Ascochyta Blight Resistance in Chickpeas
Proceedings of a Training Course
3-10 March 1984, NARC,
Islamabad, Pakistan

PARC
Pakistan Agricultural Research Council, Islamabad, Pakistan

ICARDA
International Center for Agricultural Research in the Dry Areas,
Box 5466, Aleppo, Syria
December 1986

International Center for Agricultural Research in the Dry Areas
ICARDA
Box 5466, Aleppo, Syria

Correct citation:

ICARDA (International Center for Agricultural Research in the Dry Areas). 1986. Ascochyta Blight Resistance in Chickpeas. Proceedings of a Training Course, PARC/ICARDA, 3-10 Mar 1984, Islamabad, Pakistan. ICARDA, Aleppo, Syria.

FOREWORD

The International Center for Agricultural Research in the Dry Areas (ICARDA) and national agricultural research programs in West Asia and North Africa have the common goal of increasing food production and improving the welfare of the rural poor. To achieve this goal, ICARDA has developed a strategy of close collaboration with national research institutions to strengthen their research and training capabilities so that the development of improved production technologies and their transfer to farmers is hastened. ICARDA, in collaboration with individual national research programs, has developed a program of in-country training courses, which are jointly conducted by ICARDA and national scientists and are tailored to the specific needs of the host country concerned.

One such course, Ascochyta Blight Resistance in Chickpeas, was held 3 - 10 March 1984 at the National Agricultural Research Center, Islamabad, Pakistan. The course was jointly coordinated by the Pakistan Agricultural Research Council (PARC) and ICARDA. It included lectures, laboratory exercises, and field practicals. The lectures and practical exercises given to the trainees are included in this volume. It is hoped that these proceedings will provide valuable practical reference material for young researchers working on chickpea improvement in Pakistan and elsewhere. They are also a good illustration of collaboration between the national programs and ICARDA.

Mohamed A. Nour
Director General

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PREFACE

In the last few years, chickpea farmers in Pakistan have suffered losses exceeding 50 million dollars due to blight, and to meet domestic needs, the government had to import chickpea at high cost. To understand the problem and find ways to cope with it, more trained breeders and pathologists are needed so that research to control the disease can be effectively undertaken.

The Cooperative Research Program on Food Legumes (Pulses), PARC, Pakistan, and the Food Legume Improvement Program, ICARDA, conducted a training course at Islamabad entitled Ascochyta Blight Resistance in Chickpeas, 3-10 March 1984. The course, conducted at the National Agricultural Research Center (NARC), aimed to enhance the knowledge and improve the skills of researchers working in chickpea improvement. The course focused on the pathology of the disease and appropriate agronomic and genetic steps to control it. The participants came from various research stations in Pakistan. The instructors were mainly from NARC, the universities in Punjab, and ICARDA.

The scientists from PARC and ICARDA have compiled their lecture and practical exercise handouts into course proceedings. These are intended for use as reference material for trainees and researchers engaged in chickpea improvement in Pakistan and elsewhere.

The editors would like to thank Mrs Fiona Thomson for her invaluable assistance in preparing the manuscript for printing. We acknowledge also the efforts of Miss Nawal Saroukhan and Miss Hasna Boustani in putting the manuscript into the word processor. We are also grateful to Dr M.C. Saxena, FLIP leader, and Dr Haware, Chickpea Pathologist at ICRISAT, for their assistance in the review of the manuscript.

Editors:
Mohamed Habib Ibrahim, ICARDA
B. A. Malik, NARC, Islamabad
M. V. Reddy, ICRISAT/ICARDA

ACRONYMS

NIAB	Nuclear Institute for Agriculture and Biology
NWFP	North West Frontier Province
PARC	Pakistan Agricultural Research Council
NARC	National Agricultural Research Center
RRI	Rice Research Institute
ICRISAT	International Center for Agricultural Research for the Semi-Arid Tropics
ICARDA	International Center for Agricultural Research in the Dry Areas
BARI	Barani Agricultural Research Institute

Pulses in Pakistan with Emphasis on Chickpeas and Ascochyta Blight

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Introduction

Chickpeas are grown as a postmonsoon 'winter' crop in Pakistan. In terms of land area occupied by chickpea, Pakistan ranks second in the world. It is a rich and cheap source of vegetable protein for human nutrition and it balances the deficiencies of the cereal diet by supplying the bulk of dietary requirements, especially to the people of predominantly rural areas of Pakistan. In addition, chickpeas are beneficial in restoring soil fertility due to their nitrogen-fixing capability. Despite the great importance of chickpeas, little research has been done to increase production, until recently.

Area, Production, and Yield of Grain Legumes and Other Crops

Area Planted to Food Legumes

Chickpeas are cultivated all over Pakistan but their cultivation is concentrated in certain areas, mainly rainfed.

The area brought under chickpea, as indicated in the terminal year of the fifth 5-year plan (Table 1), was 1456 thousand hectares, which constituted 9.8% of the area covered by cereals, cash crops, and oilseeds during the same year.

Chickpea occupies 70% of the total area under food legumes (Table 2). Lentil (*Lens culinaris*), mung (*Vigna radiata*), blackgram (*Vigna*

Table 1. Existing and projected area of food legumes and other crops in Pakistan (x000 ha).

Crop	Fifth 5-year plan (1978-83)*	Sixth 5-year plan (1983-88)**
Grains	11144	11454
Cash crops	3220	3160
Oilseeds	556	954
Groundnuts	46	60
Others	510	894
Pulses	1455	1535
chickpea	1015	1112
others	440	423

* Crops Statistics of Pakistan, July 1983.

** Planning Commission of the Government of Pakistan, October 1983.

Note: Figures in each plan period relate to the terminal year.

Table 2. Grain legume area (x000 ha) and percentage of each crop, (figures in parentheses) from 1978/79 to 1982/83 in Pakistan.

Crop	1978/79	1979/80	1980/81	1981/82	1982/83
Chickpea	1244	1129	843	923	1015
	(73.3)	(72.8)	(67.3)	(68.6)	(69.8)
Khesari	184	163	165	177	177
	(10.8)	(10.5)	(13.2)	(13.2)	(12.2)
Lentil	106	86	73	74	78
	(6.3)	(5.6)	(5.8)	(5.5)	(5.3)
Mungbean	66	69	67	67	78
	(3.9)	(4.5)	(5.3)	(5.0)	(5.3)
Blackgram	49	64	68	67	71
	(2.9)	(4.1)	(5.4)	(5.0)	(4.9)
Others*	48	39	37	36	36
	(2.8)	(2.5)	(3.0)	(2.7)	(2.5)
Total	1697	1550	1253	1344	1455

* Include pigeonpea, cowpea, mothbean, and dry beans.

mungo), and Khesari (*Lathyrus sativus*) cover 28% of the remaining area. In addition, a number of other legumes are grown in Pakistan but on a small scale, their acreage being 2% of the total area. These are pigeonpea (*Cajanus cajan*) and moth bean (*Phaseolus*

acontifolius). The planted areas of legumes are influenced by changes in chickpea acreage. Drastic decreases in acreage of chickpea during 1980-83 compared to 1978/79, were due to severe damage by *Ascochyta rabiei* (Table 2). The chickpea acreage has been projected to cover 1112 thousand hectares by the year 1987/88 of the sixth 5-year plan.

The total production of food legumes during the last year of the fifth 5-year plan was 712 thousand tonnes, out of which chickpea alone has contributed about 70%.

The projected production during the sixth 5-year plan would be 795 thousand tonnes out of which 582 thousand tonnes would be contributed by chickpea, which accounts for 73% of the total food legume production of the country (Table 3).

Table 3. Existing and projected production of food legumes and other crops (x000 tonnes) in Pakistan.

Crops	Fifth 5-year plan (1978-83)	Sixth 5-year plan (1983-88)
Grain	17390	21795
Cash crops	33419	42068
Oilseed	2081	2853
Pulses	712	795
Chickpea	500	582
Others	212	213
Vegetables and spices	2712	5105

Source: Planning Commission, Government of Pakistan, October 1983; Statistics of Pakistan, July 1983.

Note: The figures in each plan period relate to the terminal year.

Yield of Food Legumes

The national yield of food legumes is very low and is declining in some cases Chickpea yields declined greatly during 1980-82, due to severe damage by ascochyta blight. The chickpea yield of 425 kg/ha obtained during the last year of the fifth plan period has been projected to reach 523 kg/ha in the last year of the sixth plan period (Table 4). The yield of other food legumes is projected to range from 381 to 504 kg/ha.

Table 4. Existing and projected yield (kg/ha) of food legumes and other crops in Pakistan.

Crop	Fifth 5-year plan (1978-83)	Sixth 5-year plan (1983-88)
Cereals		
wheat	1695	2116
rice	1695	2000
maize	1724	1687
sorghum	572	710
millets	487	550
Oilseeds		
groundnut	1208	1567
others	655	825
Pulses		
chickpea	425	523
others	381	504

Source: Crop Statistics of Pakistan, July 19[illegible], Planning Commission, Government of Pakistan, October 1983.

Note: Figures in each plan period relate to the terminal year.

Problems of Food Legumes

The major problems in food legume production are:

1. Diseases and pests: The main diseases of chickpea in Pakistan are ascochyta blight, wilt, and root-rot. Indigenous commercial cultivars were highly susceptible to blight during the epidemics in 1980-82 and resulted in a pulses shortage. Imports reached 1.71 million tonnes (Table 5) by 1982/83. Amongst the insects, the most damaging are the pod-borer (*Heliothis armigera*) and cutworms (*Agrotis* spp.).
2. Lack of yield stability and the inherent low-yielding capacity of the commercial cultivars grown.
3. Lack of improved production technology to meet the needs of various categories of farmers.
4. Continued allocation of marginal lands which has led to the erosion of genetic variability responsive to better management practices.
5. Lack of good seed production and procurement systems for quicker dissemination of improved seeds.
6. Lack of trained manpower and literature.

Table 5. Imports and exports of food legumes in Pakistan during the period 1973/74 to 1983/84.

Year	Production (x000 t)*	Per capita consumption (kg/annum)	Total imports**		Exports quantity (t)
			quantity (t)	value (x000 US$)	
1973/74	836	8.69	164	133	
1974/75	716	8.24	308	77	
1975/76	784	7.59	122	32	
1976/77	844	8.01	769	232	6043
1977/78	812	8.25	305	115	2555
1978/79	736	7.72	612	276	
1979/80	512	6.82	1995	603	
1980/81	525	4.02	1072	7576	
1981/82	481	5.98	96084	37869	
1982/83	712		170946	38103	
1983/84 (July-Sept)			13779	5360	

* Crop Statistics of Pakistan, July 1983.

** Pakistan Economics Survey (1981/82) and Ministry of Commerce, Government of Pakistan.

Note: Chickpea imports were 14 thousand tonnes costing US$ 743 million.

Achievements

Pulses research at federal level and in the provinces of Sind, NWFP, and Baluchistan was nonexistent till 1979/80. Some improvement work on chickpea was in progress in Punjab at Ayub Agricultural Research Institute, University of Agriculture, Faisalabad, and NIAB but the resources allocated were negligible. In 1980, the national cooperative research program, launched by PARC, commenced throughout the country, and NWFP and Sind established chickpea research stations at Karak and Dokri, respectively. This enabled recruitment of more chickpea researchers.

As a result of the aforesaid infrastructure the achievements made in chickpea research were as follows:

1. About 3000 strains/lines were screened during 1980-83 against ascochyta blight. About 60 lines showed various degrees of tolerance during 1981-83; the most promising lines of desi types were ICC-76, 607, 641, 1467, 2920, 7514, CGP 8503, 8519, NEC 138-2, CM-68, CM-72, C-44, and AUG-480. The kabuli types showing resistance included ILC-72, 183, 194, 195, 484, 201, 202, and PCH

128. During 1982/83 when the same germplasm was replanted to confirm the performance against blight, 43 lines were found tolerant up to podding.

2. Three chickpea cultivars, ILC-195, C-235, and C-44 were graded into three groups, bold and healthy, diseased and shrivelled, and control. All yield components gave maximum values in the graded and healthy seed group but interaction between varieties and grading did not show a significant difference for any yield component except 100-seed weight.
3. Reciprocal crosses (1000) were made between kabuli ILC-195 and locally adapted CM-72 varieties. There was only 50% setting of pods. Crosses have been planted at NARC during 1983/84.
4. Seed of tolerant lines, namely CM-72, CM-68, C-44, C-235, RC-32, AUG-480, NEC 138-2, and ILC-195 which showed good tolerance in various major chickpea-growing areas are under multiplication and have been given to farmers. CM-72 and C-44 have been released to farmers by two institutes in Punjab.
5. Laboratory tests have identified effective fungicides, namely Calixin-M, Benlate, Captan, and Tecto-60 as seed dressers, and Bravo as a foliar spray. Based on these findings the seeds distributed by government agencies, especially from research institutes, are sold dressed. Fungicides have also been supplied to seed depots for distribution to farmers in the major chickpea-growing areas. Further field testing is being carried out using various combinations of fungicides. Results will be used as one of the major components of the recommended production package.
6. Harvest index (HI) studies were carried out, the main objective being to select the most physiologically efficient cultivars i.e., with high HI, for further use in the breeding program. Cultivar ILC-195 has the highest HI of 27.65%. Correlation studies revealed significantly positive association of HI with economic yield.
7. The National Uniform Trials used nine promising cultivars contributed by pulse breeders in Pakistan. Trials were planted at 20 locations throughout the country. The performance of different cultivars at different locations is summarized as follows.

CM-72 ranked first a. NIAB producing about 1942 kg/ha, followed by C-141 which produced 1914 kg/ha.

At ARS and Bahawalpur, CM-72 ranked second i.e., at station and in farmers' fields producing 1936 and 910 kg/ha, respectively. E-1289 topped the list at ARS, and the local check (C-235) in farmers' fields.

At ARI, Sariab, cultivar NEC 138-2 produced the highest yield of 1016 kg/ha followed by CM-72 which produced 834 kg/ha.

Future Plans

They include the following:

1. Germplasm collection (local and exotic) and evaluation for various traits such as disease and insect resistance, yield, earliness, quality, HI, etc. will continue to be the major activities.
2. Selection of promising material during the first phase of the project, for use in hybridization programs to breed cultivars for disease resistance and short duration and development of high-yielding varieties for the southern part of the country, especially in the rice zone. Breeding of cultivars suitable for normal planting is another objective of the selection program.
3. Breeding for high HI values by increasing podding capacity.
4. Breeding for improved yield stability and adaptability.
5. Breeding for high yield using component analysis and selection of parents through combining ability.
6. On-farm testing of the improved lines: to be given special attention.
7. Strengthening the team of chickpea researchers.

Training

The following staff of the pulses program completed their training during the first phase of the project.

Name	Employed at	Duration	Training institute
M. Ashraf Zahid	NARC	6 months	ICARDA
Dr Sajjad H. Quershi	NARC	4 weeks	ICRISAT
Muhamed Bashir	NARC	2 years (MSc)	University of Faisalabad
Mr Bashir Ahmed Malik	NARC	3 years (M Phil)	Quiad-e-Azam University of Islamabad
Muhamed Yousaf	AARI	6 months	ICARDA
Muhamed Nazir Merchant	Dokri	6 months	ICRISAT
Hamid-ulla Jan	Karak	6 months	ICRISAT
Manzoor Ahmed	AARI	6 months	ICARDA

Publications Produced by the Pakistan National Program.

	Title	Journal	Volume/year
1	The collection of natural genetic variability of *Vigna* species in Punjab	Research and Development in Agriculture	Submitted
2	The collection of natural genetic variability in chickpea and lentil in Pakistan	Pakistan Journal of Agricultural Research	Accepted
3	Prospects of broad bean cultivation in Pakistan	FABIS Newsletter, ICARDA	6, 1983
4	Yield potential of improved lentil cultivars in Pakistan	LENS Newsletter, ICARDA	10(1), 1983
5	Harvest index in chickpea	Pakistan Journal of Agricultural Research	2(4), 1981
6	Floral biology and yield in chickpea	Pakistan Journal of Agricultural Research	3(1), 1982
7	Efficacy of herbicides in chickpea	International Chickpea Newsletter	6, 14, 1982
8	Relative reaction of some chickpea desi germplasm lines to ascochyta blight in Pakistan and Syria	International Chickpea Newsletter	8, 1983
9	Efficacy of Calixin M and other fungicides against ascochyta blight in chickpea	International Chickpea Newsletter	8, 1983
10	Effect of fungicidal seed treatment on germination, eradication of *Ascochyta rabiei* of diseased chickpea seed in blotter test	Pakistan Journal of Agricultural Research	Accepted, 1983
11	Genetic variability in mungbean	Pakistan Journal of Agricultural Research	Accepted, 1983

12	Identification of physiologically efficient genotypes of mungbean	Pakistan Journal of Agricultural Research	Submitted
13	Genetic variability and correlation studies in cowpea	Tropical Grain Legume Bulletin	Submitted
14	Documentation, characterization and preliminary evaluation of lentil germplasm	Pakistan Journal of Botany	Submitted
15	Grain legume status in agriculture	Progressive Farming PARC	3(1)
16	Current agronomic techniques in chickpea	Progressive Farming PARC	23-26, 1983

17 General Recommendation Bulletins (Urdu)
A) Chickpea cultivation
B) Lentil cultivation
C) Mung cultivation
D) Mash cultivation

Chickpea Cultivation in Sind, Pakistan

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Introduction

Pulses are important mainly due to their high protein content which varies from 20 to 26% (excluding groundnut and soybean). Due to the high prices of proteins from animal sources, pulses are a practical and cheap source of protein, hence they are quite rightly called poor man's meat.

The main pulses grown in Sind are:

1. *Rabi* pulses: a. chickpea (*Cicer arietinum*)
   b. khesari (*Lathyrus sativus*)
   c. lentil (*Lens culinaris*)
2. *Kharif* pulses: a. moong (*Vigna radiata*)
   b. mash (*Vigna mungo*)
   c. anhar (*Cajanus cajan*)

Area, Production, and Problems

Data on the area, production, and average yield of different pulses in the last 5 years are given in Tables 1, 2, 3, and 4.

As seen in Tables 1-4, chickpea has the greatest acreage and production of pulses in Sind.

Chickpea is popular due to its multipurpose uses: culinary dishes of high palatability, confectionary, and animal feed. It also increases the nitrogen status of soil by the activity of nodular bacteria. Further, among

Table 1. Area grown to pulses in Sind Province, Pakistan, during 1978-83.

	Area in '000' acres				
Crop	1978/79	1979/80	1980/81	1981/82	1982/83
Rabi pulses					
chickpea	405.8	350.9	314.7	324.9	303.9
khesari	322.3	300.0	292.0	308.4	311.0
lentil	35.9	37.5	30.4	44.1	45.6
other *rabi* pulses	36.0	24.2	16.9	17.3	17.1
Kharif pulses					
moong	28.9	27.1	27.3	31.3	34.9
mash	3.8	4.2	4.8	5.1	5.3
other *kharif* pulses	23.6	21.2	20.2	20.5	19.6
TOTAL	856.3	765.1	707.3	751.8	737.4

Table 2. Production of pulses in Sind Province, Pakistan, during 1978-83.

	Production in '000' tonnes				
Crop	1978/79	1979/80	1980/81	1981/82	1982/83
Rabi pulses					
chickpea	114.8	99.2	88.7	106.2	99.8
khesari	59.4	55.5	53.1	55.9	56.9
lentil	6.5	6.8	5.4	9.8	8.3
other *rabi* pulses	5.5	3.6	2.6	2.7	2.6
Kharif pulses					
moong	5.0	4.6	4.8	5.4	6.1
mash	0.6	0.7	0.8	0.8	0.9
other *kharif* pulses	4.7	4.5	4.4	4.2	4.1
TOTAL	196.5	174.9	159.8	185.0	178.7

the pulses, chickpea has a unique property; as described in the literature it has medicinal value against many ailments. Its acidic secretion, in the form of oxalic, malic, and acetic acids from the glandular part of the leaf and pods, is collected before sunrise by placing a cloth on plants during the night. Collected acids are used as medicine for colic and to repel insects. Chickpea is also reported to reduce cholesterol accumulation in the blood.

Table 3. Average yield of pulses in Sind Province, Pakistan, for 1978-83.

Crop	Yield (kg/ha)				
	1978/79	1979/80	1980/81	1981/82	1982/83
Rabi pulses					
chickpea	7.5	7.5	7.5	8.7	8.8
khesari	4.9	4.9	4.9	4.8	4.9
lentil	4.8	4.8	4.8	4.8	5.0
other *rabi* pulses	4.1	4.0	4.0	4.0	4.1
Kharif pulses					
moong	4.6	4.6	4.7	4.6	4.7
mash	4.3	4.3	4.4	4.3	4.4
other *kharif* pulses	5.3	9.0	8.0	9.0	9.1

Table 4. Area and production of pulses in Sind districts during 1982/83 (area in '000' acres, production in '000' tonnes).

