	0.31	7.97*
" x NEC-1607	2.64	10.91	0.47	0.87	0.76	0.57
" x NEC-10	2.96	26.44	-1.30	-0.19	-0.49	4.29*
" x P-317	- 5.46	- 9.96	-0.08	-0.63	3.18*	-5.21*
" x P-2994	0.76	16.86	0.66	1.31	0.81	1.57
NEC-249 x NEC-1639	4.64	61.19*	0.03	-1.41	0.81	-0.68
" x NEC-1604	1.74	41.09	-4.52*	-2.26	-2.69	-0.01
" x NEC-1646	- 1.30	- 5.88	-3.32*	-1.21	-2.07	2.77
" x NEC-34	- 2.32	-16.03	-1.45	-0.14	-0.37	-3.98
" x NEC-1607	0.32	1.74	1.84	0.49	-1.92	-2.38
" x NEC-10	- 6.95	-17.73	-1.32	-0.29	2.33	-1.65
" x P-317	2.57	24.86	-0.37	3.83*	-1.99	-1.16
" x P-2994	- 0.81	13.19	0.07	-1.29	2.63	0.12
NEC-1639 x NEC-1604	11.13*	23.69	-1.03	-1.51	1.18	-3.03
" x NEC-1646	0.40	16.78	0.38	-2.96	0.31	-0.26
" x NEC-34	- 1.80	- 9.43	-2.65*	-1.89	-1.49	0.49
" x NEC-1607	- 8.71	-48.16	-0.98	-1.26	0.96	2.09
" x NEC-10	- 0.58	-23.13	-0.53	-1.46	-4.29*	-3.68
" x P-317	3.60	31.46	0.15	-2.91	2.38	-0.68
" x P-2994	8.47	19.29	-0.35	0.46	0.01	-2.41
NEC-1604 x NEC-1646	- 3.18	-15.38	2.96*	0.69	0.31	6.42*
" x NEC-34	-17.10*	-53.53*	4.67*	2.26	-1.49	7.17*
" x NEC-1607	4.16	-26.05	6.56*	2.89	-0.54	5.77*
" x NEC-10	- 8.52	-40.23	5.89*	0.11	0.71	-2.00
" x P-317	11.12*	43.36	-0.34	-1.76	-3.12*	3.49
" x P-2994	- 4.52	-22.81	0.36	0.11	0.71	-2.00
NEC-1646 x NEC-34	4.75	6.94	1.57	0.81	1.13	1.94
" x NEC-1607	18.55*	68.76*	1.39	-1.06	0.58	-0.46
" x NEC-10	-11.30*	-37.21	0.78	0.16	-0.17	-4.23
" x P-317	0.25	-10.61	1.05	-0.21	1.50	-0.73
" x P-2994	0.20	15.21	0.41	-0.34	0.63	-6.96

Contd....Table 68

Cross	Yield	Pod No.	Seed weight	Days to flower	Days to maturity	Plant height
NEC-34 x NEC-1607	- 2.78	10.11	3.89*	1.51	-0.72	-2.21
" x NEC-10	5.27	13.64	-2.85*	-2.76	0.53	-0.98
" x P-317	-15.25*	-41.76	1.48	0.86	-1.29	-7.48
" x P-2994	5.89	10.56	-0.70	-1.76	-1.67	2.79
NEC-1607 x NEC-10	- 5.33	- 4.58	0.65	-1.14	2.48	-0.38
" x P-317	2.98	- 2.98	-2.62*	-1.01	-0.84	0.12
" x P-2994	- 2.61	-40.16	1.27	4.86*	0.28	2.39
NEC-10 x P-317	5.35	6.54	-1.22	-0.78	0.41	-0.66
" x P-2994	14.58*	60.36*	-0.44	-0.41	-0.97	2.12
P-317 x P-2994	5.20	41.96	-0.18	-1.79	-1.29	4.12
SE (Sij)	5.40	26.05	0.98	1.61	1.43	2.55

* Significant at 5% level

There were only three cross combinations that flowered significantly early. These involved NEC-1572 as one of the parents which was a good combiner for early flowering. On the other hand there were 12 crosses with significant values for earliness. Some of the crosses for earliness were P-99 x NEC-1607, NEC-1639 x NEC-10, and NEC-143 x WFWG-III. These involved early x late, late x late, and early x early parental combinations.

