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ICRISAT Annual Report 1974/75

Chickpea Breeding

A.K. Auckland, K.B. Singh and Associates

Introductory Statement

The total world area grown to chickpea is estimated to be 10.5 million hectares. Chickpea is the most important pulse crop of India, Pakistan and Ethiopia, which produce 74%, 10% and 4% of the worlds crop respectively. Some other countries where chickpeas are grown, in decreasing order of crop production are Mexico, Burma, Spain, Morocco, Turkey, Iran and Tanzania. In the Indian sub-continent, the bulk of the crop is of the small seeded 'desi' type with a range of seed colours. From Afghanistan westwards the large seeded 'kabuli' types are commonly grown and these are white or light coloured. Most of the crop is consumed locally and the export trade is minimal.

The worlds average productivity of chickpea at approximately 710 kg/ha is very low: breeding programmes in various parts of the world have todate made little impact on yield improvement and most farmers continue to grow ancient land races on soils of low-fertility and under rain-fed conditions. The highest per hectare production is in Egypt (1667 kg/ha, under irrigation) and the lowest in Tanzania (187 kg/ha). In India average yields are about 700 kg/ha.

The Technical Advisory Committee of the Consultative Group for Agricultural Research assigned to ICRISAT the international responsibility

for the improvement of the chickpea crop. The chickpea breeders, germplasm botanists, physiologists, entomologists, pathologists and biochemists at ICRISAT are working as a team to achieve this improvement. The economists at ICRISAT are carrying out related studies on consumer preferences for the crop.

GERMPLASM

Dr. van der Maesen's section.

BREEDING GOALS

(1) Objectives:

The objectives of the breeding programme are:

(a) High yield and good acceptance (Palatability, seed colour, seed size etc.)

(b) Stability of yield.

(c) Resistance to diseases and pests.

(d) Higher protein content and good amino acid profiles per unit area per day.

It is believed that, in the first instance, we shall make the greatest genetic gain by deliberately delimiting our objectives to high yield and stability of yield. Specific resistances to pests and diseases can be incorporated at a later stage when the entomologists and pathologists are in a position to positively identify sources of resistance and the nature of their inheritance.

(2) Breeding Methodology

The breeding programme is now being approached from two standpoints:-

(a) The 'classical' approach. (Single 3-way, double, multiple crossing and back crossing).

Large spaced F2 populations are grown under conditions of high fertility. Phenotypic evaluation of yielding ability, especially number of pods, is made at this stage and stringent elimination of crosses made on this basis.

The crosses retained after the F2, undergo the pedigree method of breeding if assessed as "very promising" and a modified bulk method of breeding if classified as "promising". In this way, we can eliminate many crosses in an early generation, which is important for us when at this stage, our breeding programme is based upon the assessment of a large number of crosses.

Good plants and/or good crosses are advanced in off-season nurseries in the Lahaul valley (North India) or The Lebanon and we therefore obtain 2 generations per year.

(b) "Recurrent Selection" approach - using Jensen's "diallel selective mating system".

Recurrent selection provides for the broad use of germplasm, simultaneous input of parents, creation of persistant gene pools, breaking of linkage blocks, freeing of genetic variability and general fostering of genetic recombination. This method may, in the long term, be the answer

to achieving a breakthrough in yield for chickpeas. Genetic recombination is limited in "classical" breeding methods and the apparent phenotypic variability within chickpea cultivars grown in the Indian sub-continent appears minimal. We are hampered in this approach by the absence of male-sterility in chickpeas todate but this can be overcome by making large numbers of hand-crosses.

Elite lines produced from the breeding programme will be assessed for yield stability and fertilizer response at a number of sites. Chemical analysis and palatability of elite lines will also be assessed.

APPLIED BREEDING PROGRAMME

(1) Progress to date in the Breeding Programme

(a) The chickpea breeding programme at ICRISAT was initiated during the 1973/74 "winter" season at Hyderabad. 423 single crosses were made during this season between parent cultivars of largely Indian-sub-continent origin. The F1 generation of these crosses were grown in off-season advancement nurseries in either the Lahaul valley, N. India or the Lebanon and these produced enough seed for F2 generation testing at Hyderabad during the 1974/75 season, from 324 crosses. 252 of these crosses were of 'desi' x 'desi' parentage and 72 of 'kabuli' x 'desi' parentage.