Division/ district	*Rabi* pulses		*Kharif* pulses		Total	
	Area	Production	Area	Production	Area	Production
Sukkur Division	567.3	145.9	8.3	1.5	575.6	147.4
Khairpur	13.2	2.9	3.0	0.5	16.2	3.4
Jacobabad	250.7	63.9	0.1	0.01	250.8	63.6
Sukkur	76.9	23.8	1.1	0.2	78.8	24.0
Shikarpur	121.0	32.8	Nil	Nil	121.0	32.8
Nawabshah	10.2	2.7	4.1	0.8	14.3	3.5
Larkana	95.3	20.1	Nil	Nil	95.3	20.1
Hyderabad Division	110.6	21.6	49.7	9.2	160.3	30.8
Sanghar	7.5	1.5	5.2	1.3	12.7	2.8
Tharparkar	9.2	1.7	31.8	5.5	41.0	7.2
Dadu	38.4	7.4	0.2	0.03	38.6	7.4
Hyderabad	19.6	4.4	3.4	0.7	23.2	5.1
Badin	13.2	2.7	5.3	1.1	18.5	3.8
Thatta	22.7	3.9	3.8	0.6	26.5	4.5
Karachi Division	0.3	0.04	1.9	0.3	2.2	0.34
Karachi	0.3	0.04	1.9	0.3	2.2	0.34

Chickpeas have a comparatively high lysine content (one of the important essential amino acids). Thus they contribute to a balanced diet, with cereals which are rich in methionine but poor in lysine. Chickpea is reported to be relatively rich in lecithin. In spite of their usefulness, chickpeas, along with other pulses, remained neglected due to the emphasis on rice, wheat, and maize research. The more productive areas were allocated to wheat, and chickpea cultivation was pushed to marginal land.

In Sind Province there are some special features of chickpea cultivation which are not common to other places within Pakistan or in other countries. The crop is cultivated on the residual moisture of paddy hence the bulk of cultivation is without fertilizer application. There are many other reasons for low yields in Sind, topmost being the lack of high-yielding cultivars. At present, cultivation of chickpeas is restricted to three varieties, Chhola (*kabuli* type), Sanyasi, and C-612 (*desi* types). Chhola is used for chhola dishes, C-612 is preferred for dall, and Sanyasi for roasting and parching. The average farmer is unaware of the importance of using good-quality seed, plant protection measures against pod-borer, and weeding.

Like rice and wheat, the climatic zones must be studied for different varieties and this has just started in the pulses research section at the Rice Research Institute, Dokri. Trials are conducted at the Institute stations and on farmers' land in different districts of upper Sind. One major practical handicap is sowing time. Because of late-maturing rice varieties, land is ready for planting chickpeas at a very late date, and in a few low-lying areas it is delayed to the third week of December. Thereby planting is late and the growing period is shortened. In such cases yields are reduced, with low-quality seed which is small, underdeveloped, and shrivelled. If planting is done in high-moisture content soil, it results in patchy stands due to wilt at the seedling stage. Ascochyta blight has neither been reported nor observed. However, the wilt complex is a common occurrence which may be due to:

1. Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceri*).
2. Collar rot (*Sclerotium rolfsii*).
3. Root rot (*Rhizoctonia solani*).
4. Dry root rot (*Rhizoctonia bataticola*).
5. Iron chlorosis.
6. Phyllody (Mycoplasma).
7. Stunt (pea leaf-roll virus).

At present, there are no resistant lines for these diseases. In this context the disease pressure is kept low by:

1. clean cultivation i.e., diseased plants are eradicated and destroyed,
2. use of disease-free seed,
3. seed treatment with Vitavax and Benlate.

To identify varieties resistant to the wilt complex, a wilt-sick plot has been developed this year.

One of the factors limiting yield is poor land preparation. In most cases, the seed is broadcast in standing *kharif* crop of paddy rice a few days before harvest. This operation is done with zero or minimum tillage which results in poor germination, less vigorous plants, patchy stands, and weeds. This indirectly results in low yield. Farmers are therefore persuaded to adopt the technology package available.

The constraints facing chickpea production can be summarized as follows:

1. Unavailability of high-yielding varieties.
2. Lack of emphasis on plant protection.
3. Poor supply of fertilizer.
4. Lack of weeding.
5. Short maturation period due to late planting.
6. Poor methods of land preparation and planting.
7. Damage by the insect pest *Bruchus* sp.
8. Inadequate extension and research backstopping.
9. Absence of subsidy price as in other crops e.g. wheat, rice etc.

Research Work Conducted at RRI, Dokri

The importance of pulses led the Government of Sind to start a scheme for research. The main emphasis is on chickpeas and improvement work is being conducted at the main station at the Rice Research Institute, Dokri, and the substation at the Agricultural Research Institute, Tandojam. In Sind there are three released varieties of chickpea, Chhola, Sanyasi, and C-612. These cultivars provide nucleus material for further research.

The research is concentrated on varietal trials to select from the material introduced from international centers like ICRISAT and ICARDA and through the PARC local landrace collection. In designing trials some locally important aspects are also kept in view. Some of these are elaborated below.

1. Selection of promising lines for characters like maturity, to fit the cropping pattern with paddy rice rotation on residual moisture, after the harvest of late-maturing rice varieties.
2. Under Sind conditions there is no ascochyta blight but there is wilt, so seed is dressed and trials are underway to evolve resistant varieties. Wilt-sick plots have been established this year for selecting resistant varieties.
3. Due to late chickpea planting (caused by late-maturing rice varieties) susceptibility to pod-borer is considered when selecting varieties.

Pod-borer incidence has a marked association with planting time.

4. Sowing time must be optimum.
5. Land preparation by the average farmer, following a paddy rice crop, is zero, so planting is recommended after thorough preparatory tillage.

In Sind, thousands of acres are cultivated with chickpea crop on residual moisture in areas where the Indus river overflows and the receding water deposits silt. On this residual moisture chickpea is planted in early October to produce hand clipped tender shoots (i.e., leaves and twigs) in the seedling stage before flowering. In this type of cultivation the insect *Agrotis* spp. (Dhora) cuts the plant just above the soil surface, therefore control measures must be identified.

In order to disseminate the improved technology to farmers, microplot and zonal trials are being conducted on farmers' land under different agroclimatic conditions in Sind Province. Planting of microplot trials was initiated in 1982/83.

Progress and Future Plans

1. **Breeding:** Research to develop high-yielding varieties is in different stages of progress. A few lines have been identified with the desired attributes, such as high yield and short time to maturity, suited to planting time on residual moisture following harvesting of late rice varieties.
2. **Plant protection:** As a plant protection measure, trials are being conducted to screen lines for resistance to pod-borer and these lines are being included in varietal trials, both at the main station and on farmers' land. Spraying is also done with Thiodan at the rate of 1 l/acre, (one or two sprays) and this is recommended to farmers.
3. **Fertilizer application:** Being a nonirrigated crop, the average farmer does not apply fertilizer. However, from the experiments conducted at the Rice Research Institute, Dokri, 30 kg N and 60 kg P_2O_5/ha is recommended.
4. **Weed control:** Chickpea is ordinarily a weak competitor of weeds, so if weeding is not practiced, yields and seed quality are adversely affected. Moreover, broadcasting is commonly used for planting which worsens the situation. To overcome this, emphasis is placed on timely weeding and row planting.
5. **Land preparation and planting:** Chickpea planting is done in the standing crop of paddy rice which generally results in poor and patchy germination, with nonvigorous plants. Using modern methods, land should be plowed and clods crushed. Row planting is advocated.

Maturity: Because of late-maturing rice varieties land is prepared very late, and where an area is low lying, it may come into condition as late as mid-December. Because of this reduced growing period yield is affected. At the Rice Research Institute, research is underway to develop genotypes adapted to the shortened growing period. A few lines have been selected, and their performance needs to be confirmed by planting on farmers' land.

Nonavailability of technical literature and a dirth of technical personnel and experts: Compared to the technical literature on wheat, rice, maize, soyabean, and cotton, the literature on pulses is small. Technical personnel and experts are few. Serious consideration should be given to these shortcomings.

Damage in storage: Seed in stores is damaged by grain pests, temperature, moisture, and lack of aeration. Research is needed to tackle entomological aspects as well as other storage problems.

Pricing: Because of fluctuations in prices some farmers show reluctance to cultivate chickpea, so support prices form an essential incentive. An organized agency should be established like Sind Agriculture Seed Supply Organization for purchasing chickpea seed at a reasonable price. Premium should be given to the meritorious farmers.

Good seed: In order to have a continuous supply of better seed, a regular channel should be instituted for seed certification. This seed should be procured at premium price. Pure seed multiplication should be a regular feature, and a special campaign should be carried out for maximizing pulse production.

Seed quality: The study of technological aspects of chickpea should include laboratory research on seed quality such as protein, P.E.R., biological value, culinary aspects, and research on pre- and postharvest losses.

Chickpea Production in the Punjab

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Pakistan's population is increasing at the rate of 3% per annum and is expected to increase from 92 million in 1983 to 154 million in 2000. To meet present requirements for pulses, which are an important dietary constituent as they are rich in protein, production must increase by 3% annually. To increase the per capita availability of pulses, an additional production increase is needed to balance the daily diet.

Chickpea and lentil crops sown in winter, and mung and mash crops sown in both spring and summer are the major pulse crops grown in Pakistan. Of all the pulses, chickpea is the most important food legume crop, accounting for about 80% of the total area under pulses. The productivity of chickpea determines the availability of pulses. In 1983/84, the area under chickpea was 932000 ha with a total yield of 522000 tonnes (Directorate of Crop Reporting Service, 1983). The Punjab province contributes about 75% of the total area under chickpea and about 80% of the crop is grown under rainfed conditions on sandy and sandy-loam soils in northwestern parts of the province. The major chickpea-growing districts are Bhakkar, Khushab, Mianwali, Layyah, and Jhang.

The chickpea acreage in irrigated areas has decreased from 202000 ha in 1970/71 to 78000 ha during 1982/83 (Fig. 1), which is a drop from 31% to 11% of the total area under chickpea. This reduction has been due to water-logging and salinity, the introduction of high-yielding, semi-dwarf varieties of wheat, and increased use of fertilizer, farm machinery, and irrigation water by installation of tubewells. Another reason for the drop in chickpea acreage is its failure to compete with other winter season crops.

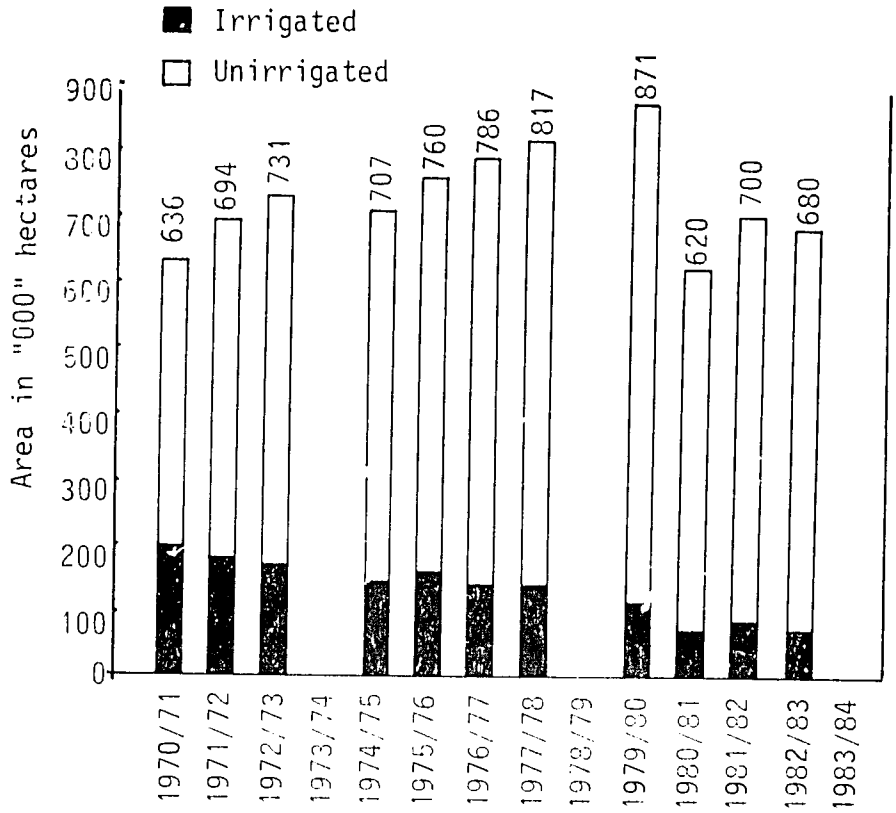

Fig. 1. Distribution of chickpea under irrigated and unirrigated conditions in Punjab.

Chickpea yields are generally low and vary considerably depending on prevailing weather conditions during crop growth.

This paper reviews the major constraints on chickpea yield in Punjab and the production technology developed and future strategies for increased pulse production are suggested.

Constraints to Chickpea Yield

Diseases

Blight and wilt are the two most important diseases of chickpea. In rainfed areas where most of the crop is grown, chickpea blight, caused by *Ascochyta rabiei*, is the major factor lowering yields. In Pakistan, serious losses due to blight were first recorded in 1911

(Butler, 1918). Research studies on blight and breeding of blight-resistant chickpea varieties were started at Rawalpindi, a high rainfall area of northern Punjab, in the early thirties. This research was transferred to Campbellpur (now Attock) in 1933. An independent section for research on pulse crops was established in 1970. Research on pulses is also being done by other government organizations such as the Nuclear Institute for Agriculture and Biology, the University of Agriculture, Faisalabad, and the Pakistan Agricultural Research Council, Islamabad.

Chickpea blight is transmitted through infected seed and blighted plant debris lying in the field. When humid conditions persist for long periods, the disease becomes epidemic and causes severe damage to the crop. The epidemics in 1978-82 caused severe losses estimated to be worth US$ 90 million. The yield per unit area is a better indicator of crop condition at harvest than total production which is influenced by changes in the cropped area (Table 1).

Table 1. Impact of blight incidence in Thal on the provincial yields/hectare.

Years	Blight observations	Yield (kg/ha)
1978/79	Severe blight in 1/3 cropped area	427
1979/80	Severe blight epidemic throughout chickpea-growing areas	245
1980/81	30-50% crop infected due to blight	374
1981/82	Severe blight epidemic throughout chickpea-growing areas	231
1982/83	No blight report	520
1983/84	No blight report	535

The occurrence of blight epidemics in the chickpea-growing areas of Thal directly influenced provincial yields (Table 1). Prior to 1978/79, when disease epidemics were recorded in Attock area only, the provincial yields were mostly around 500 kg/ha. During this period, mild blight infections were observed in the major chickpea-growing areas of Thal but this area was not hit by severe epidemics. This is supported by the study of climatic data which

show that the major chickpea-producing area received higher rainfall and, therefore, conditions were conducive to blight spread.

Nevertheless, higher rainfall can help to produce higher and more stable yields, provided more resistant chickpea varieties are developed regularly. The technique adapted at Campbellpur to score chickpea varieties resistant to blight uses blighted plant debris and another technique has been developed to ensure uniform infection. Infected plant debris is spread or a culture of blight, prepared in the laboratory, is sprayed 3-4 times on the material in the field. Humid conditions are provided by spraying the crop with water to ensure disease spread. The progress made in developing resistant varieties, as indicated by the release of varieties, is shown in Table 2.

Table 2. Release of blight resistant chickpea varieties in the Punjab

Serial No.	Varieties	Year of release
1	F_8	1939
2	C12/34	1942
3	C 612	1952
4	C 44	1983
6	CM 72	1983

The varieties C 44 and CM 72 performed better than the other varieties under both disease and disease-free conditions and C 44 had higher yields than CM 72 in both blight epidemic and blight-free areas (Table 3).

Table 3. Performance of C 44 and C 727 (check) under blight and blight-free conditions in 1981/82.

Serial No.	Location	No. of trials	Yield (kg/ha)	
			C 44	C 727
1	Thal (blight epidemic areas)	17	488	183
2	Faisalabad, Bhawal-nagar, and Bhakkar (blight free areas)	15	1782	1208

Recently, efforts have been made to screen exotic genotypes showing resistance/tolerance to blight. The genotypes ILC 72, ILC 76, ILC 195, ILC 200, ILC 201, ILC 202, ILC 2956, ILC 3279, ILC 4421, ILC 634, and ILC 6306 had good resistance to blight.

The results of preliminary studies on chemical control of blight are also encouraging. The fungicides Tilt and Daconil were effective in checking the disease by affecting spore germination. It was concluded that periodic spraying is required to control the disease by reducing the inoculum level. Blight control by periodic spraying is not feasible for general production, but it can be used to produce disease-free seed.

Wilt, predominantly caused by *Fusarium* spp., and root rot also reduce chickpea yields. The problem is more severe with individual farmers in specific fields. Chickpea variety C 727 has good tolerance to wilt and varieties C 44 and CM 72 also carry reasonable resistance. The local and exotic genotypes were also screened on sick beds and genotypes ICC 1973, GL 769, PG 114, ICC 4935, ILC 6067, E 1685, GG 688, C 235, No. 818, No. 364, and 79037 were marked as resistant/tolerant to the disease.

ICARDA and ICRISAT have comprehensive programs to screen materials resistant/tolerant to blight and wilt, respectively. Varieties more resistant to blight and wilt will be developed in the near future by various breeding programs using the resistant sources supplied by these international organizations. Previously, it was thought impossible to combine resistance to both wilt and blight in one genotype, but now there are genotypes which possess reliable resistance to both diseases.

Insect Pests

Pod borer (*Heliothis armigera*) is a serious pest of chickpea. In fields with severe infestation, it may cause over 50% loss in yield. It can be controlled with insecticides and we have successfully used Sevin dust or Sumiciden spray . Decis Hostathion, Azodrin, and Nuvacron have also been reported to effectively control pod borer.

Weeds

As well as diseases and insect pests, weeds also reduce chickpea yields by competing with the crop for food, water, and light. Important weeds are "Piazi" or "Bhugat" (*Asphodelus*

tenuifolius), "Pohli" (*Carthemus oxyacantha*), "Pathu" (*Chenopodium album*), "Lehli" (*Canvalvulus arvensis*), and a graminaceous weed locally known as "Chori" or "Bodla" (*Lolium* spp.)

Because of the importance of weeds, weed control experiments were conducted at Kallurkot and Faisalabad (Table 4).

Table 4. Effects of hand weeding and herbicides on chickpea yield.

Serial No.	Treatment	Yield (kg/ha)			Average yield (kg/ha)	Increase over check (%)
		Sites*				
		1	1	2		
1	Weedy check	363	792	1159	771	0
2	Weed free by repeated hand weeding	915	1778	1680	1458	89
3	Hand weeding twice (30-40 DAE and 70-80 DAE)	567	1638	1822	1342	74
4	Maloran @ 2.5 kg/ha	831	1229	1919	1326	72
5	Tribunil @ 3.0 kg/ha	519	1313	1757	1196	55
6	Igran @ 3.0 kg/ha	884	1847	1570	1434	86

* 1 = Kallurkot, 2 = Faisalabad.

In irrigated areas, weeds can be effectively controlled with pre-emergence application of herbicides or by hand weeding. Herbicides do not control weeds on sandy soils under rainfed conditions, where most of the chickpea crop is grown, because they need a moist soil surface to be effective.

Production Technology

Fertilizer

Fertilizer is an important input and its use has helped to increase chickpea yields. The conclusions of studies on chickpea fertilizer requirements, conducted by the Directorate of Soil Fertility during 1982/83, are outlined below.

The average of 45 trials in irrigated areas and 22 in Barani area showed that:

(1) there was a significant response to N,P, NP, and NPK over the control,
(2) the response to NP compared to N and P separately was significant,
(3) the response to K was nil, and to N_{25} P_{49}, N_{49}, P_{49} and N_{25} P_{49} K_{49} kg/ha was statistically non-significant, and
(4) the irrigated crop yielded four times more than barani crop in fertilized treatments.

Time of Planting

Date of planting and stand establishment are the most important factors determining chickpea yield, especially in the rainfed areas. The chickpea-producing areas are divided into three zones determined by planting date, which in turn depends on the ecological conditions and availability of soil moisture producing maximum yields (Table 5).

Table 5. Dates of planting in different chickpea-producing zones.

Serial No.	Zones	Date of planting
1	Northern and north eastern districts (Sialkot, Gujrat, Jhelum, Rawalpindi, and Attock)	Mid-September to mid-October
2	Thal (Bhakkar, Khushab, Mianwali, Layyah, and Jhang).	October
3	Southern and central districts (Faisal-abad, Sahiwal, Multan, Bahawalnagar, and Bahawalpur)	Mid-October to November

Seeding Rates

Poor crop stand is one cause of low yields. Clean and healthy seed at a rate of 50-60 kg/ha is recommended. In bold grain variety C 44, a seed rate of 60 kg/ha has produced the optimum plant stand required for good yields.

Planting Space

Planting geometry is important and is different for diverse genotypes under different conditions. Row spacings of 10-15 cms are optimum for high yields of recommended varieties, planted with recommended agronomic practices.

Irrigation

Most of the chickpea crop is planted under rainfed conditions. In irrigated areas, the irrigation requirements are minimum. About 100 mm of rainfall or irrigation are needed for crop establishment, while at flowering, only one irrigation or rainfall results in a good harvest.