For plant height 11 crosses had markedly high s.c.a. effects. The top few were P-99 x NEC-10, C-214 x NEC-34, and WFWG-III x NEC-1639.

HETEROSIS

Heterosis over mid-parent, better parent, and best parent was worked out for yield in all the crosses and is presented in Table 69.

One hundred and twenty eight crosses out of 153 combinations exhibited positive heterosis for yield over mid-parent. Heterotic vigour to the extent of 326 per cent was observed in the cross WFWG-III x NEC-1646. A total of 7 crosses exceeded mid-parental value by more than 100 per cent. Some of the topmost combinations were WFWG-III x NEC-1646, H-208 x NEC-1646, WFWG-III x NEC-1604, and WFWG-III x NEC-1639.

Eighty-nine crosses outyielded the better parent. The heterosis ranged from -67 to 319 per cent. The highest heterotic value recorded was in the cross WFWG-III x NEC-1646, which was followed by WFWG-III x NEC-1607 and WFWG-III x F-378. The number of crosses exceeding the better parental value by more than 50 per cent margin was 15.

For yield, the best parent in the study was NEC-10. There were 6 crosses that exceeded this parent by margins ranging from 3 to 13 per cent. The top performing crosses in order of yield were NEC-10 x P-2994, WFWG-III x NEC-1646, and NEC-1646 x NEC-1607.

It was noted that heterosis was maximum in kabuli x desi crosses. It could be due to the fact that the two types are genetically diverse.

Table 69. Heterosis in percentage over [illegible]