Up to 2000 spaced plants of each cross were grown in the 1974/75 season and a breakdown of the classification of the crosses into four categories is given in Table 1. It will be noted from this table that individual plant selections were made from crosses classed as "poor": this,

of course, being because some outstanding segregants could be found in crosses where the overall mean performance is poor. The 3817 individual plants selected were sent to The Lebanon for off-season advancement and some, depending upon the selection pressure exercised in that country, will be returned for line-row testing in India, during the 1975/76 season.

From within each of the "very promising" crosses we also selected some pods from about 20% of the "good plants" and the seed obtained by this method of modified mass selection will be issued to chickpea breeders in various countries as "F3 segregating bulks" in 1975/76. Some crosses were "difficult to assess" because they were late maturing, under Hyderabad conditions, and on these we retained seed for further assessment under the longer growing seasons of Northern India and Pakistan.

Wilt, caused by a virus was found in high frequency in some of these F2 populations and caused mortality to the extent of 3%. It was interesting to note that wherever the Northern Indian cultivar F378 was involved as a parent of the cross, that the frequency of virus affected plants was higher.

(b) In the 1974/75 season, at Hyderabad 1046 single crosses, and 613 multiple crosses were made. Percentage success in crossing was 24% - a distinct improvement over the previous seasons 13%.

Emphasis was placed on 'kabuli' x 'desi' crosses this season, in pursuance of the hypothesis that the introgression of 'kabuli' germplasm into 'desi' germplasm is essential if we are to achieve quantum yield increases for the 'desi' types in E. Asia. The reverse probably holds true

for the improvement of 'kabuli' types in W. Asia and North Africa.

(c) In the 1973/74 season we utilized less than 100 parental cultivars in the crossing programme - most of them from India. In 1974/75 included 294 varieties in the crossing programme and 33% of these were from outside India. In this season also our germplasm collection had increased and we selected a further 175 cultivars for potential parents during 1975/76. Most of these were from foreign countries and a generalised description of all the cultivars to be used in crossing next year is given in Table 2.

(d) Chickpeas go down badly with diseases if grown during the summer rains in India. However, an attempt was made, by planting 26th August (near the end of the rains) to see if we could infact manage 2 generations per year at Hyderabad.

Seed from 25 F2 populations were used and although the crop did not fully mature until early December (the requisite planting time for a normal crop being early October) there were sufficient pods matured on some early plants in order to enable us to collect seed and plant them on December 13th 1974.

The conclusions of this experiment were:-

(i) It is possible to take 2 generations per year at Hyderabad, but both would be sub-optimal and it would be ill-advised to select plants from such material.

(ii) Nodulation was sparse on the August planted crop.

(iii) Diseases like "witches-broom", an unidentified bacterial blight, and a fungus, tentatively identified as Neocosmospora sp., were prevalent. Out of season planting may be useful for assessing disease resistance in the future.

(iv) There is no dormancy in chickpea

The 'early' material sown on December 13, 1974 matured in mid-March 1975 and was harvested to be planted as F4 material in the Lahaul valley in the 1975 off-season. This will be tested as F5 rows at Hyderabad during the 1975/76 season, under normal conditions.

(2) Cultivar Adaptation Trials

A Preliminary yield trial (100 cultivars) and an Advanced yield trial (26 cultivars) were planted during the 1974 summer season at Kferdan in The Lebanon and Gondla, Lahaul valley, N. India and during the 1974/75 winter season in Hyderabad. The five best yielding cultivars, over all sites, are given in Table 3, for both trials. The lowest yielding cultivar in the Preliminary yield trial gave 702 kg/ha and that in the Advanced yield trial 1395 kg/ha.

It is interesting to note that an unspecified cultivar "Bengal Gram", which we presume is a mixed market sample from West Bengal, India gave the highest yield over all 3 trials: one may perhaps infer from this that "population-buffering" may be an important factor for yield stabilization.

(3) Cultivar Response to Fertilizers

It has often been stated that chickpeas do not respond to fertilizers. With this in mind a trial to screen 498 cultivars for their response to fertilizers was planted. Replications 1 and 2 were given a low dosage (14 N, 35 P_2O_5, 14 K_2 Zn SO_4 kg/ha) and replications 3 and 4 a high dosage (28 N, 70 P_2O_5, 28 K_2 0 and 25 Zn SO_4 kg/ha.). A Bartlett's test for homogeneity of variances showed no significance between replications 1 plus 2 and 3 plus 4. The overall mean yield of the cultivars given low fertility was 1562 kg/ha. and those with high fertility 1820 kg/ha, and this was statistically significant. However, only 24 cultivars individually showed a significant positive response to increased fertilizer dosage and 9 cultivars showed a significant negative response. Table 4 shows the response of 5 varieties giving the largest positive response and 5 varieties giving the largest negative response.