Lopping/Grazing

In fields with high soil fertility and moisture supply, excessive vegetative growth occurs at the expense of fruiting. In such a situation, lopping/grazing before flowering checks the growth of primary branches and enhances the growth of secondary branches which bear pods (Ali and Khan 1976).

Future Strategies

(1) Chickpea yields are generally low because improved production technology is not being used. Farmers should be motivated to adopt the technology developed by research organizations. Demonstration is the best means of disseminating new technology and a campaign for cultivation of pulse crops is needed to demonstrate production technology as it is being practiced in major crops like wheat, cotton, and rice.

(2) Clean and healthy seed of approved varieties with higher yield potential and disease resistance should be supplied to farmers. Besides germination and purity, seed health should also be tested because infected seed is the main source of blight inoculum and even a small quantity of infected seed can cause a severe epidemic in favorable conditions.

(3) Research on testing the efficiency of different *Rhizobium* strains and plant genotypes should be taken up to increase nitrogen fixation.

(4) Since the chickpea crop in Thal is sown in a single run, fertilizer application should be encouraged.

Research achievements are, in general, proportional to the investment made in research. The progress made in the development of high-yielding varieties and production technology in crops like wheat, rice, and maize is the result of heavy investments by developed countries, international research organizations, and Pakistan itself. The international organizations, ICRISAT and ICARDA, are conducting research on pulse crops and providing short-term training facilities to other researchers working on pulses. The material and technology developed by these organizations and elsewhere is being utilized for chickpea development. More investment in research on all pulse crops, as well as training of technical manpower conducting research on pulses, are needed to increase pulse production.

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Chickpea Diseases

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Chickpea (*Cicer arietinum* L.) is a major food legume crop grown in India and Pakistan, West Asia, North Africa, parts of Europe, USSR, and the Americas. Diseases are one of the major problems affecting production and stability. Knowledge of the various diseases affecting chickpea and their control helps to reduce losses and increase production. More than 50 diseases are known to infect chickpeas (Nene 1980), and a brief account of the major problems is given below.

Fungal Diseases

Wilt

This is a soil-borne vascular disease caused by *Fusarium oxysporum* f.sp. *ciceri*. The disease is a problem in Bangladesh, Burma, Ethiopia, India, Malawi, Mexico, Pakistan, Peru, Sudan, USA, and Tunisia. Plants are susceptible during all stages of growth, and characteristic symptoms are sudden wilting of the plants (partial or complete) while remaining green, drooping of the leaves and buds, and blackening of the xylem. Roots of freshly wilted plants remain normal. The disease becomes a problem when chickpea is grown every year in the same field. Initially it appears in isolated patches and gradually spreads through the entire field. The fungus survives in residual stubble for over 3 years and also spreads through seeds.

Control measures recommended include crop rotations and growing of resistant varieties. Screening of the germplasm and breeding

material is done using 'sickplots'. Resistance sources and varieties are known, and work on developing resistant and high-yielding varieties is in progress at ICRISAT, India (Nene *et al.* 1978). Seed treatment with a mixture of benomyl and thiram prevents the spread of disease through seed.

Root-rots

Different fungi cause root-rot in chickpea, which can be diagnosed to some extent by the type of symptoms they cause. Depending upon the soil and climatic conditions, different root-rots appear during different periods. Some of the important root-rot diseases are:

(1) Dry root-rot; caused by *Rhizoctonia bataticola*, is reported from Australia, Ethiopia, India, Iran, and USA. The problem develops when ambient day temperatures are around 30°C. Affected plants dry suddenly and the root system shows extensive rotting with most of the finer roots gone. The affected root is brittle and easily shed. Minute sclerotia can be seen on and inside the root. The disease can occur in the seedling and flowering stages.
(2) *Fusarium* root-rot; a dark lesion develops at the portion where cotyledons are attached, and finer roots show necrosis. Affected plants are stunted and chlorotic.
(3) Foot-rot; caused by *Operculella padwickii*, the external symptoms are like wilt but plants show rotting at the collar region and below.

Collar rots, stem rots, and stem blights

(1) Collar rot; caused by *Sclerotium rolfsii*, is most common during the seedling stage when soil moisture is high. Affected plants turn yellowish and show rotting of the stem at the collar region. The disease is usually associated with the presence of white mycelial strands and rape seed-like sclerotia.
(2) Rhizoctonia collar rot/damping off; caused by *Rhizoctonia solani*, the disease is more common in the early stages of crop growth when soil moisture is relatively high, but can also occur in the advanced stages. Affected plants gradually turn yellow and a distinct dark brown lesion can be seen at soil level extending to the root and stems. Damping off and drying of the seedlings occur.

(3) Stem rot; caused by *Sclerotinia sclerotiorum*, the disease appears in both the seedling and adult stages when the crop has attained good canopy, which keeps the soil moist. Individual branches or whole plants are affected and show drying above the lesion, which is usually associated with web-like mycelial growth and large irregular sclerotia.

(4) Stem blight; caused by *Colletotrichum capsici*, the disease develops in warm and humid weather. Dark brown, elongated lesions, often encircling the stems, develop all over the plant causing blighting. Leaflets also develop spots with dark brown margins and grey centers. Aceruuli, the fruiting bodies of the fungus, can be observed on the lesions.

No efficient control measures are available for root and stem-rot diseases. Agronomic and cultural practices can help in reducing the incidence. Efforts to identify sources of resistance and to incorporate them into high-yielding cultivars are under way at ICRISAT, India.

Leaf Diseases

Botrytis grey mold; caused by *Botrytis cinerea*, it appears in the adult stage when conditions are cool and humid and causes severe losses in India in certain years. Chlorotic lesions develop on the leaves, stems, and flowers causing blighting. The disease is seed-borne. Affected portions show the characteristic conidiophores of the fungus. Fungicide sprays can help to minimize plant losses but there is a need to identify sources of resistance and develop resistant varieties.

Rust; caused by *Uromyces ciceris-arietini*, it usually infects in the later stages of crop growth at podding time, and humid and cool conditions favor its development. Numerous brown pustules develop on the leaves causing defoliation. There is a need to develop rust-resistant cultivars.

Powdery mildew; caused by *Laviellula taurica* (*Oidiopsis taurica*). This disease is at present a minor problem and is favored by dry weather. Powdery growth can be seen on affected leaves.

Ascochyta blight; caused by *Ascochyta rabiei*. This usually becomes severe during the flowering and podding stages. The disease is favored by cool and humid weather (15-25°C and >150 mm rainfall). It causes extensive losses in epiphytotic years and spreads over

large areas in short periods, under favorable conditions. The disease symptoms appear on all foliar parts; on leaves and pods the spots are circular with the dark pycnidia arranged in concentric rings. On the stems, lesions are elongated and often cause girdling. The entire foliage can be blighted resulting in death of the plants. The pathogen is seed-borne and the best way of controlling it appears to be through the use of resistant varieties. Other methods include seed treatment with thiabendazole, which eradicates the seed-borne inoculum, and foliar application of chlorothalonil (Bravo) at 10-15 day intervals.

Viral Diseases

Several viruses are known to infect chickpea (alfalfa mosaic, bean yellow mosaic, cucumber mosaic, lettuce necrotic yellows, pea leaf roll, pea evation mosaic, and phyllody). Of these, pea leaf roll, phyllody, and bean yellow mosaic viruses are most common.

(1) Pea leaf roll virus: attacks 1-month old seedlings and subsequent stages. The disease is prevalent in most countries growing chickpeas. Infected plants are stunted, orange, brown, or yellow in color, depending on the cultivars, and leaflets become small and leathery. The most characteristic symptom is phloem discoloration. The disease is transmitted by aphids to chickpeas and several other legumes. Development of resistant cultivars is feasible.
(2) Phyllody: caused by mycoplasma of sasmum phyllody, it becomes more pronounced during flowering. Infected plants become bushy due to extensive proliferation and the flowers become phylloid. Partial infection of the plant is also common. The virus is transmitted by leaf hopper (*Orosius albicintus*) and is not very important at present.
(3) Bean yellow mosaic virus; young leaves of infected plants develop into shoe-string like structures and affected plants are stunted.

Nematodes

(1) Root-knot; caused by *Meloidogyne* sp., it is more common in loose soils. It appears in patches, and affected plants are chlorotic and stunted while the roots show blackening and knotting. Proper crop rotations can reduce infestations.

(2) Cyst nematode; *Heterodera* sp., occurs in patches, affected plants are stunted and chlorotic, and in severe cases yield nothing. Roots show heavy necrosis with white or brown cysts (female nematodes) and affected plants nodulate poorly.
(3) Lesion nematode; *Pratylenclus* sp. Infected plants show heavy necrosis of the root system, plants are stunted and have poor or no nodulation.

Parasitic Weeds

Orobanche sp. and *Cuscuta* sp. are known to infest the crop in some cases.

Non Infectious Problems

Frost injury, iron-chlorosis, and salt damage can be confused with some of the diseases mentioned above. Frost symptoms are seen on leaves, stems, and pods as irregular white necrotic lesions. In the frost-affected pods, seeds do not develop and they become black. In severe cases the plants are completely killed.

In cases of iron-chlorosis, the young leaves show symptoms of chlorosis and in severe cases necrosis includes the bud. Symptoms are common in the seedling stage when there is more moisture.

Salt damage occurs in patches especially in low-lying areas and results in stunting of plants, reddening of lower leaves, and sometimes death. In this case the xylem can also show reddening.

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Ascochyta Blight of Chickpea

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Introduction

Chickpea (*Cicer arietinum* L.) is an important food legume crop of dryland agriculture throughout West Asia, around the Mediterranean sea, and in parts of East Africa and Latin America. The total cultivated area in the world is about 10.4 million hectares with an annual production of about 6.8 million tonnes of grain (FAO 1978). Ascochyta blight is one of the major factors limiting chickpea production in West Asia and countries around the Mediterranean sea.

Causal Organism of Ascochyta Blight

The disease was first observed in the North West Frontier Province of British India, now in Pakistan, by Butler in 1918. The taxonomy of the fungus causing blight is uncertain and it has been called *Ascochyta rabiei*, *Phyllosticta rabiei*, and *Phoma rabiei*. *A. rabiei* is the most common and widely accepted name for the fungus containing some bicelled spores (2-4%), while *P. rabiei* has single-celled spores.

Since *Phoma* spp. can also have bicelled spores (up to 5%) it is suggested that it be called *Phoma rabiei*. The author has seen, in some samples of blight, bicelled spores to the exent of 20%. The sexual stage of *A. rabiei* is found in *Mycosphaerella rabiei* Kovachevski.

Geographical Distribution of Ascochyta Blight

The disease has been reported from the following 25 countries: Algeria, Australia, Bangladesh, Bulgaria, Canada, Cyprus, Ethiopia, France, Greece, India, Iran, Iraq, Italy, Jordan, Lebanon, Mexico, Morocco, Pakistan, Romania, Spain, Syria, Tanzania, Tunisia, Turkey, and USSR (Nene 1980). The disease is more frequently observed in Algeria, Bulgaria, Cyprus, Greece, India, Iraq, Jordan, Lebanon, Morocco, Pakistan, Romania, Spain, Syria, Tunisia, Turkey, and USSR (Nene 1982).

Yield Losses due to Ascochyta Blight

The disease has caused serious crop losses in several countries in the past and continues to take its toll. Labrousse (1930) reported ascochyta blight to be very destructive in Morocco in 1929. Sattar (1933) reported an annual loss of 25-50% of the crop since 1922 in what is now Pakistan. During the past three seasons (1979-1981) the disease caused about 70% loss in Pakistan (Malik, personal communication). According to Kovachevski (1936), 20-50% of the crop was lost annually in Bulgaria, with occasionally total loss in some fields. In the Dhepropetrovk region of USSR, blight was severe in 1956, sometimes causing 100% loss (Nemlienko and Lukashevich 1957). In Greece, 10-20% damage was reported during 1957/58 (Demetriades *et al.* 1959). According to Puerto Romero (1964) the disease caused great losses of chickpea wherever it was grown in Spain. In northern parts of India, yield losses of about one million tonnes were suspected due to the outbreak of blight during the 1981/82 season. Due to blight, damage of 30% was estimated during 1982 in northern Syria and chickpea production in Morocco during the 1976-78 seasons was reduced.

Symptoms of Ascochyta Blight

The disease affects all parts of the plant. In the field, the disease usually appears around preflowering to flowering in small circular patches which rapidly increase under favorable weather conditions. The seedlings from infected seeds show dark brown lesions near the collar region and sometimes show damping off symptoms. Initially, small, round, white necrotic specks appear

on newly-formed leaves of susceptible cultivars. Under favorable conditions the lesions expand rapidly and coalesce causing blighting of the buds. The necrosis progresses downwards, completely killing the plants (M.V. Reddy, ICARDA, Aleppo, Syria, unpublished work). In older leaflets the lesions are round or elongated with gray centers and brownish margins. The pycnidia appear as dark dots arranged in concentric rings or dispersed irregularly. On green pods, lesions are usually circular with dark margins and the pycnidia are arranged in concentric rings. The seeds produced in infected pods often carry infection in the form of dark brown lesions. When pods are infected in the early stages of development, they become blighted and produce no seed, or black shrivelled seed. Lesions on stems and petioles are brown, elongated (3-4 cm), bear pycnidia in the form of black dots, and often girdle the affected portion. When the lesions girdle the stem, the portion above the point of attack rapidly dies. In weather conditions unfavorable for disease development, affected plants start regrowth and can yield reasonably depending upon the duration of the growth period.

Epidemiology of Ascochyta Blight

Complete knowledge of the epidemiology of ascochyta blight is lacking. The fungus is known to survive in diseased debris and infected seed, from which the disease starts. The duration of survival in diseased debris depends on weather conditions such as temperature, rainfall, and relative humidity to which the fungus is exposed. Under dry conditions the fungus seems to survive for longer periods. From India, Pakistan, and Iran, the fungus was reported to survive for 2 years. Studies at ICARDA indicated that the fungus survives in debris for less than 8 months, but in infected seed it was found to survive for more than 2 years.

Studies in Pakistan showed positive correlation between winter rainfall (150 mm or more) and blight, and negative correlation with the preceding summer rainfall. Studies at ICARDA indicated that only when weekly mean temperatures were above 10°C did blight start spreading rapidly in the field. Winds, accompanied by rain, carrying spore splashes and broken diseased tissues spread the disease.

Physiologic Races of A. rabiei

The studies so far indicate that the fungus *A. rabiei* has very variable pathogenicity. Studies in India indicated the presence of two races and a biotype in northwestern states, while studies carried out at ICARDA showed the presence of six races. Studies on this problem by ICARDA and the University of Reading in England also indicated large variability in *A. rabiei*. More intensive studies on this aspect are needed in all the important chickpea-growing countries for successful use of resistant cultivars.

Control Measures for Ascochyta Blight

The various control measures suggested are:

a. Use of healthy seed for sowing. Since the disease is seed-borne, sometimes to the extent of 70%, healthy seed must be used for sowing purposes. Seed dressings with Calixin M (11% tridemorph and 36% maneb) alone or in combination with benomyl (1:1) (3 g/kg) have given almost complete eradication of the fungus from seed with deep lesions (Reddy 1980). Seed dressing with tecto (thiabendazole) has also been very effective. Sowing the infected seed at 10 cm and deeper made the seed-borne inoculum ineffective (Reddy, unpublished).

b. Crop rotations, clean cultivation, and deep ploughing to prevent inoculation from diseased debris from the previous season's crop. Burying diseased debris 10 cm or deeper made it completely ineffective in disease transmission.

c. The various foliar ,fungicides reported to reduce disease spread, such as Bordeaux Mixture, Zineb, ferbam, maneb, captan, and daconil (chlorothalonil) should be used. At ICARDA, spraying with Bravo 500 (chlorothalonil) at weekly intervals gave complete protection to a highly susceptible cultivar under severe artificial epiphytotic conditions. One spray of 5 ml Bravo/l with Nu. film 17 (1 ml/l) at the early podding stage gave economic control to a tolerant cultivar (ILC 482).

d. Cultivation of the resistant/tolerant cultivars appears to be the best way of controlling the disease. Several sources of resistance have been reported in both desi and kabuli types, but very few resistant cultivars have been released for cultivation so far. The first resistant cultivar released for cultivation was F_8 in Pakistan in 1938 (Luthra *et al* 1938). Later, C-12/34 was developed by crossing F_8 and Pb-7 but around 1950, C-12/34 lost

its resistance and another cultivar, C-235, was developed and made available to farmers (Anonymous 1963). This variety also became susceptible. Recently, ILC 482, a tolerant cultivar developed at ICARDA, has been released for winter sowing in drier zones of Syria.

Production of Ascochyta Blight-Free Seed

Since seed-borne infection is the major source of inoculum for disease development, production and supply of disease-free seed is essential for the control of blight. Production of seed in the drier zones of India and Pakistan where blight does not appear is ideal. In the Mediterranean region seed multiplication in late spring with a weekly spray of Bravo 500 should ensure complete blight control. Other tips for the production of healthy seed are to treat it with Calixin M or tecto and avoid sprinkler irrigation.

Seed Health Testing for A. rabiei

The fungus is known to be present as spores on the seed coat (Sattar 1933; Maden *et al.* 1975), as mycelium and pycnidia in the lesions on the seed coat and cotyledons (Luthra and Bedi 1932; Maden *et al.* 1975), or as mycelium in the embryo (Maden *et al.* 1975). The extent and type of seed infection depend upon the stage at which pods are infected. Pods infected in the early stages of development produce small, black, shrivelled seed, while infection remains superficial on pods that are physiologically mature and yellowish. Where gaps have developed between the seed and pod wall there may be seed infection. Pod infection at the grain-filling stage, when the pods are green and the seed is in contact with the pod wall, results in greater seed infection. Seed infection may range from slight brown discoloration to dark brown deep lesions sometimes with visible pycnidia. The lesions on white-seeded kabuli-type seeds are large and brown in color, whereas on black-seeded desi-types the lesions are comparatively small and white. On the brown-seeded type, lesions are dark brown.

For detection of seed-borne infection the blotter test has been found to be more suitable than the agar test because of less contamination by saprophytes in the former than in the latter (Maden *et al.* 1975; Reddy 1980).

In growing-on tests, the percent germination of infected seed is usually high (up to 80%) and infection develops as oval or elongate dark brown lesions at the collar region or above, with visible pycnidia. Seed-borne infection can result in damping off of the seedlings. The extent of infection from infected seed, even in the deep lesions, is not very high, usually around 20%. The location of lesions on the seed was found to play a major role in transmission; the closer the lesion to the micropylar region the higher the rate of seed transmission. It is not uncommon to observe symptoms on the above-ground parts without any lesions near the attachment of the cotyledons, indicating possible contamination of the plumule with spores during germination.

Future Strategy for Control of Ascochyta Blight

The best method for ascochyta blight control lies in developing resistant cultivars. Present knowledge on screening techniques, sources of resistance, and variability present in the fungus should enable this objective to be achieved. However, further knowledge on the genetics of blight resistance, variability in the fungus, and durable sources of resistance is essential. Satisfactory fungicides for seed dressing and foliar application were identified and the potential for combining host-plant tolerance and fungicidal spray has been shown to succeed. This information should be of use at certain locations.

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Occurrence and Distribution of Ascochyta Blight of Chickpea in Pakistan

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Introduction

Chickpea ranks first among all the legume crops in Pakistan and is mainly grown in rainfed areas, after monsoon. The average yield per hectare is estimated to be 500 kg. On the basis of rainfall and soil type, chickpea-growing areas in North West Frontier (NWFP) and Punjab provinces can be divided into two main regions. First, the north western region which comprises Rawalpindi, Jehlum, Attock, Karak, and Bannu districts where the soils are more fertile and rainfall in winter is generally up to 50 mm/month. Secondly, the Thall region which includes districts of Khushab, parts of Mianwali, Bakhar, Leiah, and Jhang; the soils in these areas are mostly sandy types and rainfall in winter normally does not exceed 13 mm/month.

Among the factors contributing to low production of chickpea in Pakistan is the occurrence of the potentially destructive blight disease caused by the fungus *Ascochyta rabiei* (Pass) Lab. The disease was reported outside Pakistan in 1891 and in 1918 Butler recorded the disease in Peshawar and Attock areas. The disease is typically epidemic, and Pakistan has experienced several epiphytotics starting in 1915. Kauser (1965) traced the history of gram blight epidemic in Pakistan from 1928 to 1959. In the blight epidemic of 1956/57 he observed blight infection on early-sown crop in late November in Attock, and December in Rawalpindi. The blight broke out again in 1957/58. In the 1958/59 crop season, blight developed severely during January and February. According to Sattar and Hafiz (1952) the appearance and development of the disease was dependent on the amount of rainfall, especially from February through April, and the disease appeared in epidemic form in those areas where the

rainfall was about 150 mm or more. Recent epidemics of chickpea blight started in the 1978/79 cropping season and for the fourth consecutive year (1981/82) the disease has devastated the crop.