		NEC-240	NEC-1572	Kaka	P-99	WFWG-III	F-378	H-208	C-214	NEC-249	NEC-1639	NEC-1604	NEC-1646	NEC-34	NEC-1607	NEC-10	P-317	P-2994
NEC-143	*	39.25	38.77	- 2.48	-32.11	54.18	1.70	0.19	34.54	9.60	15.79	10.06	- 1.35	25.04	-11.80	-38.33	- 1.92	10.61
	**	14.44	16.27	-27.51	-41.13	3.57	-27.11	-15.11	14.60	-25.71	- 9.56	-15.88	-34.29	16.30	-13.09	-45.74	- 9.59	- 5.53
	***	-13.06	-11.67	-44.93	-55.28	-21.32	-44.63	-35.11	-12.94	-43.56	-31.29	-35.07	-50.08	-11.64	-33.98	-45.74	-31.31	-28.23
NEC-240			40.01	40.89	- 4.05	8.01	29.57	19.94	- 7.66	40.41	17.65	8.95	72.09	6.07	8.41	-23.00	-20.05	36.88
			36.69	23.72	- 9.98	-17.17	8.40	15.57	-11.59	40.41	10.20	1.28	30.46	- 7.28	- 9.85	-42.68	-29.53	30.66
			-29.83	-39.50	-49.78	-59.50	-47.00	-39.04	-52.75	-31.34	-46.11	-50.47	-36.21	-39.41	-33.52	-42.68	-54.84	-29.71
NEC-1572				11.68	13.68	40.08	53.19	17.62	30.92	4.97	22.10	35.93	27.84	50.85	30.71	- 0.06	54.74	1.50
				- 3.93	9.15	5.65	25.71	16.05	28.34	2.49	11.89	23.59	- 4.65	34.68	10.85	-28.93	39.34	- 0.80
				-50.68	-39.11	-45.77	-35.47	-38.78	-31.41	-47.39	-42.59	-36.56	-51.06	-11.99	-18.26	-28.93	-10.69	-46.65
Kaka					33.48	114.78	94.09	26.78	29.14	8.48	21.86	7.84	78.67	12.35	0.02	- 7.84	51.02	27.42
					10.98	83.19	83.44	7.83	9.24	- 4.74	13.69	1.38	50.31	-12.03	- 2.49	-36.88	19.07	7.50
					-38.09	-32.27	-32.17	-43.12	-41.61	-53.42	-51.45	-57.41	-44.42	-42.52	-44.63	-36.88	-23.68	-42.17
P-99						95.80	23.22	66.23	68.31	65.87	73.52	- 6.54	80.13	44.73	3.61	31.80	15.20	27.30
						43.70	- 2.04	61.70	64.78	55.63	53.18	-18.08	30.81	34.15	- 8.99	2.67	7.75	25.03
						-19.83	-45.35	- 9.79	- 8.07	-13.18	-14.54	-54.30	-27.02	-12.34	-32.89	2.67	-30.94	-30.25
WFWG-III							110.06	6.20	59.93	50.88	127.78	133.99	326.47	84.37	-39.49	72.22	38.88	34.84
							88.30	-20.62	19.01	15.70	83.48	89.67	319.47	29.00	-59.04	8.58	- 2.28	0.13
							-38.02	-58.13	-36.39	-43.42	-21.64	-20.32	9.46	-15.70	-69.80	8.58	-37.37	-46.14
F-378								14.43	11.68	11.99	17.85	91.45	25.96	15.91	27.83	5.58	59.44	20.86
								- 7.08	- 9.76	- 6.31	4.35	70.73	11.28	-12.85	- 7.55	-29.83	20.67	- 2.59
								-50.98	-51.77	-54.19	-55.44	-28.28	-63.37	-43.05	-31.83	-29.83	-22.66	-47.60
H-208									33.85	55.22	0.20	23.76	165.61	- 0.29	18.54	-15.23	0.25	3.20
									32.99	49.56	8.58	11.17	96.35	- 9.90	-10.43	-35.26	- 8.61	2.20
									-28.93	-21.11	-42.73	-41.36	3.57	-41.13	-25.03	-35.26	- 4.14	-45.02
C-214										14.36	16.76	40.94	27.71	24.54	18.54	10.35	- 0.80	29.00
										9.50	5.03	25.87	- 5.99	13.21	2.23	-15.33	- 9.05	28.59
										-41.48	-43.86	-32.73	-49.76	-26.03	-24.61	-15.33	-41.71	-30.83
NEC-249											53.00	29.21	48.87	2.13	7.05	-23.00	28.43	22.74
											43.31	20.11	12.86	-10.72	-10.98	-42.68	13.21	17.16
											-29.92	-41.27	-44.82	-41.66	-34.35	-42.68	-27.44	-36.98
NEC-1639												95.50	80.88	14.55	-19.21	4.25	44.70	82.51
												93.92	43.89	- 5.29	-36.27	-25.61	20.56	58.04
												-17.17	-38.55	-38.11	-53.00	-25.61	-22.73	-14.98
NEC-1604													44.18	-59.50	24.80	-25.67	69.78	4.84
													15.41	-66.74	- 2.04	-48.64	40.53	- 6.64
													-51.52	-78.26	-27.77	-48.64	- 9.93	-49.78
NEC-1646														67.63	120.48	-22.65	53.05	63.72
														16.19	47.97	-55.57	6.66	20.27
														-24.08	9.12	-55.57	-31.64	-35.30
NEC-34															- 6.30	11.72	-41.39	40.03
															-11.64	- 7.63	-41.96	-27.65
															-34.84	- 7.63	-62.07	-16.59
NEC-1607																-20.61	18.10	1.74
																-31.04	10.38	-12.02
																-31.04	-18.60	-35.12
NEC-10																	16.31	47.33
																	- 4.57	13.29
																	- 4.57	13.29
P-317																		43.68
																		22.14
																		-15.31

* Heterosis over mid-parent; ** Heterosis over better parent; *** Heterosis over best parent

In general, crosses showing significantly positive s.c.a. effects also exhibited high heterosis. Although the expression of heterosis was considerable, its exploitation for commercial use is very difficult because production of hybrid seed on a large scale in this crop is impracticable for the present.