The negative response to fertilizer application in interesting: it may be caused by an early increase in vegetative growth, which is detrimental to high yields if soil moisture becomes limiting later in the season. We intend to investigate further the genotypes giving these responses in the 1975/76 season.

(4) Inheritance of simple characters.

The inheritance of flowers per peduncle (Table 5), Leaf colour (Table 6) and stem colour (Table 7) were studied.

Flowers per peduncle:- Single flower per peduncle was found to be completely dominant over double flowers per peduncle in the F_1. Two F_2 populations segregated in the ratio of 3 single: 1 double flower per peduncle. Pooled analysis of the data confirmed the single gene inheritance.

Leaf Colour:- Green x anthocyamin pigmented leaf colour crosses produced pigmented leaf colour in the F_1 hybrid. Plants within F_2 families segregated and gave a good fit to 3 ~~green~~ pigmented: 1 ~~pigmented~~ green, indicating single gene dominance. The pooled analysis of the data also gave similar result.

Stem Colour:- Three crosses produced purple stem colour, one cross produced light purple colour and one cross produced green colour in F_1 generation. The F_2 populations of the first three crosses segregated in the ratio of 3 purple: 1 green. The fourth cross gave a good fit to 9 purple: 7 green. The F_2 plants in last cross segregated in the ratio of 3 green: 1 purple.

(5) Heritability Estimates of Seed Size

An experiment was designed to estimate the heritability of seed size in 3 crosses. The crosses were made between large x large (L-550 x GW 5/7), small x small (JG-62 x F-378) and large x small (L-550 x E-100). The seed size of the parents was 33.2, 22.2, 15.5, 12.2 and 12.1 gms/100 seed for GW5/7, L-550, JG-62, E-100 and F-378 respectively. The parents,

F_1, F_2, BC, and BC_2 of each cross were grown in a randomized block design with 3 replications at Hyderabad during the 1974/75 season. Narrow sense heritabilities were worked out by Warren's method and these were:-

Cross	Heritability %
L-55 x GW 5/7	50.3
JG-62 x F-378	29.5
L-550 x E-100	85.0

It is interesting to note that the estimate for the large x small seeded cross (L-550 x E-100) was the highest.

LOOKING AHEAD IN CHICKPEA IMPROVEMENT

(1) Work at Hissar

The ICRISAT site at Hyderabad, where the main breeding programme takes place, is outside the main chickpea growing areas of the Indian sub-continent. Chickpeas are more widely grown in Northern India and give higher yields there. High yields appear to be associated with length of maturity period. Approximate maturity periods for varieties commonly grown in Coimbatore, Hyderabad, Uttar Pradesh and the Punjab are 90, 110, 155 and 165 days respectively. It was imperative that we obtain land in Northern India in which to carry out concurrent (with the Hyderabad site) selection within segregating populations. An agreement of understanding has now been drawn up between ICRISAT and the Haryana Agricultural University at Hissar and it is proposed to initiate this work during the winter season of 1975/76.

(2) International Cooperation

The objectives and scope for our international cooperation programmes are:

(a) To make introductions of varieties into other countries

(b) To supply segregating populations to strengthen national and regional programmes.

(c) To identify genotypes with wide-range adaptability for use in international breeding programmes.

(d) To release varieties with special characteristics, e.g. disease resistanco, high protein etc. to other countries.

For the winter season of 1975/76, International Chickpea Cooperative Trials (49 varieties) and Elite germplasm lines have been sent to cooperators in India, Pakistan, Thailand, Chile, Ethiopia, Sudan, Burma, Mexico, Bangladesh and the Philippines. F3 segregating material from our best crosses have also been distributed to Pakistan, Chile, Ethiopia, Mexico and Philippines and to other stations in India; it is hoped that cooperators can select locally adopted material from these. Similar cooperation between ICRISAT and the chickpea growing countries of West Asia and North Africa is envisaged for the summer of 1976.