Disease Surveys

To record the incidence, distribution, and extent of damage caused by ascochyta blight in Pakistan, regular surveys were conducted in the 1981/82, 1982/83, and 1983/84 seasons starting in November. The surveys covered the chickpea-growing areas of Punjab (Attock, Khushab, Mianwali, Bakhar, Jhang, and Leiah) and NWFP (D.I. Khan, Bannu, and Karak). Each year the total number of inspected fields was about 200, selected at random from each district on the basis of previous years' crop acreage.

Percentages of disease incidence in each selected field were calculated by counting 500 plants in randomly selected rows at five random spots. The district averages were worked out on the basis of the disease incidence record at various locations in each district, while the provincial averages were based on the disease percentages of various districts in the province.

The observations recorded in the 1981/82 cropping season and the inferences deduced were as follows:

1. Chickpea blight appeared in epidemic form in both Punjab and NWFP for the third consecutive year showing thereby the buildup of inoculum, prevalence of conducive environmental conditions (suitable temperature, timely rainfall), and absence of resistant cultivars.
2. The disease was first observed in traces on a few individual plants in December 1981 at the National Agricultural Research Centre, Islamabad, and in a few fields near Attock city.
3. As shown in Table 1, the disease was absent or its incidence negligible in Khushab, Mianwali, Jhang, Leiah, and D.I. Khan districts up to the last week of February 1984 as dry conditions prevailed, whereas in Karak, Bannu, and Attock districts, the disease was epidemic.
4. In the third week of April 1982, not a single field could be located where the disease was absent and it appeared in severe epidemic form in all districts. Some fields, with a 100% disease incidence, had already been ploughed.
5. Ascochyta blight damaged up to 50% of the crop in Punjab and 33.7% in NWFP. Jhang and Khushab districts, where the incidence was 95.8 and 65%, respectively, were severely affected, followed

Table 1. Percent incidence of ascochyta blight of chickpea in different districts of Pakistan during 1982-84.

District	1982		1983		1984
	February 21-28	April 11-21	February 6-17	March 16-25	Februar 15-21
Attock	11.04 (0-80)*	26 (10-80)	2 (0-2)	8.1 (0-1)	0.0
Khushab	0.25 (0-1.4)	65 (5-100)	9 (0-35)	17.5 (1-25)	0.0
Mianwali	1.32 (0-12)	34 (5-100)	5 (0-30)	30.7 (5-65)	0.0
Leiah	0.0	28.1 (5-75)	0.0	5.5 (0-10)	0.0
Jhang	0.36 (0-18)	95.8 (95-100)	3.5 (0-8.3)	14.7 (0-14)	0.0
D.I. Khan	0.0	21.6 (5-30)	0.0	5.8 (0-7)	0.0
Bannu	8.1 (0-3.8)	39.2 (10-80)	12.1 (0-50)	29.1 (2-18)	0.0
Karak	2.8 (0-7.2)	24.4 (2-80)	7 (0-30)	14.1 (0-29)	0.0

* Range in fields.

by Mianwali, Leiah, and Attock districts. In three districts of NWFP, the incidence varied from 39.2 to 21.6%.

6. The infection percentages and disease intensities were the highest (95.8%) in Jhang district. The farmers in these areas used seeds of their local landraces which were probably infected with the pathogen. The second highest incidence was recorded in Khushab district where cleaned seeds, obtained from the Punjab seed corporation, had been used in addition to seeds of local populations.
7. Cleaned seeds resulted in lower infection percentages compared to uncleaned seeds. , This shows that cleaning seed lots from shrivelled and diseased seeds reduces the perpetuation of seed-borne infection.
8. Infection was reduced in crops raised from pure and clean seeds of known varieties. Of all the varieties, C-44, CM-72, RC-32, AUG-480, and C-235, in descending order, performed best but their reaction at different locations was variable.
9. Damage due to blight (and other diseases) was comparatively low in areas of NWFP, where the farmers followed crop rotations or had uprooted and burnt plants from diseased patches at the initial stages of infection.

The results of two survey studies carried out in the 1982/83 season and the main conclusions drawn thereof are summarized as follows.

1. As in earlier years, blight was observed in November and December 1983. At NARC, Islamabad, only 31-day old seedlings were killed by the disease.
2. Until 17 February 1982, no field was infected in Leiah and D.I. Khan districts in which the rainfall was less compared to other districts. In Attock district, the disease incidence was negligible due to a smaller crop area and use of clean seed of known varieties.
3. In Jhang district, at the time of first and second surveys, disease incidences were 3.5 and 14.7%, respectively, which were low compared to the last year's incidence of 95.8%. This situation arose due to nonavailability of seed from the previous year's crop and farmers planted pure, clean seed brought from other sources.
4. The 1982/83 crop received heavy rainfall starting in November 1982. Regarding the rainfall frequency, this season seemed to be a typical blight epiphytotic year, but for various reasons the crop had less damage compared to earlier years.
5. Some progressive farmers in Khushab, Mianwali, and Leiah districts have used cleaned and Benlate-treated seed.
6. Interesting observations on the reactions of different varieties at different locations were recorded. Some varieties known to be tolerant were found to be susceptible, and susceptible varieties showed resistant reactions at some locations. This shows the variability in *Ascochyta rabiei* and the possible presence of physiological races of the pathogen.

The 1983/84 crop season was completely different from the previous two seasons, as there were virtually no rains in almost all the chickpea areas from November 1983 to 20 February 1984. The following observations were recorded from 1 to 21 February 1984 regarding the crop and the incidence of ascochyta blight.

1. In Rawalpindi, Jhelum, and Attock districts, the area under chickpea decreased considerably. Due to blight epidemics, farmers have replaced it with groundnut. However in the Thall areas of Khushab, Mianwali, Bakhar, and Leiah districts, where farmers do not have an alternative crop, the area under chickpea seems to have increased. The crop stand and overall growth of the plants in these Thall areas seemed to be satisfactory. The effects of drought conditions were only visible on the tops of sand dunes where the crop stand was poor and surviving plants were stunted.

2. It was encouraging to learn from many farmers that they clean their seed lots and even treat them with Benlate.
3. This year, more farmers had the opportunity to purchase seed of known tolerant varieties like CM-72, CM-68, RC-32, C-44 etc.
4. Throughout the chickpea-growing areas, ascochyta blight was observed only in two adjacent fields in Katha area of Khushab district. This was an early infection, which probably appeared in the seedling stage without killing the plants altogether. Fields with heavy soils were waterlogged, providing the pathogen with the necessary moisture at the time of infection, but as drought conditions occurred after infection, disease spread was checked.
5. The local and exotic experimental material of chickpea (including the susceptible checks) planted at the Chickpea Research Station, Kalurkot, were all free from infection. At NARC, Islamabad, the disease could only be created artificially in screening nurseries in the first week of February 1984 by providing sprinkler irrigation to the crop.
6. As clear, sunny days with relatively high temperatures followed the rains of 19 and 20 February, there seemed to be no immediate danger of blight spread. Although the amount of initial inoculum in the area seemed to be low by February, the presence of susceptible varieties (C-727 and C-235) in farmers'fields and the expected heavy rains in the months of March and April may trigger disease appearance and spread.

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Pathogenic Behavior of Ascochyta rabiei Isolates on Different Cultivars of Chickpea in Pakistan

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Chickpea, a major pulse crop of Pakistan, is grown mainly in rainfed areas after the monsoon rains, and the crop is severely infected during the growing season by the fungus *Ascochyta rabiei* (Pass.) Lab. Several epiphytotics of the disease were recorded in this part of the world, but since the 1978/79 season, the crop has been affected every year. The varieties which were released earlier as resistant to the disease became susceptible. Therefore, several research workers investigated the existence of races in *A. rabiei*. Luthra *et al.* (1939) and Arif and Jabbar (1965) observed much variability in the size, growth, sporulation, and other cultural characteristics of fungal isolates, but they did not find any evidence of the existence of races. Bedi and Aujla (1969) indicated the presence of several races in the state of Punjab in India, while Vir and Grewal (1974) established the existence of two physiological races on the basis of pathogenicity and growth characteristics of different isolates. Singh *et al.* (1981) indicated the existence of four races.

The findings of previous workers and our observations during recent epiphytotics on the symptomatology and differential reactions of local cultivars at various locations, suggest the existence of physiological races of *A. rabiei* in Pakistan. This paper reports the results of some preliminary experiments on characterization of different isolates and their pathogenic capabilities on chickpea cultivars.

During the 1982/83 season, 25 isolates of *A. rabiei* were collected from different chickpea cultivars and locations in Pakistan. Initial isolations were made on potato dextrose agar, but for all subsequent studies chickpea seed-meal agar was used. These

isolates were preserved on autoclaved chickpea seeds. According to their morphological characteristics, isolates were classified into six groups. Ten isolates were subjected to detailed morphological and cultural studies. Much variability was found in growth rate, colony diameter, pycnidial formation, size of pycnidia, and pycniospores among the isolates.

For pathogenicity tests isolates differing in morphological and cultural characteristics were used; six desi and two kabuli cultivars were selected. Eight seeds treated with Benlate + Calixin-M at 3 g/kg (1:1 parts) were sown in 8 cm diameter plastic pots, and only five seedlings were kept in each pot. Cultivars were inoculated with each isolate separately. Inoculated plants (25 days after sowing) were kept under separate cages of dosoti cloth, replicated three times. An inoculum of *A. rabiei* was prepared on chickpea meal agar and a spore suspension prepared from 10-day old cultures. Plants were sprayed with spore suspensions (40,000 spores/ml) and cages were kept moist by sprinkling water on the cloth twice daily. Disease ratings (using a 1-9 scale, with 1-4 = resistant and 5-9 = susceptible) were taken periodically on an individual plant basis. The rating taken in the first week of March is shown in Table 1.

Table 1. Reaction of eight different isolates of *A. rabiei* on eight different cultivars of chickpea in Pakistan.

A. rabiei isolate number	Chickpea cultivar							
	RC-32	C-727	Pb-1	C-44	CM-72	C-141	ILC-195	ILC-200
1	S	S	S	R	R	R	R	R
2	S	S	S	S	R	R	R	R
4	S	S	S	S	R	S	R	R
6	R	S	S	R	R	R	R	R
10	S	S	S	S	R	R	R	R
12	S	S	S	S	R	R	R	R
13	R	S	S	S	S	R	R	R
18	S	S	S	S	R	R	R	R

R = resistant; S = susceptible.

As shown in Table 1, variation in the pathogenicity of the isolates was very pronounced. Isolate no. 4, from a field in Attock district, was most virulent, as only two cultivars (CM-72 and ILC-195), were resistant to this isolate. Isolate no. 13 from Islamabad, originally isolated from cultivar CM-72, showed susceptible reactions to lines CM-72, C-44, Pb-1, and C-727. The least virulent isolate (no. 6), which came from ILC-200, showed susceptible reactions to Pb-1 and C-727.

Cultivars C-727 and Pb-1 were susceptible to all the isolates while ILC-195 and ILC-200 were resistant. Keeping one representative each of susceptible and resistant lines and rearranging data from Table 1 may explain the pathogenic variation in *A. rabiei* in Pakistan (Table 2).

Table 2. Disease assessment in the form of resistant (R) and susceptible (S) reaction shown by eight isolates of *A. rabiei* on six cultivars of chickpea in Pakistan.

A. rabiei isolate number	Chickpea cultivar					
	C-727	RC-32	C-44	CM-72	C-141	ILC-195
4	S	S	S	R	S	R
2,10,12, 18	S	S	S	R	R	R
13	S	R	S	S	R	R
1	S	S	R	R	R	R
6	S	R	R	R	R	R

R = resistant; S = susceptible.

Data in Table 2 indicate that the isolates tested can be divided into five broad groups. Isolate no. 4, which represents race 1, the most virulent race, produced a resistant reaction on cultivars CM-72 and ILC-195 only. Isolate nos. 2, 10, 12, and 18 form race 2 which seems to be more prevalent. This race was present in Chakwal, Shakargarh, Faisalabad, and Kaghan, from where these isolates originated, and was absent in Thall areas. Isolate nos.13, 1, and 6 form races 3, 4, and 5, respectively.

Preliminary data support the existence of pathogenic races of *A. rabiei* in Pakistan but no firm conclusions can be drawn since the results presented are unreliable. Work is in progress and more isolates and cultivars will be used to obtain a clearer picture of the race situation in Pakistan.

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Slow Blighting-a Resistance Mechanism that Needs to be Explored if it Exists in Chickpea Germplasm

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Chickpea blight caused by *Ascochyta rabiei* (Pass.) Lab. is a disease long known for its ravages on chickpea crops. When conditions are favorable for *A. rabiei* infection, the disease occurs in alarming epidemics and causes total failure of the chickpea crop. This occurs due to the lack of suitable, resistant, commercial cultivars, and suggests the need for identifying resistant sources in the chickpea germplasm.

Like cereal rusts and rice blast, chickpea blight can be called a compound interest disease (van der Plank 1963). Its causal organism, *A. rabiei*, completes many reproductive cycles per growing season of the chickpea crop, provided the environmental conditions remain favorable for multiplication of the pathogen. The epidemic development of the chickpea blight, like other compound interest diseases, depends on two factors: (a) the amount of disease or inoculum at the start of the epidemic, (xo) and (b) the rate of multiplication of the disease or apparent infection rate (r). Resistance in chickpea cultivars may reduce xo and/or r. If xo is reduced, the epidemic may be slowed down (Parlevliet 1979). Any resistance in chickpea cultivars that could slow down the rate of multiplication of the disease, giving enough time to the cultivars to mature without suffering appreciable yield damage, could be termed 'slow blighting' (or rate reducing resistance). This is analogous to the slow rusting of certain wheat cultivars. Since slow rusting is a resistance mechanism that is effective against compound interest diseases, slow blighting in chickpea germplasm against *A. rabiei* should be explored, if it exists. It has been observed that in disease screening nurseries of chickpea germplasm, some entries developed severe blighting or epidemic in a short period (5-7 days) while others, receiving the same amount of inoculum, were not

diseased to the same extent even after a much longer period (3-4 weeks). This suggests that the latter type of entries possess in their genetic background something that slows down the development of chickpea blight epidemic. This may be a case of rate reducing resistance or slow blighting.

The above observation led to experiments in which 36 entries having variable levels of susceptibility or resistance were evaluated for the occurrence of slow blighting in some of the test cultivars or advanced lines. The entries were planted in 3 m long, 2-row plots with 36 cm distance between rows and a plant to plant distance of 15cm. Treatments were replicated four times, and plots in each replication were interplanted with two rows of linseed in order to avoid interplot interference. At right angles to the rows of test entries two rows of highly susceptible local chickpea cultivar (C-6227) were planted. When the entries were at about mid pod stage, the susceptible C-6227 rows were inoculated with an aqueous spore suspension (approx. 1.5×10^4 spores/ml water), so that the inoculum buildup over C-6227 would cause a disease epidemic. Assessment of disease severity was made every 7 days for 4 weeks, beginning 2 weeks after inoculation of the susceptible C-6227. From the disease severity data apparent infection rate (van der Plank 1963) or the area under the disease progress curve (AUDPC) was calculated (Wilcoxon *et al.* 1975). Using information from this experiment, some entries were ranked fast blighter, some slow blighter, and some intermediate. These results encourage the reevaluation of the entries by planting the experiment this year and it is suggested that extensive research studies be initiated in which more entries/advanced lines be evaluated for the occurrence of slow blighting in chickpea. Cultivars with slow blighting resistance will continue to be promoted to help reduce the losses of chickpea, even if only slight disease development is seen on those cultivars in the fields.

The components of rate reducing resistance in many host-parasite relationships may involve (1) resistance to infection, (2) resistance to colonization, and (3) resistance to reproduction of the pathogen on its host. These components are measured by infection frequency (proportion of spores which result in sporulation lesions), latent period (the time from infection to spore production), lesion size (area showing disease symptoms), spore production (spores produced per unit area of affected tissue), and infection period (period over which the diseased tissue sporulates) (Parlevliet 1979). In chickpea it is a common observation that the pods of some cultivars develop more or smaller lesions, take more time for symptom development, or develop lesions with no or few pycnidia compared to

other cultivars. It is likely that slow blighting, if it occurs in chickpea, may be responsible for these differences and can be measured by infection frequency, lesion size, latent period, and pycnidial number (spore production). More chickpea cultivars with different levels of resistance should therefore be evaluated for differences in their components of slow blighting or for associated variations of the components.

The genetic basis of resistance in chickpea is not fully explored. There are some reports describing resistance to *A. rabiei* as monogenically controlled and reporting that the resistance gene is dominant to its recessive allele conditioning susceptibility (Hafiz and Ashraf 1953). However, occurrence of chickpea cultivars with various levels of resistance suggests that the genetics of resistance to *A. rabiei* is not as simple as is understood and that there may be polygene systems that confer different degrees of resistance in different cultivars. There may be some complimentary gene actions which need to be explored by making carefully planned crosses.

Reducing resistance is monogenic in some host-pathogen relationships while in others it is polygenic. The type of resistance that exists in chickpea for slow blighting, whether mono or polygenic, should be determined. Rate reducing resistance may be race or nonrace specific. In *A. rabiei*, the race situation is very obscure due to the lack of suitable differentials although breakdown of resistance of some previously resistant cultivars suggests the occurrence of races in *A. rabiei*. When the race spectrum of *A. rabiei* is secured, it may be possible to explore whether the mechanism of slow blighting is race or nonrace specific.

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Identification of Ascochyta Blight of Chickpea in the Field and its Control Through the Use of Chemicals

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Chickpea blight, caused by *Ascochyta rabiei*, appeared in the epidemic form in Pakistan during 1978-82 and reduced yields by one half. This report discusses symptoms of the disease and results of a few trials on the chemical control of the disease.

Symptoms

All above-ground plant parts and growth stages are prone to attack by the disease. In Punjab, seedlings are attacked during October, November, and December, if there are rains and the atmosphere is humid. On stems, branches, and petioles, lesions are brown and elongated, bearing black dots (pycnidia) and often girdle the whole stem (Figure 1). When this occurs the portion of the plant above the point of attack rapidly dies and in the early stages of the disease tender branches topple over. If the main stem is girdled near the collar region, the whole plant dies. On green pods the lesions are usually circular with dark margins and the pycnidia are arranged in concentric circles (Figure 1). In severe cases the fungus can infect the seeds which become shrivelled. In the initial stages of the disease individual plants are attacked, but if the weather during February, March, or the first week of April remains favorable, the disease patches spread and the whole field may be destroyed. The severity of the disease mostly depends on weather conditions.

Trials were carried out using different chemicals to identify methods of disease control. These trials and the results obtained are discussed below.

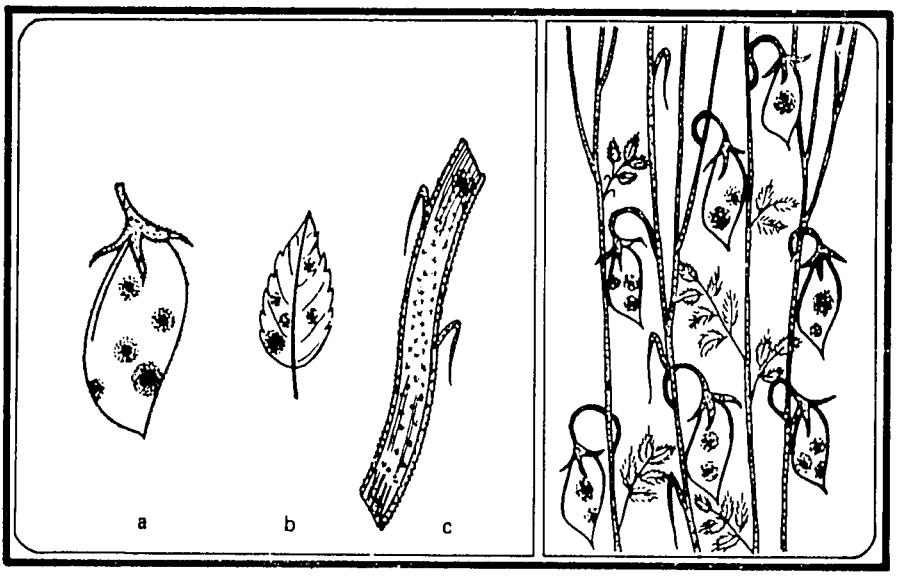

Figure 1. Diagrammatic representation of chickpea blight symptoms (a) on pod (b) on leaf (c) on stem.

Seed Treatment

Seed of the chickpea variety C-612 was treated with different chemicals at the rate of 3 g/kg seed. Seeds were planted in 6" earthen pots and when the seedlings were about 3 inches tall the pots were covered for 96 hrs with polyethylene bags and incubated at 18-24°C in the greenhouse. Results were recorded after 10 days' incubation.

The results indicate that none of the chemicals completely eradicated the seed-borne infection (Table 1). However, seeds treated with Tecto, Benlate, Derosal, and Baytan gave the lowest percentage of infection.

Spray Fungicides

A. Efficacy of different spray fungicides against chickpea blight
Prior to chemical spraying, the disease was artificially created in the field by spraying plants with an inoculum of *A. rabiei*. In total, three sprays of chemicals were applied at 2-week intervals (Table 2).