Summary

An 18 x 18 diallel set was analysed for combining ability for grain yield, pod number, seed-weight, days to flower and maturity, and plant height. This study revealed that though both general and specific combining ability variances were significant, the former had much larger variances than the latter. This indicates that additive gene effects were more important for all the characters. A number of good combining parents for various characters have been identified. A comparison of *per se* performance and combining ability revealed that there was good agreement between the two for all characters except yield. Eighty-four per cent of the crosses expressed heterosis over the mid-parent. Several crosses produced more than 100 per cent yield over the mid-parent.

LINE X TESTER ANALYSIS

Some of the possible reasons for limited progress in cultivar improvement program in chickpea are the use of narrow genetic base, random choice of parents in hybridization, and inadequate information about the nature of gene action. ICRISAT has collected and evaluated over 10,000 germplasm lines. In order to make the best use of the world collection it was necessary to identify a few lines which have good combining ability for different characters of economic value. Line x tester analysis was used to evaluate a few germplasm lines for combining ability.

Materials and Methods

Seven parents were chosen as testers (males) and 31 as lines (females) for this study. The special features of these parents are given in Table 70. In 1974-75, 217 crosses were

Table 70. Special characteristics of the parents used for in Line x Tester analysis

Parent		Origin	Kabuli/ Desi	Seed color	Special characteristic(s)
	Testers				
1	Ceylon-2	Ceylon	Desi	Brown	High harvest index
2	P-502	India	Desi	Brown	Double podded
3	F-61	India	Desi	Yellow	Drought tolerant
4	P-148	India	Desi	Brown	More pods on secondary branch
5	T-3	India	Desi	Yellow	Large seeded, widely adapted
6	JG-39	India	Desi	Brown	High protein content
7	P-861	Iran	Desi	Brown	Multiseeded
	Lines				
1	Jam	Iran	Kabuli	S.White	Released variety of Iran
2	Pyrouz	Iran	Desi	Brown	Promising cultivar from Iran
3	P-2940	Iran	Desi	Yellow	More branches and more pods
4	Pant-102	India	Desi	Yellow	Good plant habit and high yield
5	V-4	Mexico	Desi	Brown	High yield
6	F-240	India	Desi	Brown	High yield and wide adaptation
7	P-1243	India	Desi	Y.Brown	High yield
8	P-514	India	Desi	Brown	Multiseeded
9	P-10	India	Desi	Brown	More secondary branches and pods
10	NEC-721	Iran	Desi	Yellow	Upright habit
11	L-432	India	Desi	Yellow	Large seeded
12	P-662	India	Desi	Brown	Good podding

Contd....Table 70

	Parent	Origin	Kabuli/ Desi	Seed color	Special characteristic(s)
13	P-436	India	Desi	Yellow	More pods, double podded
14	P-6218	India	Desi	Brown	Good under rainfed conditions
15	T-103	India	Desi	D.Brown	Very early
16	P-4235	Afghanistan	Desi	L.Brown	Good podding, pods generally above the plant canopy
17	No.296	India	Desi	Green	Dwarf culture
18	BG-1	India	Desi	Yellow	Drought tolerant, wide adaptation
19	BR-70	India	Desi	Brown	Bronze leaves
20	Chafa	India	Desi	Yellow	Early, wide adaptation
21	G-130	India	Desi	Yellow	High yield and wide adaptation
22	G-543	India	Desi	Yellow	Good under blight prone areas
23	L-532	India	Kabuli	S.White	Large seeded
24	No.501	India	Kabuli	S.White	Large seeded
25	P-272	India	Desi	Brown	Double-podded
26	P-3172	Iran	Desi	Black	More pods per secondary branch
27	P-4357	Iran	Desi	Y.Brown	More pods per secondary branch
28	Pant-104	India	Desi	Yellow	Good yield, wide adaptation
29	L-534	India	Kabuli	S.White	High yield and wide adaptation
30	NEC-835	Iran	Desi	Yellow	Tiny pods and late
31	NEC-1077	Iran	Desi	Yellow	Good fruiting, small seeded

made. These crosses were grown during 1975-76 in a randomized block design with three replications in 3m long rows spaced 75 cm apart, each accommodating 15 plants. Data on five competitive plants in each replication were recorded for grain yield per plant, pods per plant, 100-seed weight, number of primary and secondary branches, days to flower, and plant height.