TABLE 1

CLASSIFICATION OF F2 POPULATION AT HYDERABAD DURING 1974-75

Class	F2 populations		No. of plants selected		
	No.	%	'Desi'	'Kabuli'	Total
Very promising	31	9.6	827	57	884
Promising	70	21.6	1245	129	1374
Difficult to ascertain	108	33.3	1037	148	1185
Poor	115	35.5	349	25	374
Total	324	100.0	3458	359	3817

TABLE 2

DESCRIPTION OF THE PARENTS IN THE CROSSING PROGRAMME

Special character	No. of entries	Origin
High Yield	147	India, Egypt, Iran, Ethiopia, Greece, Netherland, Israel, Iraq, Jordan, Spain, Sudan, Pakistan, U.S.A., Algeria, Tunisia, Turkey, Mexico, Morocco, Nigeria, Cyprus, Afghanistan
High yield & attractive plant type	5	India, Iran
High harvest index	5	India, Russia, Iran
Upright habit	9	India, Iran
Tall erect	16	Greece, Morocco, USSR, Peru, Egypt, Pakistan, USA, India, Iran
Dwarf	7	India, Iran
Prostrate	1	India
Large no. of primary branches	5	India, Morocco, Iran
Large no. of secondary branches	6	India, Iran
Large no. of pods	24	India, Iran
Two pods per peduncle	25	India, Pakistan, Iran, Turkey, Yozgat
More no. of seeds per pod	20	India, Pakistan, Iran
Large seed size	16	India, Mexico, Morocco, Iran, USA
Very early	5	India, Iran, Ethiopia
Close podding	1	India
Large pods with seeds of small size	6	India, Spain

Table 2 contd..

Round seed	2	India
High anthocyanin content	1	India
Red colour of the leaves	1	India
High chlorophyll content	3	India, Pakistan
High protein content	1	India
Good performance under poor conditions	4	India, Turkey
Good light penetration	3	India
Wilt resistant	2	India
Drought resistant	1	India
High susceptible to wilt	1	Iran
Blight resistant	18	Israel, Iran, Bulgaria
Vigorous	7	India, Iran, Afghanistan
Seed colour	-	Variable from white to black

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TABLE 3

CULTIVAR ADAPTATION TRIALS

Yields in kg/ha

Cultivar and Origin	Lebanon	Lahaul	Hyderabad	Mean
Best five (Preliminary Yield Trial)				
Bengal Gram (India)	1889	2824	2245	~~2125~~ 2319
P - 2974 (Iran)	1736	2546	1701	~~2045~~ 1974
K - 4 (?)	1472	2222	2350	2015
P - 3284 (Iran)	2472	1896	1481	~~1937~~ 1950
V - 4 (Mexico)	2360	1896	1280	~~1902~~ 1845
Best five (Advanced Yield Trial)				
T - 3 (India)*	2233	2592	2077	2300
B - 110 (India)	1455	3038	1524	2005
C - 214 (India)	1544	2569	1899	2004
Annegiri (India)	1445	2621	1921	1996
Pant - 102 (India)	2066	2175	1748	1996

* All the varieties in this trial were from India

TABLE 4

CULTIVAR RESPONSE TO HIGH FERTILIZER APPLICATION

Yields in kg/ha

Cultivar	Origin	Low Fertilizer	High Fertilizer	Difference
P - 36	Uttar Pradesh, India	1561	2597	+ 1036
P - 1363 - 1	" " "	1381	2084	+ 703
Radhey	" " "	1292	2022	+ 731
P - 1236	" " "	1420	2117	+ 697
NP - 34	Maharashtra, India	1536	2203	+ 667
(740x940)F-7	Maharashtra, India	2042	1333	- 708
T - 18	" "	2231	1625	- 608
P - 234	Uttar Pradesh, India	2022	1420	- 603
B - 110	W. Bengal, India	2236	1642	- 595
P - 3951	Iran	1970	1445	- 525

L.S.D. at 5% = 487 kg/ha

TABLE 5

SEGREGATION OF FLOWER(S) PER PEDUNCLE IN F_2 POPULATIONS

Cross	Flower per peduncle		Expected ratio	X^2	P - Value
	Single	Double			
JG-62 x BEG-482	385	115	3 : 1	1.066	0.50 - 0.20
JG - 62 x F - 61	364	136	3 : 1	1.290	0.50 - 0.20
Pooled	749	251	3 : 1	0.005	0.95 - 0.90

TABLE 6

SEGREGATION OF LEAF COLOUR IN 3 F_2 POPULATIONS

Cross	Leaf Colour		Expected ratio	X^2	P - Value
	Antho-cyamin	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

TABLE 7

SEGREGATION OF STEM COLOUR IN F_2 POPULATIONS

Cross	Stem Colour		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
C-104 x H-208	265	235	9 : 7	2.131	0.25 - 0.10
L-550 x B-108	139	361	1 : 3	2.091	0.25 - 0.10