Table 1. Effect of different seed-dressing fungicides on blight incidence of chickpeas.

Fungicides	Infection (%)
Tecto	Traces
Derosal	2.38
Baytan	2.63
Benlate	3.03
Vitavax	5.88
Daconil	7.89
Topsin M	10.26
Calixin-M	12.76
Panoctine	17.94
Panoram	21.21
Control	45.00

During the first fortnight of April the weather remained cloudy with intermittent rain and in this period the disease spread again. The disease incidence was recorded in the last week of April. After the third spray, diseased twigs from each treatment were collected and the percentage spore germination was studied in distilled water in the laboratory (22°C). The results are given in Table 3.

Table 3 shows that minimum disease incidence was recorded with Tilt treatment followed by Daconil treatment, while minimum spore germination occurred with Tilt, Derosal, and Daconil. It is interesting to note that the disease incidence was also low with Tilt and Daconil treatments in the field.

B. Persistence of different chemicals. Tilt, Daconil, Bordeaux Mixture, Derosal, Dithane M-45, Bayletan, and Tecto were selected from the field experiment to determine how long sprayed chemicals give protection to the crop against chickpea blight. The chemicals were sprayed on potted plants (five 3-week old plants/pot), and each day one pot from every treatment was inoculated with a spore suspension of the pathogen. Inoculated pots were covered with polyethylene bags for 96 hr to ensure disease spread in the greenhouse. Care was taken to avoid contact of the polyethylene bags with the plants. The experiment was conducted for 15 days and observations on every pot were recorded 1 week after inoculation. The results indicated that Daconil gave protection for 10 days followed by Tilt which gave 7 days'protection (Table 4).

Table 2. Chemicals used and rate of application for the control of chick-pea blight.

Common name	Chemical name	Dose
Bordeaux Mixture	Copper sulphate + lime	4:4:50
Daconil	Chlorothalonil	1:5 g/l
Bayletan	Triadimefon	1:5 g/l
Tilt	1-2 (2-4 Disch Lorpheny 1-4-prophye 1,3-Dioxlan 2-4 methy) 1,24, Triazole	1.5 cc/l
Derosal	Carbendazinn (Benomyl)	1 g/l
Diathane M-45	Zinc + manganese + ethylene bisdithiocarbamate	2 g/l
Vitigran blue	Copper oxychloride	5 g/l
Tri-miltox forte	Copper oxychloride + copper sulphate + carbonate + mancozeb-20%	2.5 g/l
Rubygan	Fenarimol	1 cc/3 l
Tecto	Thiabendazole	1 g/l
Captan	N-(trichloromethyl) thiol -4- cyclohexene 1,2 dicarboximide	2 g/l

To protect crops with chemicals, repeated sprays are necessary (Nene 1982). The number of sprays makes the use of chemicals uneconomical, but the information obtained can be utilized in the seed production program.

Table 3. Efficacy of different spray fungicides against chickpea blight and spore germination of *A. rabiei*

Treatment	Disease incidence (%)	Decrease over control (%)	Average spore germination (%)
Control	86.67		43.18
Bordeaux Mixture	66.67	26.29	38.70
Daconil	38.33	63.05	20.51
Bayletan	61.67	32.61	22.22
Tilt	25.00	80.44	11.76
Derosal	85.33	36.96	19.11
Dithane M-45	53.33	43.49	26.09
Vitigram blue	55.00	43.96	28.12
Trimiltox forte	58.33	36.96	33.33
Rubygan	65.00	28.26	33.75

Table 4. Duration of effectiveness of different fungicides.

Fungicides	Day of disease appearance
Daconil	10
Tilt	7 (Traces)
Dithane M-45	4
Bordeaux Mixture	1
Bayleton	1
Berosal	1
Tecto	1
Control	1

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Fungicidal Control of Ascochyta Blight of Chickpea

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Chickpea blight caused by *Ascochyta rabiei* (Pass.) Lab. has been known for its ravages since the days of Theophrastus and Pliny. This disease appears almost regularly in epidemics in the rainfed (barani) and irrigated areas of Pakistan. The fungus infects all above-ground parts of the chickpea plant (*Cicer arietinum*) i.e., foliage, stems, and pods, and the disease is perpetuated from season to season through infected chickpea seeds or through infected plant parts lying on the surface of fields. In certain years and under favorable conditions, it causes total failure of the chickpea crop. This occurs due to a lack of suitable resistant commercial varieties under general cultivation. Use of fungicides, though more expensive than genetic resistance, could be an alternative control measure for blight at least until resistant varieties become available. Two practices are commonly employed in the use of fungicides against *A. rabiei* infection. One is fungicidal seed treatment and the other is foliar application of spray fungicides.

Seed Treatment

Disease-free seed is important for successful cultivation and high yields. Among the various factors that affect chickpea seed health, the most important is the seed-borne fungus *A. rabiei* which lowers seed germination and reduces seedling vigor. Germination of chickpea seed infected with *A. rabiei* and other microorganisms is reduced and the infected seedlings which survive are less vigorous, with poorly developed root systems and weak stems. Such seeds, or the resulting seedlings, serve as the sources of inoculum for the onset and spread

of chickpea blight disease. Chemical treatment of seed not only helps improve seed quality by controlling the seed-borne pathogens but also eradicates the sources of seed-borne inocula (Malik *et al.* 1983).

Sattar (1933) was probably the first to successfully eradicate seed-borne *A. rabiei* by immersing the infected seed in 0.5% copper sulphate solution. The same practice was utilized in Spain by Delcanizo (1972). Zachos (1951) reported effective eradication of seed-borne inoculum by 2 hours immersion of seed in 0.0005% malachite green or by 4 hours immersion in 0.05% formalin. About 12 years after his first report Zachos *et al.* (1963) subsequently found that 12 hours immersion in primacin at the rate of 150 ug/ml eradicated the inoculum completely. During the last two decades various effective organic fungicides have been used to control or reduce the seed-borne inoculum. Lukashevich (1958) recommended dusting dry or presoaked seed with 0.2 or 0.1% granosan, respectively, to reduce seed-borne infection and enhance seed germination. Similarly Askerov (1968) reduced infection of seedlings by using granosan (1-2 kg/t of seed). Thiram at the rate of 5 kg/t of seed was reported to be effective by Khachatryan (1961). Kaiser *et al.* (1973) found that the incidence of blight in chickpea seedlings was greatly reduced, and emergence markedly increased, when infected seeds were treated with certain chemicals, especially with the systemic benzimidazoles benomyl and thiabendazole (TBZ). He reported that treatment of seed with different fungicides before planting did not protect the foliage of seedlings against infection when the seedlings were artificially inoculated 2-3 weeks after emergence. This was supported by the work of Ilyas and Bhatti (1982) in which none of the eight fungicides used protected the plant from infection sources other than the seed-borne inoculum.

Ilyas and Bashir (1983) and Bashir and Ilyas (1983) concluded that fungicides such as benomyl, thiabendazole, daconil, topsin M, and karathane, which were most effective *in vitro* in inhibiting mycelial growth, pycnidial production, and spore germination, could be tested for effective seed treatment to reduce seed-borne inoculum. Malik *et al.* (1983) and Reddy (1980) reported that Calixin M alone or in combination with benomyl was effective in eradicating seed-borne *A. rabiei* by seed treatment.

Foliar Application of Spray Fungicides

For the control of foliar infections of *A. rabiei* on chickpea crops,

various inorganic and organic spray fungicides have been reported to be effective and reduce losses. The inorganic fungicides included sulphur and Bordeaux Mixture. Lukashevich (1958) obtained good control of chickpea blight by spraying 3% aqueous sulphur at 500-600 l/ha and increased yield from 31 to 82.8%. Askerov (1968) and Radkov (1970) also recommended the use of sulphur for effective control of the disease. Although Labrousse (1930) did not find spraying with Bordeaux Mixture commercially practicable under Moroccan conditions of crop cultivation, Kovachevski (1936) considerably reduced the severity of the disease with three to four sprays of 1% Bordeaux Mixture. Radkov (1970) and Delcanizo (1972) also recommended Bordeaux Mixture. Delcanizo used two applications of 2% Bordeaux Mixture, one before and the other after flowering.

The organic fungicides reported to be effective in the control of gram blight include ferbam (Puerta Romero 1964), zineb (Solel and Kostrinsky 1964), captan (Vir and Grewal 1974), daconil (Se Nycrick *et al.* 1977) and dithane Z-78 (Vir and Grewal 1974). Solel and Kostrinsky (1964) obtained effective control and yield increase by six sprays with zineb (65 W) at the rate of 3 kg/200 l water/ha. Vir and Grewal (1974) found that captan at 1 kg/400 l water was effective when sprayed four times and zineb was next to captan in efficacy.

Bashir and Ilyas (1983) found that foliar applications of fungicides varied in their effectiveness in reducing disease ratings, percent pod infection, and percent diseased seeds. They found that daconil, benomyl + daconil (1:1), and captan at 450 g (a.i.)/acre were the most effective treatments in reducing disease ratings and percent pod infection. Daconil, benomyl + daconil, captan, benomyl + dithane M-45, and dithane M-45 alone, were the most effective treatments for seeds with lesions of *A. rabiei*. The most effective spray treatments, which significantly increased yield, were, in descending order, benomyl + dithane M-45, benomyl + daconil, captan, daconil, morestan, and benlate + karathane. Sprays of brassicol (PCNB) and karathane at 450 g (a.i.)/acre were phytotoxic; the phytotoxicity of the former resulted in a significant decrease in chickpea yield. However, Ilyas and Bhatti (1982) reported no phytotoxicity when brassicol was applied at the rate of 225 g (a.i.)/acre.

Ilyas and Bashir (1983), using various systemic organic fungicides, found that the most effective spray fungicides in reducing disease rating were tilt and TBZ, while the most effective fungicides in reducing percent pod infection and percent diseased seeds were tilt, TBZ, and benomyl. Chickpea plots sprayed with TBZ, thiophanate-methyl, benomyl, tilt, carboxin, and sicarol gave significantly higher yields than non-sprayed controls. Tilt

phytotoxicity to chickpea flowers resulted in lower yield than with TBZ spray.

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Seed-Borne Diseases of Chickpea

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Introduction

Chickpea (*Cicer arietinum* L.) is infected by about 50 pathogens of which six are of major importance (Nene 1980). They include fungi, bacteria, viruses, mycoplasmas, nematodes, and parasitic weeds, and they not only reduce crop yields but also affect the stability of production. The average yield of chickpeas is about 700 kg/ha which is very low, although yields of about 1500 kg/ha are obtainable with some minimum inputs of nitrogen, phosphorus, irrigation, and better management. The susceptibility of the present cultivars to a large number of diseases and the fear of losing the entire crop through disease discourage farmers from applying any inputs to the crop and realizing potential yields. Disease control is essential to increase and stabilize chickpea production.

Seed-Borne Diseases

Production and use of healthy seed for sowing and exchange are essential for good crop productivity, especially in chickpea where the major diseases are seed-borne. Those of chickpea are ascochyta blight (*Ascochyta rabiei* Lab. Pass.), wilt (*Fusarium oxysporum* f. sp. *ciceri*), gray mold (*Botrytis cinerea*), and alternaria blight, and all are seed-borne (Luthra and Bedi 1932; Haware *et al.* 1978; Cother, 1977; Gurha *et al.* 1982).

The presence of physiologic races in *A. rabiei* and *F. oxysporum* further necessitates strict control on the exchange of seeds. In addition to the above four major seed-borne diseases several other

fungi, some of which cause minor foliar diseases, root-rots, seed rots, and seed decay, have been reported on seed of chickpea. Mitra (1935) reported *Mystrosporium* sp., a fungus causing a new blight disease, to be seed-borne. Zachos (1952) reported 27% of seed in Crete to be attacked and prevented from germinating by *Pleospora herbarum* (*Stemphylium botroysum*). *Alternaria* sp. and *Mycogone* sp. were recorded on stored seed from India (Anonymous 1954). Das and Sengupta (1961), reported *Stemphylium sarciniforme*, causing leaf-spot of chickpea, to be seed-borne.

Westerlund *et al.* (1974) reported *Fusarium solani* f. sp. *pisi* as a seed-borne disease causing root-rot of chickpea in USA. Shukla and Bhargava (1977) also reported *F. solani* to be associated with chickpea seed in India.

Mengistu and Sinclair (1979) reported 15 fungi and a bacterium, *Bacillus subtilis*, on seed from Ethiopia.

Deo and Gupta (1980) reported from India 34 fungi, belonging to 18 genera, on stored seed. Out of these, 4 species of aspergilli (*A. candidus*, *A. flavus*, *A. stellatus*, and *A. tamarii*); 5 species of penicillia (*P. chrustosum*, *P. chrysogenum*, *P. islandicum*, *P. lividium*, and *P. simplicissinum*); 3 species of alternaria (*A. alternata*, *A. humicola*, and one unidentified); 3 species of fusaria (*F. equiseti*, *F. fusarioides*, and *F. moniliforme*), appeared quite frequently while *Acremonium percisinum*, *Chaetomium globosum*, *Cladosporium tenuissinum*, *Curvularia lunata*, *Drechslera halodes*, *Gliocladium roseum*, *Monillium* sp., *Paecilomyces variotii*, and *Ulocladium chartarum* were sporadic. *A. flavus* showed maximum incidence and *A. percisinum* the least. D'Ercole and Sportelli (1982) from Italy recorded *A. solani*, *F. moniliforme*, *F. roseum*, *F. oxysporum*, *Penicillium* species, *Cladosporium herbarum*, and *Rhizopus nigricans* more often than *B. cinerea*, *Mycosphaerella* spp., *Ascochyta* spp., and *Acremonium* spp., from surface-sterilized seed.

At ICRISAT, India, *Alternaria spp.*, *Ascochyta rabiei*, *Aspergillus* spp., *B. cinerea*, *Curvularia* sp., *Fusarium* spp., *F. oxysporum*, *Penicillium* spp., *Phoma sorghina*, *Rhizoctonia bataticola* and *Rhizopus* spp. were isolated from unsterilized seed. From surface-sterilized seed, *A. rabiei*, *Alternaria* spp., *B. cinerea*, and *F. oxysporum* were isolated. At ICARDA, Syria, *A. rabiei*, *Penicillium* spp., *Cladosporium* sp., *Rhizopus* sp., and an unidentified bacterium were detected in blotter tests.

Control of Seed-Borne Diseases

Control of seed-borne diseases in chickpea is essential as seed-borne

fungi such as *A. rabiei* and *B. cinerea*, in extremely low proportions, can cause severe disease epiphytotics under favorable conditions, resulting in complete loss of the crop. Methods to minimize the role of seed-borne fungi are (1) production of healthy seed for sowing purposes, (2) development and cultivation of resistant varieties, and (3) fungicidal seed dressing to eradicate seed-borne fungi (Table 1). The combined use of the three methods is necessary in many situations.

Table 1. Seed-borne diseases/mycoflora of chickpea and their control.

Disease	Causal organism	Recommended seed dressing	Reference
Ascochyta blight	*Ascochyta rabiei*	Calixin M 3 g/kg Calixin M + Benlate (1:1) 3 g/kg Thiabendazole 3 g/kg	Reddy 1980 Reddy 1984
Wilt	*Fusarium oxysporum* f. sp. *ciceri*	Benlate T (benomyl 30% + thiram 30%) 2.5 g/kg	Haware *et al.* 1978
Gray mold	*Botrytis* cinerea	Bavistin 25% + TMTD 50% 2.5 g/kg	Grewal 1982
Mystrosporium	*Mystrosporium* sp.	Formalin 0.5%	McRae 1932
Pre-and post-emergence rot	seed mycoflora	Agroson G N,Agallol Captan; Thiram	Suhag 1973
Storage fungi	(34 fungi belonging to 18 genera)	Ceresan, Dithane Z 78, calcium propionate, sorbic acid.	Deo and Gupta 1983

Ascochyta blight

Seed-borne inoculum of *A. rabiei* is the most important primary source of inoculum for blight development. A number of studies were conducted to find a suitable fungicidal seed dressing for eradication of the fungus from infected seed.

Sattar (1933) suggested disinfecting the seed in 0.5% copper sulphate solution for 10 min. and treating internally infected seed by presoaking in water at 20°C for 6 hrs, then dipping in hot water at 53°C for 15 min. Zachos (1951) reported that dipping surface-sterilized infected seed in 0.005% malachite green for 2 hrs, 0.05% formalin for 4 hrs, or hot water at 45-47°C for 10 min. gave 84, 93.3, and 87.5% control, respectively. Khachatryon (1961) found seed treatments with thiram and 50% T.S.E. at 5 and 10 kg/tonne most effective. Ibragimov *et al.* (1966) reported that phenthiuram (40% thiram, 10% cu trichlorphenolate, 20% Y-BHC, and phenthiuram molybdate at 3-4 g/kg controlled blight. Karahan (1968) reported that treatment of seeds with Arasan-75 at 300 g/100 kg seed was most effective.

Kaiser *et al.* (1973) reported that seed treatment with benomyl and TBZ greatly reduced seedling infection. Seed dressing with calixin M (11% tridemorph + 36% maneb, 3 g/kg), a mixture of benlate and calixin M (1:1) at 3 g/kg, and thiabendazole (Tecto 60) at 3 g/kg, almost completely eradicated *A. rabiei* from deeply infected seed (Reddy 1980; Reddy *et al.* 1982).

Foliar spraying of chlorothalonil (Bravo 500) at 10-15 day intervals produced healthy seed even from a highly susceptible cultivar under favorable conditions for blight development. Lines with high resistance to blight and with no pod and seed infection were identified. Use of such lines to develop blight-resistant cultivars could greatly reduce seed infection by *A. rabiei*.

Wilt

Seed treatment with Benlate-T (benomyl 30% + thiram 30%) at the rate of 2.5 g/kg seed eradicated the internally seed-borne *F. oxysporum* f. sp. *ciceri* and remained effective for at least 1 year after treatment (Haware *et al.* 1978; Haware and Nene 1981).

Gray mold

Grewal (1982) reported that seed dressing with a combination of Bavistin (25%) and TMTD (50%) showed a synergistic effect and controlled internal and external seed infections of *A. rabiei* and *B. cinerea*.

Other seed-borne fungi

The above fungicides recommended for ascochyta blight, wilt, and gray mold also eradicate most other seed-borne fungi. Some of the fungicides found effective specifically against storage fungi are also reported.

McRae (1932) reported that seed disinfection with 0.5% formalin killed the spores of mystrosporium leaf blight. Suhag (1973) obtained best control of pre-and postemergence rot by treating the seed with Agroson GN, Agallol, Captan, and Thiram. Deo and Gupta (1983) reported that seed treatment with Ceresan, Dithane Z-78, calcium propionate, and sorbic acid considerably decreased the incidence of storage fungi and maintained good germination.

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Screening Techniques for Ascochyta Blight of Chickpeas

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Introduction

Blight caused by *Ascochyta rabiei* (Pass.) Lab. is the major disease of chickpea in North Africa, West Asia, and South Europe. Since the first reports of the disease, use of resistant cultivars has been considered the best means of control. Availability of simple and efficient screening techniques is essential for any resistance breeding program, and for ascochyta blight of chickpea, several workers have worked on the development of suitable screening techniques. A brief review of such procedures used in the field and greenhouse, or pot culture, is given. The various rating scales, information on nutrient media, and agronomic and environmental factors affecting host-plant resistance are also reported.

Field Screening Techniques

Luthra *et al.* (1938) were among the first to test materials in the field, where blight had occurred frequently. Artificial inoculations were made by spraying plants with aqueous suspensions of pycniospores. The plants were covered with Sarkanda to provide the moist conditions needed for disease development. The inoculation was repeated to provide a heavy dose of infection.

Spreading diseased debris over plants also produced an artificial inoculum and infection appeared after rain even if it occurred months after inoculation. The fungus on debris remained active for 3 years. Both methods of artificial inoculation gave equally good results.

Luthra *et al.* (1941) mixed blighted debris with seed at planting and found this method to be as efficient as spore suspension and debris methods in causing disease. Using blighted debris, infection occurred in the seedling stage.

Bedi (1949) used dried fungal cultures in place of diseased debris and claimed it superior to spore suspension and debris methods. In the spore suspension spray method, the inoculated plants must be covered with bell jars, glass chambers, or Sarkanda screens and so it has limited use in the field, while in the debris method, inoculations must be delayed until fresh blighted material becomes available. Also, the viability of spores in the debris could not always be relied upon because their germination declined considerably during the intervening summer. The dried cultures of the fungus, however, were viable for 33 months.

Sattar and Hafiz (1957) suggested the debris method of inoculation as a more practical method on a field scale since the spore suspension method required large amounts of inoculum and artificial humidity for at least 3 days. Also, in the debris method, infection occurred when temperature and humidity were optimum, whereas in the spore suspension spray method it was difficult to inoculate during optimum conditions. The dried cultures of the fungus and diseased debris were found to be equally effective.

Aujla (1964) followed the dried mycelial mat method of Bedi (1949) to inoculate varieties grown in separate plots with different isolates. Each plot was covered with a 7-8 ft high Sarkanda screen to protect it from neighbouring plots.