Statistical analyses for all the characters were done following the methods developed by Kempthorne (1957)[1].

Results and Discussion

Analysis of variance (Table 71) revealed that hybrids differed for most of the characters. Significant differences were obtained between males for all characters except for number of primary branches, indicating sufficient variability in the testers selected for the study. The differences between females (lines) were not significant for yield, number of primary and secondary branches, whereas for other characters these were significant. Except for number of primary and secondary branches, the line x tester interaction was significant for the remaining characters. The mean squares due to testers were of larger magnitude in comparison with those due to lines or line x tester for yield, seed-weight, number of secondary branches, days to flower and plant height. The results indicated existence of more diversity in males for these characters. On the other hand, for pods per plant and number of primary branches, mean squares due to lines exceeded those for the testers indicating that for these characters there was more scope of exploitation in the female parents.

The general combining ability (g.c.a.) variances and specific combining ability (s.c.a.) variances were also estimated and are presented in Table 71 (actual yields can be found in Table 50). The s.c.a. variances were more than g.c.a. variances for grain yield, pods per plant, and number of primary branches, whereas the opposite was true for seed-weight, number of secondary branches, days to flower, and plant height. These estimates indicate a preponderance of non-additive gene action for the first set of characters and additive for the

[1]Kempthorne, O. (1957). An Introduction to Genetical Statistics. John Wiley & Sons, Inc., New York.

Table 71. Analysis of variance, and estimated general and specific combining ability variances for various characters

Source	d.f.	Yield	Mean Squares					
			Pods/plant	100-seed weight	Primary branches	Secondary branches	Days to flower	Plant height
Replication	2	957.02	10940.30	0.42	1.22	88.91	22.31	88.75
Hybrids	216	110.61*	2814.22*	21.74*	11.56*	9.16	16.29*	33.10*
Testers	6	884.54*	6369.53*	224.37*	5.96	22.51*	212.07*	233.54*
Lines	30	112.94	7453.71*	79.76*	12.85	10.22	44.17*	102.61*
Line x Tester	180	84.41*	1922.47*	5.31*	11.55	8.54	5.12*	14.84*
Error	432	55.80	1268.90	2.03	9.49	8.62	2.89	9.69
$\hat{gca}$		7.27	87.53	2.57	-0.38	0.14	2.16	2.69
$\hat{sca}$		9.54	217.86	1.09	0.69	-0.03	0.74	1.71

* Significant at 5% level

second.

Summary

A 31 x 7 line by tester was studied for yield and other agronomic characters during 1975-76. The results indicate that non-additive gene action was more important for yield, pod number, and primary branches, whereas additive gene action was predominant for seed weight, secondary branches, days to flower, and plant height. Results of the topcross study for yield, pod number, and primary branches are contrary to those of the diallel analysis and also contrary to conclusions of studies on crop plants in general. It will be worthwhile to examine the method of analysis and other aspects of the topcross approach as time permits.

General combining ability effects for testers as well as lines along with their standard errors are given in Table 72. It can be seen that among the testers, P-502 and T-3 were good combiners for yield, P-502 for pods per plant, P-502 and T-3 for seed-weight, T-3 for number of secondary branches, P-502 and P-861 for earliness, P-648 for plant height, and none for primary branches, Thus, P-502 and T-3 appear promising as good combiners. Among the lines 6 were good combiners for grain yield, 3 for pods per plant, 10 for seed-weight, 3 for number of primary branches, 1 for number of secondary branches, 8 for earliness, and 12 for plant height. The line BG-1 was a good combiner for yield, pods per plant and seed weight, P-272 for yield, pods per plant and earliness, P-436 for yield and earliness, and NEC-1077 for yield and seed-weight. The good combiners for yield (P-436, P-272 and P-1243) were also early and dwarf. BG-1 and NEC-1077, however, were good combiners for yield and tallness and average combiners for earliness.