Vedysheva (1966) suggested the introduction of infected debris in autumn as well as spring to prepare the ground for infection under Kuban conditions in USSR.

Aujla and Bedi (1967) conducted field trials at Gurudaspur in the Punjab State of India where the disease appeared in an endemic form. They combined inoculation with diseased debris and dried cultures of the fungus and obtained heavy infection.

Grewal and Vir (1974) screened varieties under artificial epiphytotic conditions in the field at Delhi, India. Ninety-day old plants were sprayed with a mixed inoculum of two pathogenic races and covered with 12 x 40 ft 'Dsooti' cloth tents. To provide high humidity the plots were irrigated and the tents were sprayed with water for 36 hr.

Aslam *et al.* (1976) created a blight epiphytotic by spraying plants with a suspension of the single spore isolates of the fungus twice daily, at sunrise and sunset. The single spore isolates were grown on acidified chickpea dococation agar (500 g crushed chickpea seed, 20 g agar, 1l water) at 15°C for 10-15 days to produce 20-50

conidia/microscopic field at X 40 magnification. The intermediate check lines, consisting of very susceptible varieties, were kept moist to provide inoculum to adjacent test lines.

A technique to create severe artificial epiphytotics of blight on a field scale at the ICARDA farm, Aleppo, Syria, was standardized. The technique consisted of uniformly inoculating plants sown in winter (rainy season) by scattering the diseased debris, collected from the previous season, and providing sprinkler irrigation for 1/2-1 hr/day, whenever needed.

The system produced very severe infection (complete killing of the susceptible lines) over five seasons. Throughout the field, rows of a susceptible line were planted as indicator-cum-spreader rows. Around the field a strip of susceptible line was planted to provide an additional dose of inoculum.

Inoculation with debris can be done any time between December and March. The technique did not depend on natural weather conditions for blight development, and provision of sprinkler irrigation is an important factor especially at the podding stage when the weather is usually dry. Using this method, blight epiphytotics were created successfully during the past 5 years at ICARDA, indicating the technique's reliability.

Greenhouse/Pot Culture Screening Techniques

Bedi and Aujla (1967) artificially inoculated 10-day old seedlings by spraying mycelial and spore suspensions on leaves and placing them under disinfected glass incubators for 48 hrs at room temperature. The sprayed seedlings were then transferred to glasshouses to allow symptoms to develop.

Kaiser (1973) sprayed spores, washed from agar slants and strained through gauze, on plants of different ages using an aerosol spray kit. The inoculum density in various tests ranged from 10 - 5000x10^6 spores/cc. Immediately after inoculation, plants were placed in a chamber for 3-5 days at 100% relative humidity (RH) and then returned to the greenhouse at 12-28°C.

Chauhan and Sinha (1973) found that 20°C and 85-98% RH for 144 hrs were optimum for disease development and sporulation in the glasshouse. No symptoms were noted at 10 or 30°C and a minimum of 84 hrs at optimum RH was necessary for disease development. In younger plants, the lesions were larger and symptoms appeared sooner. Under continuous light, lesions were smaller and sporulation was markedly reduced.

Vir and Grewal (1974), in their studies on physiologic specialization, inoculated 40-day old seedlings in 8" pots by spraying a spore suspension of a 10-day old culture (10 X 10^3 spores/ml) grown on chickpea meal agar (chickpea meal 40 g, agar 20 g, distilled water 1 l). Inoculated plants were incubated for 48 hrs in humidity chambers, and final observations on stem and foliage infection were recorded 3 weeks after inoculation.

Reddy and Nene (1978; 1979) standardized a greenhouse isolation plant propagator technique to be used for screening germplasm and other laboratory studies such as race identification. In each pot, ten 10-15 day old seedlings were sprayed with a spore suspension (40,000 spores/ml) of a 10-15 day old fungal culture grown on 4% chickpea seed meal agar (CPSMA) and incubated at 20-25°C with 12 hr light. Each seedling was sprayed with approximately 1.5 ml of suspension. After inoculation the seedlings were covered with plastic covers for 10 days to create high humidity (60-100%) and the temperature was maintained at 20-25°C by running desert coolers, whenever necessary. The technique was satisfactory for screening throughout the year in a blight-free area.

At ICARDA plastic houses equipped with perfo-irrigation and temperature controls were used for screening chickpeas against blight during the winter season when outside temperatures were low for blight development. Ten to fifteen day old seedlings, grown in 20 cm plastic pots in a plastic house at 15-20°C, were inoculated with spore suspension (100,000 spores/ml), and perfo-irrigated for 5 min. twice daily for 5 days. The disease development was very severe causing complete death of susceptible lines. The reaction of the lines in the field inoculated with diseased debris and in the plastic house was found to be highly correlated.

Disease Rating Scales

Aujla (1964), while studying different isolates of *A. rabiei*, devised a pathogenicity index as follows: F = free from any infection, T = traces or flecks of infection, L = light infection where immature pycnidia were seen, M = moderate infection in which fully mature pycnidia were formed and scattered on the surface, S = severe infection in which the whole plant was covered with pycnidia, but the plant still living, VS = very severe infection in which only the stalks of the plant remained.

Bedi and Aujla (1969) evaluated different chickpea varieties by the following disease index: 1=1-10, 2=11-20, 3=21-30, 4=31-40,

5=41-50, 6=51-70, 7=71-90, 8=91-100% foliage infection. The disease index/replication was calculated as follows:

$$\frac{\text{(No. of plants in each infection group) X (Respective degree of infection)}}{\text{Total number of plants/replication}}$$

Aujla and Bedi (1967) evaluated the varieties using the following rating scale: 1 = 0-1, 2 = 2-4, 3 = 5-10, 4 = 11-20, 5 = 21-50, 6 = more than 50% foliage infection. Varieties showing disease ratings of 1-2 with immature pycnidia in the lesions were considered resistant, others showing increased infection were rated as susceptible. The disease index/replication was calculated as Bedi and Aujla (1969).

Morrall and McKenzie (1974) devised the following qualitative rating system to measure the amount of disease in various plots: HE = healthy, with no lesions visible on any plants in the plot; TR = trace, having a few scattered lesions, usually found only with careful searching; SL = slight, where lesions are common and readily observed on plants, but defoliation and damage not great, (one or two patches in a plot); MO = moderate, where lesions are very common and damaging, intermediate between SL and SE; SE = severe, all plants in a plot have extensive lesions, defoliation, and dying branches, but few, if any, are completely killed; DE = dead, with all plants, or all but parts of a few, completely killed. The numerical values assigned to the above categories were: HE = 0, TR = 1, SL = 2, MO = 3, SE = 4, and DE = 5.

Grewal and Vir (1974) graded the varieties 21 days after inoculation using the following scale: immune = no infection; resistant = few minute localized lesions on the stem and up to 5% foliage infection; moderately susceptible = stem lesions 2-6 mm long which may girdle the stem, and/or 5-25% foliage infection; susceptible = stem lesions bigger than 6 mm and girdling the stem, and/or 25-75% foliage infection; highly susceptible = all young shoots and leaves killed.

Aslam *et al.* (1976) employed only three grades in the preliminary screening for resistance viz; very susceptible (+++), tolerant or moderately susceptible (++), and resistant (+). For more specific gradation of a variety, the Morral and McKenzie scheme was followed.

Reddy and Nene (1978; 1979), adapting the Morral and McKenzie system, devised a 9-point rating scale with: 1 = resistant, no lesions visible; 3 = moderately resistant, few scattered lesions usually seen after careful searching; 5 = tolerant, lesions common and easily observed on plants, but defoliation and/or damage not

great (only one or two patches in a plot); 7 = moderately susceptible, lesions very common and damage occurring; 9 = susceptible, lesions extensive on all plants, defoliation and drying of branches and some plant death.

Singh *et al.* (1981) used a 1-9 scale for scoring the material where: 1 = no lesions visible on plants (highly resistant); 3 = lesions visible on less than 10% of plants, no stem girdling (resistant); 5 = lesions visible on up to 25% of plants, stem girdling on less than 50% of plants resulting in the death of a few plants and causing considerable damage (susceptible); 9 = lesions profuse on all plants, stem girdling present on more than 50% of plants, and death of most plants (highly susceptible).

Reddy *et al.* (1981) devised a more comprehensive scale to score the reaction of individual plants and plots, taking into consideration the infection on both vegetative parts and pods. Details of the scale are given in Table 1. The important criteria used in the scale are lesion size on stems, extent of stem breaking, and extent of pod infection.

Effect of Age of Plants and Environmental Factors on Resistance

Effect of Age

Sattar (1938) found that the susceptibility of plants to disease increased with age and was greatest at the flowering-fruiting stages, when the plants excrete maximum malic acid. He suggested that inoculations be done at that stage. However, Luthra *et al.* (1941) and Aslam *et al.* (1976) did not find any influence of host plant age on resistance. Experiments conducted at ICARDA also showed that plant age in the vegetative stage had little effect on plant resistance but many lines showing good resistance in the vegetative stage developed serious pod infections.

Effect of Fertilizers

Luthra *et al.* (1941), studying the effects of nitrogen (N), phosphatic (P), potassic (K) and organic fertilizers, did not find any influence on host plant resistance. Work at ICARDA also showed that N, P, and K and rhizobium inoculation did not influence the reaction of lines to blight infection.

Table 1. A quantitative 9-point rating scale for ascochyta blight of chickpea (single plants and rows or plots).

Disease rating	Reaction category	Branches broken (%) Single plants	Row/ plots	Stem lesion type	Pods with lesions (%)
1	Highly resistant (HR)	0.0	0	-	0
2	Highly resistant-resistant (HR-R)	0.0	1-5	0-2 mm long	1-5
3	Resistant (R)	0.0	6-10	2-6 mm long girdling	6-10
4	Resistant-tolerant (R-T)	0.0	11-15	6 mm long, with girdling but no breaking	11-15
5	Tolerant (T)	40.0	16-40	6 mm long, with girdling and breaking	16-40
6	Tolerant-susceptible (T-S)	50.0	41-50	"	41-50
7	Susceptible (S)	75.0	51-75	"	51-75
8	Susceptible-highly susceptible (S-HS)	100.0	76-100	100 % gridling	71-100
9	Highly susceptible (HS)			Plants completely killed	

Effect of Irrigation and Rainfall

Luthra *et al.* (1941) did not find any influence of different amounts of irrigation and rainfall on the reaction of resistant lines.

Effect of Light

The reaction of resistant lines grown at very low light intensity and aeration did not change, although infection was greater because the shoots were soft and succulent (Luthra *et al.* 1941).

Plant Spacing

Reddy and Singh (1980) found no change in the reaction of lines with varying degrees of resistance when grown at two inter-row spacings of 30 and 20 cm.

Effect of Temperature, Relative Humidity, and Inoculum Load

Studies at ICARDA showed that temperatures ranging from 5 to 30°C, 100% relative humidity periods ranging from 0 to 30 days, and inoculum loads of 50 thousand to 7.5 million spores/ml of water (1-3 ml/seedling) did not influence the reaction of resistant lines.

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Breeding Ascochyta Blight Resistant Chickpeas

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Introduction

Breeding for disease resistance in crops has received more attention than breeding for any other character in recent years. This is because disease can cause extensive damage to plants and resistant cultivars can increase and stabilize yield. Resistant cultivars add little to the cost of cultivation and disease resistance is genetically controlled, whereas mechanical failure, unfavorable weather, and non-availability of chemicals may prevent the application of fungicides. Also, resistant cultivars are important for low income crops, like chickpea, because chemical control is uneconomical.

Diseases were not a major threat to agricultural production when agriculture was 'shifting'. They became a problem when large-scale continuous cultivation of crops started in areas in the valleys of the Nile, Euphrates, Tigris, and Indus rivers. In the 19th century, plant breeders recognized the importance of disease resistance and a few resistant cereal cultivars were developed through intervarietal hybridization. Systematic work started with the rediscovery of Mendel's laws of inheritance and the demonstration by Biffen in 1905 that resistance to rust was genetically controlled.

It was soon realized that the resistance of one cultivar could be transferred to another. Further, it was observed that a cultivar resistant at one location may be susceptible at others and Stackman and Peimeisel (1917) established the concept of physiologic races to explain this. Flor (1942), working with flax rust, proposed the gene-for-gene hypothesis which has become the main guideline for breeding resistant cultivars.

When a cultivar is more resistant to some races of pathogen than others, the resistance is called vertical or perpendicular. When the resistance is the same for all races of the pathogen, it is described as horizontal. Both van der Plank (1963) and Robinson (1973) have questioned the durability of such resistance on the basis of non-race specificity, although Ellingboe (1981) and others support the existence of horizontal resistance. Although horizontal resistance was proposed in 1963, no cultivar has yet been bred with this kind of resistance.

Breeding approaches involving major resistance genes have been suggested which would ensure the resistance stability and restrict the evolution of the pathogen. These approaches include using multiline cultivars (Jensen 1952; Borlaug 1953), the deployment of resistant genes (Knott 1971), and the pyramiding of multiple gene resistance.

For breeding chickpea cultivars resistant to blight caused by *Ascochyta rabiei* (Pass) Lab., multiline cultivars and pyramiding multiple gene resistance could be used in the future. The deployment of major resistance genes has been used extensively, and this may continue. There is a suggestion that for any given area/region, a set of cultivars with different resistant genes may be recommended to stabilize production.

Screening Technique

One of the important requirements in disease resistance breeding is the ability to artificially create disease epiphytotics with ease, speed, and reliability but this requires large-scale screening to separate plants into resistant groups. This may have limited the development of ascochyta blight-resistant cultivars. Singh *et al.* (1981) developed a reliable and convenient technique to create disease epiphytotics and screen a large number of germplasm accessions and breeding material. This technique involves; (1) sowing a susceptible check at frequent intervals, (2) inoculating the material with infested debris collected in the previous season, (3) providing sprinkler irrigation, if necessary, to create high humidity, and (4) if necessary re-inoculating the material with a spore suspension prepared from freshly infected plants. This technique has been tested at ICARDA for 5 years.

Wherever possible, hotspots could be identified where the environmental conditions naturally favor a major build-up of the disease. One such location is the coastal site at Lattakia, Syria,

in the Mediterranean region. Lattakia is warm, humid, and wet during the growing season and ascochyta blight develops naturally in epiphytotic form. Such hotspots would be used to confirm results, rather than for raising breeding material.

Sources of Resistance

To identify sources of resistance to ascochyta blight, over 14,000 germplasm accessions of chickpeas have been screened at Tel Hadya, ICARDA's principal research station, located in northern Syria. A number of resistant or tolerant lines were identified and given to national programs including the program in Pakistan. These resistant lines have been grown at many locations in Pakistan where ascochyta blight is a major problem and at each location resistant sources have been identified. Four lines (ILC 72, ILC 3279, ILC 3346, and ILC 3856) have been consistently resistant across locations and years in Pakistan. Thus, these lines are very useful parents in transferring resistance genes into high-yielding lines through intervarietal hybridization.

Genetics of Resistance

Hafiz and Ashraf (1953) were the first to report that the inheritance of ascochyta blight-resistance was dominant and monogenic, with both F_8 and F_{10} having a dominant gene for resistance. Vir *et al.* (1975) reported that resistance in cultivar 113 was controlled by a single dominant gene pair and Eser (1976) found a single dominant gene for resistance in a line designated as code number 72-012. Singh and Reddy (1983) reported a single dominant gene controlling resistance in four parents (ILC 72, ILC 183, ILC 200, and ICC 4935) while resistance in ILC 191 was conferred by a single recessive gene. The gene symbols *Rar* 1, for the recessive gene for resistance in ILC 191, and *Rar* 2 for the dominant gene for resistance in ILC 200 were proposed.

Breeding Methods

In principle, the breeding methods used for disease resistance are the same as for other characters. The most commonly employed methods are briefly described here.

1. *Pedigree method:* When resistant sources are found in cultivated species and they are expected to contribute to yield, adaptation, and seed quality, then either the bulk or the pedigree method is used. Though both methods can be employed, the latter is preferred because there is better genetic control.
2. *Backcross method:* If the resistant source is wholly unadapted, the backcross method is used.

With chickpea, following hybridization, the pedigree method of breeding has been employed more often than others and it has produced a large number of cultivars. As most of the sources of resistance to ascochyta blight occur late in maturity, there are two possibilities to follow:

A. Backcross-pedigree:

A X B
(Resistant parent) (High-yielding and widely adapted parent)
F1 X B (First backcross)
Follow pedigree method

B. Three-way cross:

A X B
(Resistant parent) (High-yielding and widely adapted parent)
F1 X C
(Another high-yielding and widely adapted parent)
Follow pedigree method

In addition to the above methods, plant introduction followed by selection could be an important method especially when resources are limited. A number of cultivars have been developed using this method, such as F8 in 1938 in India, VIR 32 in 1969 in USSR, and ILC 482 in 1982 in Syria. This method is the cheapest, easiest, and quickest of the methods described.

Maintenance of Resistance

Due to the evolution of new physiologic races of the ascochyta blight pathogen, a resistant cultivar will eventually become susceptible. This happened in Pakistan where the chickpea cultivar F8, released in 1938, became susceptible and was replaced by C 12/34 in 1946. This cultivar also became susceptible to a new unknown race of *A. rabiei*

and was replaced by another cultivar, C 727, in 1962. Due to susceptibility, C 727 was replaced by C44 and CM 72 in 1983, but these cultivars will also become susceptible. Therefore, breeding for ascochyta blight resistance is a continuous process.

Due to the time lag between the resistance breakdown of cultivars' resistance and replacement with new ones, Pakistan has suffered severe yield losses from ascochyta blight. To avoid further losses, a set of cultivars with different resistance sources should be recommended to stabilize production. Also, there should be pyramiding of multiple gene resistance and such sources used in a hybridization program.

Concluding Remarks

All the basic ingredients for breeding ascochyta blight-resistant cultivars and stabilizing chickpea production in Pakistan exist. What is required in future is a sustained effort to combat ascochyta blight.

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Breeding for Ascochyta Blight Resistance in Chickpeas in Pakistan

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Introduction

Chickpea (*Cicer arietinum* L.), an important pulse crop of Pakistan, is mainly grown in rainfed areas after monsoon. The total cultivated area of chickpea varies between 1 and 1.2 million hectares and annual production is about 600 thousand tonnes during normal years. Average yields/hectare are estimated to be around 550 kg. Chickpea plays a vital role in human diets in terms of protein and is important in restoring soil fertility through the symbiotic fixation of atmospheric nitrogen.

Of the various diseases of chickpea, ascochyta blight, caused by *Ascochyta rabiei* (Pass.) Lab., is the most devastating seed-borne disease. Wet, cool weather favors disease development. Since *A. rabiei* is readily seed-borne, care is needed in seed distribution to reduce disease spread.

History

The disease was first reported by Butler in 1918 in the North West Frontier Province of Pakistan and has always been considered economically important. Butler's report represents perhaps the best documented account of early blight epidemics in Pakistan. Records of subsequent epidemic years were reviewed by Kauser (1965) (Table 1).

Losses

The disease caused large losses in Pakistan during 1979/80, 1980/81, and 1981/82, reducing chickpea production by 48, 48, and 46%,

respectively, which caused US$ 158 million loss to farmers (Table 2). This necessitated the import of pulses worth about US$ 90 million (Table 3) up to September 1983/84.

Table 1. Frequency of chickpea blight epidemics in Pakistan from 1928/29 to 1981/82.

Blight year	Disease incidence
1928-31	Gram crop suffered badly for three consecutive years, gram area was reduced drastically
1936-40	Almost complete failure of the crop in Attock and adjoining districts
1947-54	Blight years in succession; crop damage varied in different years
1956-59	Severe blight epidemic on gram areas
1972-74	Mild blight
1974-75	No blight report
1975-76	Mild blight
1976-77	Mild blight
1978-82	Severe epidemics of gram blight

Table 2. Yield loss estimates due to ascochyta blight during 1979-82 in Pakistan.

Year	Production (x000 tonnes)	Yield loss (%)	Value (million US$)	Loss (million US$)
1976/77 (Disease-free and growing conditions optimum)	690*	0	195	0
1979/80	313**	48	125	70
1980/81	338***	48	152	43
1981/82	300****	46	150	45

*US$ 300/tonne; **US$ 400/tonne; ***US$ 450/tonne; ****US$ 500/tonne

Table 3. Imports of pulses in Pakistan 1979-84.

Year	* Production (x000 tonne)	** Consumption (kg/annum)	Total Imports	
			Quantity (tonnes)	Value (US$x000)
1979/80	512	6.82	1995	603
1980/81	525	4.02	1072	7576
1981/82	481	5.98	96084	37869
1982/83	712		170946	38103
1983/84			13779	5360

* Crop Statistics of Pakistan, July 1983

** Economic Research Section, Government of Pakistan

*** Pakistan Economic Survey (1981/82) and Ministry of Commerce, Government of Pakistan

Strategies to Control Blight

Infrastructure

To be effective in controlling this disease research programs need coordination at national and regional level. This would improve utilization of limited resources and avoid duplication of effort. The Cooperative Research Program on Pulses Improvement in Pakistan is based on this concept. There are 10 coordinated units throughout the country, in various pulse-growing areas, which are supported by this program in terms of material, training, and funds. This has helped to build a network for successful implementation of the research program.

Availability of Research Material

Since the implementation of the Cooperative Research Program (July 1980), over 4000 germplasm lines have been collected from within Pakistan, ICRISAT, and ICARDA and screened for blight resistant sources.

Sources of Resistance

A screening program for blight resistance is being carried out at various main centers: NARC, Islamabad; Ayub Agricultural Research Institute; University of Agriculture, Faisalabad; and NIAB, Faisalabad.

Both laboratory and field screening techniques have been developed and standardized. The following lines have been identified as resistant.

1. Desi types: ICC-76, 1069, 1119, 1903, 7513, 7514, NEC-138-2, PCH-15, ICC-6945, 667, 641, 2920, 1467, 1468, CGP-8503, 8518, 8519, CM-72, CM-68, C-44.
2. Kabuli types: ILC-72, 3279, 200, 201, 191, 195, 183, 202, 208, 2956, PCH-128, 6306, 6304, 482.

Preliminary studies at NARC, Islamabad, indicated physiological races of the fungus in Pakistan, which was also reported in Syria by an ICARDA pathologist.

Breeding Methods

The most important factor reducing chickpea cultivation is a lack of stability in chickpea production during the last 3-4 years, which is primarily due to ascochyta blight.

Breeding of blight disease-resistant cultivars is of prime importance for production stabilization. The resistant cultivar is the best and cheapest method of controlling the disease from the growers' point of view. However, other methods of controlling the disease are required, hence the need to develop efficient methods to combat blight and prevent resistance breakdown. In any crop improvement program, development of disease-resistant cultivars continues to be important.

The breeding methods used for developing blight resistance in chickpea are the same as those used in self-pollinated crops for creating other traits of economic importance.

Introduction

This method uses deliberate and planned transfer of seeds and plants of economic importance from one area to another, undergoing normal procedures of quarantine evaluation, multiplication, and distribution. The breeder may obtain materials from other countries, germplasm banks, and/or by organized explorations. The seeds so obtained may be:
(a) directly used as varieties,
(b) used after selection, or
(c) used for hybridization.

Selection

Selection:
(a) is effective only on heritable characters,
(b) acts on the existing genotypes as a whole and not on a single gene,
(c) changes the gene frequency, and
(d) does not create new genes, but can create new genotypes which can be maintained.

Mass selection: The breeder can select a large number of plants from a variable population using phenotype. Selected plants are bulked without progeny test, and agronomically inferior plants with obvious defects are discarded or rogued out.

Pure line selection: A new cultivar is developed from the progeny of a single pure line of a heterogeneous population in a mixture of several pure lines. This pure line theory was developed by W.L. Johannsen, a botanist from Denmark, soon after the rediscovery of Mendel's laws in 1900. The essential features of this theory are:
(a) Variation between different pure lines is genetic as well as environmental.
(b) Variation within a pure line is environmental.

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(a) Variation between different pure lines is genetic as well as environmental.
(b) Variation within a pure line is environmental
(c) Selection between different pure lines will produce a superior pure line for a particular character, but selection within a pure line will not be effective for further improvement. The progeny of different individuals of a pure line tends to congregate around the line mean.
(d) Within a pure line, mutations may accumulate over a long period.

Hybridization

Useful genes are transferred by breeding from different sources to produce better plant material. This technique results in additional variability by recombining the genes present in the different parents

of a self-pollinated crop to create new genotypes, which leads to transgressive segregation. The success of a hybridization program in the case of a self-pollinated crop like chickpea, depends on the careful choice of parents. As the objective is to replace the existing cultivar with a superior one, the existing cultivar should be used as one of the parents.

The pedigree method

The main features of this method are:
(1) F_2 populations are space planted.
(2) The good plants in every generation are selected until homozygosity is obtained.
(3) The records of the individual may be traced from generation to generation.
(4) There is preliminary evaluation of experimental strains.
(5) There is final selection of superior pure lines.
(6) Seeds are multiplied and released.

The bulk method

Selection is delayed until the F_5 or F_6 generation. The segregating material is grown under drill conditions from the F_2 generation onwards which allows selection to shift the gene and genotype frequencies

The backcross method

This method is used to improve an otherwise good cultivar which has become deficient in one or two characters of economic importance. With each backcross, the donors' contribution is reduced and the recurrent parent contribution increases. Some considerations are:

(1) Availability of a satisfactory recurrent parent.
(2) Availability of a satisfactory non-recurrent parent.
(3) Maintenance of the character being transferred.
(4) Use of a reasonable number of backcrosses to recover the genotype of the recurrent parent.

Sources of Resistance

Within the Species

To develop blight resistant cultivars diverse sources of resistance are needed from local and exotic chickpea material. Resistant material selected from areas where blight is common is thought to be of great value as a source of resistance.

From Related Species and Genera

Sometimes, related wild species are almost completely immune to a particular disease. *Cicer reticulatum* and *C. anatolicum* are examples, showing good resistance against blight.

Collaboration

Collaboration with leading research centers at national and international level must be established to obtain segregating material which may contain blight resistant lines. Such lines may provide material for direct use or may be used as donors in resistance breeding programs.

Mutation Breeding

Sources of resistance may not be available in the naturally-occurring variation of a species and so mutagenic agents may be useful.

The breeding techniques needed to develop blight resistant cultivars require:

(a) detailed information about the pathogen, its life history, modes of reproduction, perpetuation, survival, dissemination, and infection so the breeder may then design efficient techniques to screen available chickpea genotypes,

(b) information on the heritable variation in the pathogenic capabilities of the parasite,

(c) information about the heritable differences in disease resistance within the host species,

(d) information on the genetic factors controlling resistance to a particular disease, their diversity, and inheritance,

(e) knowledge of the rate of mutation of the pathogenic organism, and

(f) the testing of parental lines and breeding material against an adequate sample of a pathogen of the prevalent races, under an adequate sample of environments, to develop a variety with stable resistance.

Collaboration with a plant pathologist is helpful in making detailed studies on the pathogen and in creating artificial epiphytotics to correlate the genotype and the phenotype for disease resistance.

Utilization of Sources of Resistance in the Breeding Phase

Crossing Block and Planning of a Crossing Program

The crossing block should be arranged so that mistakes are minimized. There should be no labelling; tagging the crossed flowers with colored thread should be enough to harvest the crosses at maturity. To facilitate crossing, paired row planting of selected parents is suggested.

Single Crosses

Single crosses are made between an adapted cultivar and a parent carrying disease resistance. The pedigree method is used in handling the segregating population if the resistant parent is contributing agronomic characters such as improved adaptation, quality, and yield. Selection for disease resistance commences in the F_2 generation of the cross, where segregation first occurs. However, this early selection pressure adversely affects other agronomic characters since selection of single plants for disease resistance at F_2 would limit the combination of favorable genes in the selfing series. Linkage of genes with undesirable effects would result in further problems. Therefore, it is important that the selection for disease resistance be started in the F_3-F_4 generation.

Backcrossing

Backcrossing is useful if the resistant parent in the single cross is an unadapted parent and is being used only for transferring the resistant gene(s) to an adapted parent.

Modified backcross is a method in which more than one parent can be used as donor and provides genes resistant to blight from a diverse source in an adapted cultivar.

Multiple Crosses

These may include:
1. The three way cross (AXB) x C
2. The double cross (AXB) x (CXD)
3. Complex crosses (AXB) x [(CXE) x E]
   [(AXB)XC] x [(DXE)x(FXG)]
   [(AXB)x(CXD)x(EXF)x(FXA)] etc.

In such crosses segregation occurs in the F_1 generation and poor plants are rogued. Selection must be carried out beyond F_6, F_8, or F_{10} depending upon the material used.

These crosses provide recombination among genes from many parental strains.

The Value of Horizontal Resistance in Breeding for Disease Resistance

In cultivars where vertical resistance does not last long, due to rapid changes in pathogens, horizontal resistance is favored. This uses parents which have shown moderate resistance over the years and at different locations. The intermating of selected plants in the segregating generation helps to break undesirable linkages between genes governing horizontal resistance and developmental traits and to concentrate horizontal resistance.

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Breeding for Ascochyta Blight Resistance in Chickpea Through Induced Mutations

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Chickpea is the most important grain legume crop in Pakistan. Average yields are between 550 and 710 kg/ha, and so are very low. Besides excessive vegetative growth and poor harvest index the occurrence of ascochyta blight, caused by *Ascochyta rabiei*, is the most important factor contributing to low and erratic yields. Varietal resistance is the best method of blight control.

Genetic improvement of chickpea has been going on in Pakistan for a long time but progress in breeding high-yielding and blight resistant varieties has been limited by scanty genetic resources. The earlier varieties F8, C12/34, C235 and C727 are no longer resistant.

Approaches to the Synthesis of Resistant Cultivars

Conventional Breeding

Most of the early plant breeding work on blight resistance in the Indo-Pakistan subcontinent involved the introduction of resistant line F8 and its subsequent use in a hybridization program by using the classical single cross method. The transfer of resistance factors from F8 to local high-yielding varieties has not produced the desired results, which may be partly due to detrimental side effects

caused by pleiotropy or linked genes on productivity factors. Back cross and recurrent selection methods may have given better results due to increased genetic recombination, but continued crossing and recurrent selection could cause genetic disintegration of co-adapted linkages, developed over centuries in the landraces of chickpea.

Mutation Breeding

Mutation is a constant phenomenon and may occur in any population at a low rate depending on the plant species and the growth environment. Most mutations are undesirable and thus the weaker or less suited mutants do not survive, leaving the fittest ones to perpetuate and contribute further. The mutation rate may be increased by using mutagens (agents capable of causing mutation) such as gamma rays, X-rays, and ethylmethanesulphonate. Ionizing radiation causes changes in the genetic make-up which are permanent and are passed on to the following generations. Although most induced changes are undesirable and the frequency of useful mutations is low, development of methods to maximise mutation rate and efficient screening procedures allow selection of desirable mutations at a higher rate. Mutations which may be lost through the course of evolution can be artificially induced, saved, and made use of in evolving new types to meet changing needs.

Advantages of mutation breeding

1) Mutation breeding can confer a specific improvement on a variety without altering its otherwise acceptable phenotype.
2) Mutation breeding does not disrupt co-adapted linkages of agronomically superior varieties.
3) It can create new and complex loci for resistance which can confer durable resistance.

Varieties with improved resistance can be developed

About 225 varieties of crop plants possessing useful characters have been evolved through mutation induction and of these, 58 varieties have been successfully evolved on the basis of improved disease resistance (14 varieties of barley, 8 of beans, 6 of wheat, 6 of oats, 4 of rice, 4 of durum wheat as well as varieties of soybean, jute, mustard, cotton, peppermint, millet, and sugar cane).

Relevance of induced mutations for breeding resistant varieties

In any breeding program the design should be as simple and inexpensive as possible. To decide whether induced mutation, or some other method, could be used the following criteria should be considered:

1) If effective resistance is already present in cultivars of superior agronomic value, induced mutation is not necessary.
2) If useful and effective resistance is not available among cultivars of superior agronomic value, and a major breeding effort is justified on the basis of the damage caused by the pathogen, as is the case of ascochyta blight, the breeder may choose between a long-term hybridization program, involving one or several primitive parents, or a large scale mutation induction program using the best among the available cultivars.
3) If the required resistance cannot be found in natural cultivars or in gene collections, the breeder must use mutation induction. A typical example is the search for effective resistance against soybean rust (*Phakospora pachyrrhizi*) under tropical conditions in south-east Asia.
4) With crop plants having rare combinations of yield and quality traits or environmental adaptation, breeding for resistance through hybridization may break down the gene combination and the original combination may be lost. An excellent demonstration of the potential of induced mutations is the breeding of disease resistant clonal varieties of *Mentha piperita* and *Mentha cardiaca*. Both plant species are cultivated in the USA for their etheric oil, the quality of which decides the market price. Plants were susceptible to *Verticillium dahlia* but crossing adapted cultivars with resistant wild relatives caused deterioration in the quality of the oil. Irradiation of bales of peppermint rhizomes with thermal neutrons and subsequent natural selection for 6 years led to resistant plants from which two excellent varieties 'Todd's Mitcham' and 'Murray Mitcham' were developed and are now widely grown in USA.

Recommended mutation breeding methodology

A successful mutation breeding experiment requires a clearly defined breeding objective, a suitable parental variety, effective mutagenic treatment, growing of the M_1 generation, handling and selection of the M_2 generation and in the M_3 and subsequent generations, and qualified personnel.

Effective mutagenic treatments

1) *Plant material:* Two or three agronomically superior chickpea cultivars should be used as parent material. Ideally mutation induction may be used if the genotype needs improvement only in one or a few well defined and easily identifiable characters. Wherever possible, promising advanced generation lines from the breeding material may also be used for mutation induction. Dry seeds are best for irradiation because they are easier to plant, with machinery or by hand, and can be stored prior to sowing. The seed moisture content should be 12% before irradiation.
2) *Mutagens:* Preferably two mutagens should be used, a physical mutagen (ionising radiation) and a chemical mutagen like ethylmethane sulphonate (EMS).
3) *Doses:* To select suitable doses, laboratory tests of seedling growth response to various mutagen doses should be conducted because small genetic differences can cause significant changes in radiosensitivity, which influences not only the total rate of mutation but also the spectrum of recoverable mutations. For selection of doses it should be noted that survival rate in the greenhouse is generally higher than in the field. The dose selected should result in 50% M_1 survival.

Population size of M_1

At least 10,000 seeds should be treated/dose and cultivar. Raising the M_1 generation requires comparatively less space, effort, and cost but adds to the chances of success.

Growing the M_1 generation

The M_1 generation should be grown with closer spacing than normal. A spacing of 15cm, row to row, and 10cm, plant to plant, is being practiced at NIAB to restrict primary branching. Along with M_1 material, a control should be grown for comparison of germination, growth, survival, M_1 injury, and sterility, and to assess phenotypic variability. In chickpea, all pods from the main branch and two or three pods from each secondary branch of all the surviving M_1 plants should be harvested separately. Where pod numbers are low, all the seed should be harvested.

Handling and selection of the M_2 generation

The M_2 generation can be raised by the following two methods:

1) Individual M_1 plant progenies can be grown as M_2 families. Although this method requires more labor, mutations are easily detected because more than one mutant will occur in the same progeny. In contrast to selection of mutants in a bulk the mutants selected are known to be genetically identical.
2) Dose-wise bulk of M_2 seeds can be most efficiently practiced in a disease resistance program where mass screening methods on a single plant basis are used. The selection procedure in the M_2 generation depends on the breeding objectives. Macro mutations of any kind can be selected directly and for micro mutations, M_2 plants which appear normal should be selected at random. When searching for disease resistance, however, the selection method is of particular importance. If a mutagen-treated population is infected by a particular pathotype, there will be resistance differences only with regard to this pathotype. If a mixture of pathotypes (a natural population or an artificial mixture) is used there will be resistance to all components of the mixture. With a very high infection pressure, it will not be possible to detect mild forms of resistances, which are not included in the definition of resistance in the strict sense but are nevertheless of potential practical value. The uniformity of inoculation with more or less natural infection pressure is much more appropriate to detect differences in degree of resistance. The breeder should know the threshold limit for tolerable damage and thus aim at a level of resistance that is economically justified.

Selection procedure in M_3 and subsequent generations

The principles of selection in M_3 and subsequent generations are the same as in hybridization programs. M_2 mutants are ordinarily considered homozygous for the selected traits, however, progeny tests are essential to identify all mutant lines. Reselection from the M_3 generation may be necessary to stabilize a potentially useful variant.

Results Achieved at NIAB

Mutation induction experiments on chickpea resistance to ascochyta

blight, using gamma rays and a chemical mutagen have been carried out at NIAB since 1974. The following results have been obtained:

1) Two blight resistant mutants (CM 68, CM 72) and one moderately resistant mutant (CM 359) have been induced from variety 6153. Mutant CM 72 has been approved by the Punjab Government for its release as a variety on the basis of its blight resistance, wider adaptability, and high yield.
2) Three moderately resistant mutants (CM 84/79, CM 88/79, CM 113/79) have been induced from variety C 727. In the 1983 cooperative yield trials conducted at 10 different locations, these mutants gave higher yields than the parent variety and have been included in National Uniform Yield Trials in 1983/84.
3) Ten moderately resistant mutants from C 727 and nine resistant mutants from 6153 in the M_4 generation are being tested in micro yield trials and disease screening nurseries for yields and blight resistance. Depending upon their performance they may be included in multilocation Cooperative Yield Trials and National Yield Trials.
4) Variety CM 72 has been used in a crossing program particularly with the upright and compact plant type, mutant UR 16, induced from variety C 727. From the F_2 population of a cross between CM 72 and UR 16 and its reciprocal, recombinants have been selected with upright growth habit and resistance to blight.

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Production of Chickpea Seeds Free from Ascochyta Blight*

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One of the most important diseases affecting chickpea (*Cicer arietinum*) is ascochyta blight caused by *Ascochyta rabiei*. Infected chickpea seed and debris are important in the epidemiology of the disease (Kaiser 1972; Luthra and Bedi 1932; Sattar 1933; Zachos *et al.* 1963). One approach to the control of ascochyta blight is to produce pathogen-free seed for planting, which is also essential for international exchange of germplasm.

Spread of the Pathogen Through Infected Seed

Infected seed introduces the pathogen into blight-free areas, as occurred in 1973 when ascochyta blight of chickpea was reported for the first time in North America (Morral and McKenzie 1974). Similar introductions by seed occurred in southwestern Iran in 1968 (Kaiser 1972) and Australia in 1973 (Cother 1977a; 1977b). Therefore, great care must be exercised in moving chickpea seed for research and commercial purposes from ascochyta blight infested areas to prevent the introduction of the pathogen into blight-free areas or more virulent strains into regions already infested.

Survival in Infected Seed

A. rabiei survives for extended periods on internally infected chickpea seeds, which may give rise to infected plants under

* Condensed version of Control of Ascochyta Blight of Chickpea through Clean Seed by W.J. Kaiser. Pages 117-122 in Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpea Seeds (Saxena, M.C. and Singh, K.B. eds.), ICARDA, 4-7 May 1981, Aleppo, Syria. Martinus Nijhoff Publishers, The Hague, The Netherlands.

favorable blight conditions. At ICARDA the fungus survived in 65% c infected seed stored for 2 years at room temperature, but it survive for less than 8 months in diseased debris in the field.

Controlling Ascochyta Blight Through Clean Seed

The production and use of ascochyta-free seed is essential to preven spread of the disease to blight-free areas. It may be necessary t use a combination of practices, like crop rotation, field sanitation, and chemical seed treatments to produce blight-free seed. The following five factors are critical in the production of chickpea seed free from *A. rabiei*.

Arid environment

Ascochyta blight needs cool, wet weather to develop and spread. Dry, warm weather impedes disease development and spread, so seed production fields should be in arid areas where little or no rainfall occurs during the flowering and fruiting periods or at harvest. If plants are irrigated during the growing season, this should be done by furrow irrigation rather than overhead sprinkling. In Pakistan, Sind region is suitable for seed multiplication as it is a blight-free area.

Crop rotation

Chickpeas should be grown in rotation with other crops, such as cereals, to prevent the buildup of *A. rabiei* on any infested debris that may be left in the field after harvest. Only chickpeas are susceptible to *A. rabiei*. Ascochyta propagules on chickpea debris lose viability as the debris begins to decompose and certain practices, such as ploughing, speed up debris decomposition.

Field sanitation

A. rabiei can multiply on chickpea debris left in the field after harvest, thereby providing a potential source of fungal inoculum which may initiate new centers of infection from rain-splashed conidia. Therefore, any chickpea debris that remains in the field after harvest should be destroyed by burning or burying.

Chemical seed treatment

Chickpea seeds introduced into an ascochyta blight-free area should be treated with an effective fungicide as a precaution. This is particularly important where the origin of the seed is uncertain. Seed treatment with some of the newer systemic fungicides shows promise in controlling surface and deep-seated seed infection.

The incidence of ascochyta blight in chickpea seedlings in Iran was reduced by more than 80% and emergence increased by over 45% when inoculated seeds were treated with benomyl (Benlate) or thiabendazole (Mertect) (Kaiser 1973). Reddy (1980) reported the eradication of *A. rabiei* in naturally infected chickpea seeds with the systemic fungicide tridemorph (Calixin M), used alone or in combination with benomyl.

Foliar spraying of fungicides

In seed production plots where blight may develop, spraying with Bravo at 7-10 day intervals will prevent infection.

Field inspection

Ascochyta blight can be present in chickpea plantings in low levels which makes detection of the pathogen difficult. Therefore, it is essential that seed production fields are inspected carefully at intervals up to the time of harvest by qualified, trained personnel. These inspections will also be useful in identifying the presence and potential importance of other seed-, soil-, and vector-borne diseases. Field inspections should be coordinated with laboratory tests to detect *A. rabiei* and other seed-borne pathogens on chickpea seeds.