However, the results indicate seven parents, P-502, T-3, BG-1, P-436, P-272, NEC-1077, and P-1243, were good general combiners for yield. A number of good combiners for other characters have also been identified.

INHERITANCE OF QUALITATIVE CHARACTERS

A study was initiated in 1974-75 to determine the inheritance of three qualitative characters: flowers per peduncle, leaf color, and stem color. Data were recorded on two

Table 72. General combining ability effects and their standard errors for testers and lines

	Yield	No. of pods	100-seed weight	Primary branches	Secondary branches	Days to flower	Plant height
Testers							
Ceylon-2	-2.71*	0.75	-1.08*	-0.18	0.33	2.28*	0.53
P-502	2.51*	14.90*	0.90*	-0.42	-0.23	-2.34*	-2.06*
F-61	-1.26	- 4.05	-0.87*	0.07	-0.31	-0.05	0.37
P-648	-2.47*	- 1.76	-1.28*	-0.12	-0.47	-0.04	2.78*
T-3	5.42*	5.44	3.13*	0.15	0.95*	1.26*	-0.14
JG-39	-2.37*	-10.98*	-0.33*	0.22	-0.01	0.07	0.13
P-861	0.88	- 4.31	-0.47*	0.29	-0.27	-1.18*	-1.61*
SE (gi)	0.77	3.69	0.15	0.32	0.30	0.18	0.32*
Lines							
Jam	-1.75	-43.37*	1.99*	-0.48	-0.49	2.09*	3.33*
Pyrouz	-3.36*	- 8.61	-0.64*	-0.16	0.17	2.09*	1.09*
P-2940	-0.73	3.62	0.54	-0.32	-0.30	-1.62*	1.90*
Pant-102	-1.87	- 0.23	-2.02*	-0.51	-0.41	-0.43	-1.43*
V-4	-1.19	-21.28*	1.05*	-0.09	-0.25	1.62*	2.09*
F-240	-1.85	4.82	-1.50*	-0.30	1.03	1.28*	-0.33
P-1243	4.89*	12.01	0.52	-0.35	-0.25	-0.14	-2.29*
P-514	1.44	14.01	-0.22	-0.31	-0.58	-0.86*	-3.19*
P-10	1.48	9.96	-0.36	-0.15	2.93*	-1.86*	-3.14*
NEC-721	0.39	14.10	-1.02*	-0.35	-0.23	-0.05	2.19*
L-432	-2.43*	-32.08*	0.87*	-0.45	-0.34	1.95*	0.66

Contd....Table 72

	Yield	No. of pods	100-seed weight	Primary branches	Secondary branches	Days to flower	Plant height
P-662	-1.47	-25.04*	4.06*	-0.56	-1.19	-1.52*	2.61*
P-436	3.30*	19.25*	-0.56	-0.49	-0.03	-2.29*	-2.38*
P-6218	-1.25	3.25	-2.33*	-0.12	-0.07	0.09	0.04
T-103	1.76	28.15*	-0.11	0.60	-0.36	-2.19*	-2.72*
P-4235	0.08	10.73	-2.21*	-0.24	-0.28	-0.62	3.14*
No.296	-1.02	4.53	-1.37*	-0.15	0.39	-0.05	-3.05
BG-1	5.10*	16.63*	1.31*	-0.12	0.22	1.28*	1.19
BR-70	-1.70	12.44	-1.77*	1.62*	0.11	1.66*	-0.86
Chafa	0.77	13.15	-1.12*	-0.30	-0.22	-0.33	-0.95
G-130	-0.14	12.30	-1.09*	-0.27	0.36	1.33*	0.00
G-543	-2.89*	0.34	-1.65*	2.02*	0.12	0.90*	-2.14*
L-532	1.13	- 9.75	2.64*	-0.22	0.11	1.33*	1.80*
No.501	-1.11	-44.23*	5.03*	1.27	0.05	0.81*	1.76*
P-272	3.53*	24.25	-0.35	-0.35	-0.03	-2.95*	-3.05*
P-3172	-3.42*	- 4.18	-1.79*	-0.40	-0.68	0.14	2.52*
P-4357	1.15	0.58	1.51*	-0.51	-0.33	-2.43*	1.57*
Pant-104	-1.78	- 6.37	-1.58*	-0.41	-0.68	-0.43	-1.95*
L-534	1.28	-30.32*	3.55*	2.58*	0.14	0.66	1.80*
NEC-835	-1.74	10.77	-2.53*	-0.13	0.52	1.09*	-2.86*
NEC-1077	3.38*	10.53	1.13*	-0.32	0.59	-0.67	2.66*
SE (gj)	1.13	7.77	0.31	0.67	0.64	0.37	0.68

* Significant at 5% level.

crosses for the first character, 3 for the second and 4 for the third. Only two generations, F_1's and F_2's, were studied. The results are briefly discussed below:

1. Flowers per Peduncle

Single flower per peduncle was found to be completely dominant over double flower per peduncle in the F_1. The two F_2 populations segregated in the ratio of 3 single:1 double flower per peduncle (Table 73). Pooled analysis of the data over two crosses confirmed the monogenic behaviour of this character. The double-flowered trait of JG-62 differed by one gene from the single flowered trait of BEG-482 and F-61.

Table 73. Segregation of flower(s) per peduncle in F_2 generation

Cross	Flower(s) per peduncle		Expected ratio	X^2	P-Value
	Single	Double			
JG-62 x BEG-482	385	115	3:1	1.066	0.5 - 0.20
JG-62 x F-61	364	136	3:1	1.290	0.5 - 0.20
Pooled	749	251	3:1	0.005	0.95- 0.90

2. Leaf Colour

Green vs. anthocyanin pigmented leaf colour crosses produced pigmented leaf colour in the F_1 hybrid. Plants within F_2 populations gave a good fit to 3 pigmented:1 green (Table 74). The inheritance of this character was controlled

Table 74. Segregation of Leaf Colour in F_2 generation

Cross	Leaf colour		Expected ratio	X^2	P-Value
	Anthocyanin	Green			
F-496 x BR-70	347	121	3:1	0.182	0.75 - 0.50
Ceylon-2 x BR-70	381	119	3:1	0.384	0.75 - 0.50
RS-11 x BR-70	373	127	3:1	0.042	0.90 - 0.75
Pooled	1101	367	3:1	0.000	Perfect fit

by a single gene. The pooled analysis over all the three crosses gave a perfect fit, confirming thereby that the inheritance was governed by a single gene. The colored leaf of BR-70 differed from the other three parents by one gene.

3. Stem Color

Out of the four crosses involving purple and green stem colors, three crosses produced purple stem color and one cross gave light purple in the F_1 generation. The F_2 population of the first three crosses segregated in the ratio of 3 purple:1 green stem (Table 75). The pooled analysis over these three crosses also confirmed this nature indicating one dominant gene for purple color. The fourth cross, however, gave a good fit to 9 (purple):7 (green), which showed that two dominant complementary genes were responsible for the purple color in that cross.

Table 75. Segregation of Stem Color in F_2 populations

Cross	Stem color		Expected ratio	X^2	P-Value
	Purple	Green			
L-550 x F-378	376	124	3:1	0.010	0.90 - 0.75
L-550 x BEG-482	367	133	3:1	0.682	0.50 - 0.25
L-550 x No.56	324	117	3:1	0.594	0.50 - 0.25
Pooled	1067	344	3:1	0.305	0.75 - 0.50
C-104 x H-208	265	235	9:7	2.131	0.25 - 0.10

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