Conclusions

If the above practices are followed, it should be possible to prevent the introduction of ascochyta blight into disease-free areas or significantly reduce or eradicate the disease from infested areas. The success of the clean seed program will be greatly strengthened if seed is produced under arid conditions.

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Laboratory Techniques for Isolation and Multiplication of Ascochyta rabiei

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Isolation of Ascochyta rabiei

The blight pathogen *Ascochyta rabiei* can be isolated from dried or fresh pieces of infected leaves, stems, pods and seeds. Diseased plant pieces are surface sterilized in 0.1% mercuric chloride for 1-3 minutes, depending on the size of the piece and freshness of sample (less time for leaves and fresh samples, more time for seeds, and intermediate for stems and pods). The sterilized pieces are then washed twice in sterile distilled water, dried on sterile filter paper, and placed on agar slants or plates.

Media for Isolation and Multiplication of A. rabiei

For isolation and limited multiplication chickpea seed meal dextrose agar (CSMDA), either in slants or plates, can be used. The medium contains 40 g chickpea seed meal, 20 g dextrose, and 18 g agar/l of distilled water. To prevent bacterial contamination, a mixture of penicillin and streptomycin is added to the medium after cooling to 40°C, and before plating. One ml penicillin (60 mg, 100,000 units in 200 ml sterile distilled water) is added to 10 ml of medium to bring the concentration of penicillin in the medium to 50 units/ml. One ml streptomycin (1 g (745 units/mg) in 750 ml sterile distilled water) is added to 10 ml of medium to bring the concentration of streptomycin in the medium to 100 units/ml.

For large-scale multiplication of *A. rabiei* for use in field inoculations, chickpea seed meal dextrose broth (40 g chickpea seed meal + 20g dextrose + 1 l water) is used. Fifty ml of the medium can be used in 250 ml flasks and for inoculation, either pieces of fungus from agar slants or plates or a spore suspension of fungus in sterile distilled water can be used.

Incubation

A. rabiei grows and sporulates best at 20°C with 24 hr light. The optimum growth and sporulation occurs after 10 days.

Rating of Ascochyta Blight of Chickpea

M.V. Reddy
ICARDA, Aleppo, Syria

A 1-9 scale is conveniently used for scoring blight severity on single plants or groups of plants (row, plot) in pots in the greenhouse or in the field. While scoring blight damage more emphasis is given to breakage of stems and pod infection, as such symptoms are more damaging than lesions on leaves and stems. The scale for scoring blight severity on single plants and groups of plants is as follows:

1. No infection.
2. Infection only on leaves, spots on leaflets, breaking of leaves, and drying. No infection on stems.
3. Infection on stems, lesions less than 6 mm long, no broken or dry branches (single plants); when rows or plots are rated, 1-5% breaking or drying of branches and pod infection.
4. Stem lesions more than 6 mm long, can cause girdling but no breaking or drying of branches (single plants). In rows or plots, 6-15% breaking of branches,drying, and pod infection.
5. 16-40% breaking or drying of branches and pod infection.
6. 41-50% breaking and drying of branches and pod infection.
7. 51-75% breaking and drying of branches and pod infection.
8. 76-100% breaking and drying of branches and pod infection.
9. Complete plant death.

Data Recording in Breeding and Disease Nurseries

Akhlaq Hussain
NARC, Islamabad, Pakistan

Introduction

To evaluate plant material in the field, appropriate parameters should be recorded, depending on the breeding objectives. Such parameters may include:

1. Yield.
2. Yield stability.
3. Disease resistance.
4. Resistance to insect pests.
5. Grain quality and consumer acceptability.
6. Resistance to drought, salinity, and alkalinity.
7. Response to fertilizer and irrigation.
8. Harvest index.
9. Modified plant type.

Field Notebooks

Data may be recorded in notebooks or on loose sheets, clipped together. Both methods should have column headings for most of the characters, and contain the particulars of the experiment or nursery, such as:

1. Nursery information and layout.
2. Randomization table.
3. Sowing plan.
4. Data sheet.

The 1983 Chickpea International Nursery will be used as an example.

Nursery information and layout

Title of nursery	Chickpea International F_3 Trial-1983 (CIF_3T-83)
Number of entries	11
Number of checks	1
Total entries	12
Number of replicates	3
Design	Randomized complete block
Number of rows/plot	4
Row length	4 m
Row spacing	30 cm
Plant spacing	10 cm
Total plot size	4 x 1.2 = 4.8 m^2
Sowing date	
Area harvested	
Seed treatment	If any
Date of harvesting	
Replications	R1 5501 - 5512
	R2 5601 - 5612
	R3 5701 - 5712

Randomization table

Entry Number	Cross (pedigree)	Plot numbers R1	R2	R3
1	ILC-1922xILC-183	5501	5603	5711
2	ILC-190xILC-183	5502	5610	5706
3	ILC-517xILC-200	5503	5611	5710
4	ILC-1920xILC-482	5504	5608	5702
5	ILC-190xILC-194	5505	5605	5704
6	ILC-190xILC-183	5506	5607	5709
7	ILC-493xILC-194	5507	5604	5712
8	ILC-482xILC-1281	5508	5601	5708
9	ILC-482xILC-876	5509	5609	5701
10	ILC-482xILC-190	5510	5602	5703
11	(ILC-1922xILC-1919)xILC-482	5511	5606	5705
12	Local check	5512	5612	5707

Sowing Plan

Rep. I	Rep. II	Rep. III
5501	5601	5701
5502	5602	5702
5503	5603	5703
5504	5604	5704
5505	5605	5705
5506	5606	5706
5507	5607	5707
5508	5608	5708
5509	5609	5709
5510	5610	5710
5511	5611	5711
5512	5612	5712

Field Notes

Days to germination, to 50% flowering, and to maturity, flowering period, stand, disease reaction, insect pest attack, height, number of pods, branches, and plant type should be recorded in the field.

Laboratory Notes

Seed color, size, seed yield/plant and yield/plot, 100-seed weight, and quality parameters should be recorded in the laboratory.

Record Keeping

It is important to keep records to;
1. maintain the pedigree for each variety,
2. handle large numbers of varieties, progenies, and single plant selections, and
3. reduce confusion and mistakes.

Data Scoring

Only those characters which are of importance in the nursery should be scored. Characters which are time consuming to measure may be

scored visually e.g. on scales of 1-5 or 1-9. For effective data scoring;

1. ratings should be consistent; low numbers should represent a desirable characteristic and high numbers represent undesirable characters,
2. as far as possible the scoring of a particular character, such as blight, stand, or lodging, should be carried out by the same person or persons to keep the scoring uniform, and
3. many characters, such as yield components, cannot be measured with visual rating and must be recorded from five or ten plants.

Germination

Germination can be scored either as the number of plants germinated in a row on a given date after planting, or as the number of days from planting to approximately 80-90% emergence. The second method is preferable as it is easy to compare lines using a single score. In scoring characters which vary with time (germination, flowering, or maturity), it is best to score the nursery at regular intervals.

Flowering

Flowering is scored when 50% of the plants in a row have flowered. The end of flowering can be scored as the number of days from planting until 50% of plants cease to flower. The flowering period or flowering duration is the difference between these two scores.

Maturity

This is the number of days from planting to a given stage of maturity e.g. 90% of plants in a row are ready for harvest; plants become yellow, lower leaves on the stems start shedding, pods and seeds harden.

Stand

This score can be carried out by visual observation and rating from 1-5, for example:

1. 90% complete stand = very good.
2. 80-89% = good.
3. 70-79% = acceptable.

4. 60-69% = poor.
5. 60% = very poor.

When dealing with a limited number of nurseries, the number of plants/meter can be counted.

Plant Type

This score is essential for classifying plant growth in a breeding nursery, e.g. branching, leaf size, etc.

Branching

Branches are grouped into two main classes, primary and secondary, which can be counted on five randomly selected plants from each row.

Plant Height

Plant height can be measured at the end of flowering from the soil surface to the upper tip of the plant.

Lodging

This is best scored on a visual basis using a 1-5 rating scale:

1. No lodging.
2. Less than 25% plants lodged.
3. 25-50% lodged.
4. 50-75% lodged.
5. More than 75% lodged.

Vigor

A visual estimate of plant vigor is useful, using a 1-5 scale:

1. Outstanding.
2. Very good.
3. Good.
4. Poor.
5. Very poor.

Insect Pests

Insect pest damage assessment is done on a visual rating scale of 1-5 at regular intervals during the season.

1. No damage.
2. Less than 10% of plants or pods affected.
3. 11-20% plants or pods affected.
4. 21-40% plants or pods affected.
5. More than 40% plants or pods affected.

Disease

Ascochyta Blight

Vir and Grewal (1974) suggested a 5-point scale for screening chickpea plants against ascochyta blight, while Morrall and McKenzie (1974) developed a 6-point scale for use in the field.

Though different researchers have used different scales for measuring disease severity of gram blight, the scale 1-9 is generally used by pathologists currently working at ICARDA and ICRISAT. For example:

1. No disease visible on any plant (highly resistant).
3. Lesions visible on less than 10% of the plants, no stem girdling (resistant).
5. Lesions visible on up to 25% of the plants, stem girdling on less than 10% of the plants but little damage (tolerant).
7. Lesions present on most plants, stem girdling on less than 50% of the plants resulting in the death of a few plants and causing considerable damage (susceptible).
9. Lesions profuse on all plants, stem girdling present on more than 50% of plants, death of most of the plants (highly susceptible).

Scientists at NARC score for blight resistance at preflowering, 50% flowering, and pod formation.

Root Rot, Wilt, and Viruses

A 1-9 scale is used:

1. No infection (resistant).
3. Less than 1% plants affected (moderately resistant).
5. 2-5% of plants affected (tolerant reaction).
7. 6-10% of plants affected (moderately susceptible).
9. 10% of plants affected (highly susceptible).

Pods

The number of pods/plant is recorded from five plants in each row. The average number of pods/plant has a very high correlation with yield and may be a useful score in breeding programs for selection in F_3 or F_4 lines.

Seeds

Number of seeds/pod can be recorded from five to ten pods. To estimate 100-seed weight, two to three samples of 100 seeds can be taken either from the bulk of randomly-selected plants or from the row bulk.

Yield

Yield is measured on a plant and on a plot basis. Yield/plot should be recorded from central rows to avoid border effects.

Harvest Index

This is measured as a percentage:

$$HI\% = \frac{\text{Economic yield} \times 100}{\text{Biological yield}}$$

It is an estimate of the physiological efficiency of genotypes.

Other Characters

There are many other characters which can be recorded such as flower color, plant pigmentation, hairiness, nodulation, and reaction to nutrient deficiencies.

General Recommendations for Growing Nurseries

1. Planting should be done at an appropriate sowing date.
2. Fertilizer should be applied at recommended doses.

3. Nurseries should be irrigated only if this is traditional practice or the weather is so dry there is a need to save the germplasm.
4. Insect pest control and weeding of the plots should be practiced wherever required.

References

Morrall, R.A.A. and McKenzie, D.L. 1974. A note on the inadvertant introduction to North America of *Ascochyta rabiei*, a destructive pathogen of chickpea. Plant Disease Reporter 58: 342-345.

Vir, S. and Grewal, J.S. 1974. Physiologic specialization in *Ascochyta rabiei* the causal organism of gram blight. Indian Phytopathology 27: 355-360.

Crossing Techniques in Chickpea (Cicer arietinum L.)

Akhlaq Hussain
NARC, Islamabad, Pakistan

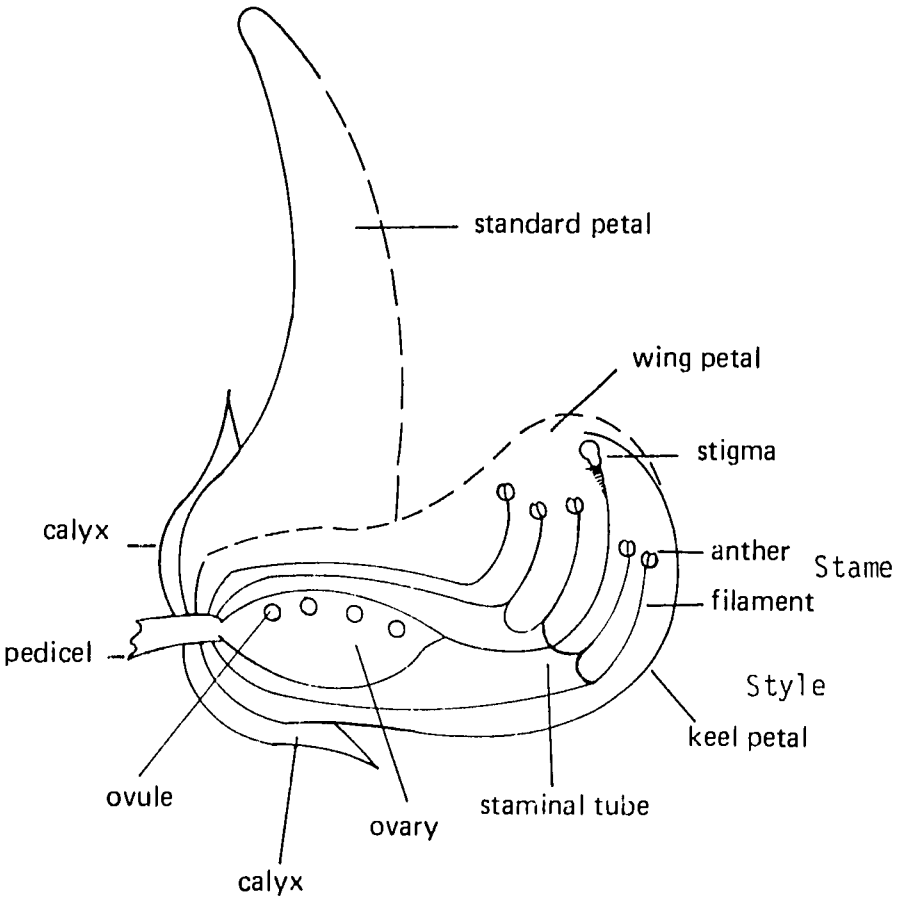
Flowers

The flowers of chickpea (*Cicer arietinum* L.) are papilionaceous, zygomorphic, solitary, and borne on short joined penduncles (Fig. 1). Pedicels arise from the leaf axil and are situated opposite the leaves. The calyx tube is oblique, gamosepalous, and densely covered with glandular hairs. The corolla consists of standard petals with colored forking veins. The wings are almost half as broad as the standard petal and inside the wings there is the keel, enclosing the reproductive organs. There are ten (9+1) stamens and the anthers are bicelled, orange, and basifixed. The floral formula for *Cicer* sp. is K(5) C(2+2+1)A (9+1)G1.

Pollen from half-open flowers, in which anthers have just burst, is best for artificial hybridization as pollen viability remains constant throughout the flowering period. The number of flowers produced /day/plant is 1.25-3.46 (Malik *et al.* 1982) and natural pod setting varies from 18 to 59% (Aziz *et al.* 1960).

Although chickpea is naturally a self-pollinated plant, about 1.6% cross pollinations accrue from wild bees (Niknejad and Khosh-Khui 1972). Natural self-pollination occurs 12-24 hr before the flower opens i.e., when the keel is still closed and foreign pollen cannot reach the stigma. Fertilization takes place 24 hr after pollination. The color of the flowers is a varietal character, and may be white, greenish white, or with various shades of pink or blue. The pink flowers fade to blue as they wither.

Figure 1. Diagrammatic representation of a longitudinal section of a typical papilionaceous flower.



Crossing Techniques

Equipment

Fine forceps, 95% alcohol for forceps sterilization, thread, tags, a magnifying lens, and a lead pencil are required for crossing.

Techniques

Floral buds in the hooded stage (corolla has elongated and anthers are about half the height of the style) should be selected, as the stigma in such buds is highly receptive. These buds should be held lightly at the base between thumb and first finger. The front sepal should be drawn back or snipped off and standard petals should be held slightly back by pressing with the index finger to facilitate emasculation. The keels may now be easily opened when manipulated by forceps and on opening, the stigma and stamens are exposed. Stamens must be removed with great care. The stigma is higher in relation to the pollen sacs, and this facilitates the removal of anthers without any pollen touching the stigma. Singh and Auckland (1975) reported 24% pods set when artificial pollination was done the same day as emasculation and 15% when it was done the day after emasculation. However, the success rate of individual persons ranged from 5-50%. Eser (1977) reported only 10-20% success with pollination done the day after emasculation, but 70-80% when emasculation was followed by immediate pollination. The high success rate was also attributed to early morning hybridization (7-10 hours).

References

Aziz, M.A., Khan, M.A. and Shah, S. 1960. Causes of low setting of seed in gram (*Cicer arietinum*). Agriculture Pakistan 11: 37-48.

Eser, D. 1977. Personal communication. Plant Growing and Breeding Department, Faculty of Agriculture, University of Ankara, Turkey.

Malik, B.A., Hussain, S.A., Haqqani, A.M. and Choudhary, A.H. 1982. Pakistan Journal Agricultural Research 3(1): 1-5.

Niknejad, M. and Khosh-Khui, M. 1972. Natural cross pollination in gram (*Cicer arietinum* L.) Indian Journal of Agricultural Science 42(4): 273-274.

Singh, K.B. and Auckland, A.K. 1975. Chickpea breeding at ICRISAT Pages 3-17 *in* Proceedings of a Workshop on Grain Legumes, ICRISAT, Hyderabad, India.

PROGRAM

Saturday March 2	Arrival of trainees at at NARC Training Institute and assignment of rooms	Dr M. Sarfraz Khan Rana, NARC
Sunday March 3		
08.00 - 09.00	Registration	Dr H. Ibrahim (ICARDA) Mr & Mrs Khalique Ahmed, NARC
	Inaugural Session	
09.00 - 09.05	Recitation from the Holy Quran	
09.05 - 09.20	Welcome address	Dr G.R. Sandhu, Director General, NARC
09.20 - 09.50	Overview of the Food Legume Program of ICARDA with emphasis on chickpea improvement	Dr K.B. Singh (ICARDA)
09.50 - 10.10	Inaugural address	Dr M.Yousef Chaudri, Member (Crop Science) PARC
10.10 - 10.20	Vote of thanks	Dr H. Ibrahim (ICARDA)
10.20 - 11.00	Tea	
	Technical Session	
11.00 - 11.30	Chickpea in Pakistan with emphasis on ascochyta blight	Mr Bashir Malik
11.30 - 12.30	Ascochyta blight disease on chickpea: occurrence, symptoms, biology, and control	Dr M.V. Reddy

Blight Resistance in Chickpeas

Monday March 4		
08.00 - 10.00	Screening techniques	Dr M.V. Reddy
10.00 - 10.30	Tea	
10.30 - 13.00	Identification of disease in the field	
14.00 - 16.00	a. Inoculation of chickpea plants in the field and the layout of nurseries	Dr M.V. Reddy
	b. Rating of disease in the field	Dr M.V. Reddy
Tuesday March 5		
08.30 - 10.00	Occurrence and distribution of ascochyta blight in Pakistan	Dr S.H. Qureshi
10.00 - 10.30	Tea	
10.30 - 12.30	Laboratory techniques: isolation, multiplication of the fungus	Dr S.H. Qureshi
13.30 - 14.30	*Ascochyta rabiei:* races and their implication in chickpea breeding	Dr S.H. Qureshi
Wednesday March 6		
08.00 - 09.00	Identification and control of ascochyta blight on chickpeas	Mr A. Saleem
09.00 - 10.00	Visit to chickpea pathology experimental plots	Dr S.H. Qureshi

10.00 - 12.00	Data recording in breeding and disease nurseries	Dr A. Hussain
13.00 - 14.30	Visit to chickpea breeding experimental plots	Dr A. Hussain
Thursday March 7		
08.30 - 10.00	Crossing technique and layout of crossing block	Dr A. Hussain
10.30 - 12.00	Data recording practical	Dr A. Hussain
12.30 - 14.00	a. Insect pests of chickpeas	Mr Khalique Ahmed
	b. Laboratory techniques: isolation, multiplication of the fungus	Dr S.H.Qureshi
14.00 - 15.00	Chickpea cultivation in Sind	Mr N.M. Merchant
Friday March 8		
08.30 - 10.30	Role of fungicides in control of ascochyta blight	Dr M.B. Illyas
10.30 - 12.00	Crossing practical	Dr A. Hussain
13.30 - 15.30	a. Slow blighting	Dr M.B. Illyas
	b. Chickpea cultivation in Punjab	Dr M. Tuffail
Saturday March 9	Visit to BARI Chakwal	
Sunday March 10		
08.00 - 10.00	Mutation breeding	Mr M.Ahsanul Haq
10.30 - 12.30	Chickpea breeding in Pakistan	Mr B.Malik
18.00 - 20.00	Graduation ceremony	

LIST OF TRAINEES

1. Abdul Wadoud	Gram Botanist, Agricultural Research Station, Ahmadwala, Karak (NWFP)
2. Fateh Ullah Khan	Assistant Plant Pathologist, Agricultural Research Station, Ahmadwala, Karak.
3. Bashir Ahmad	Assistant Research Officer, Agricultural Research Institute, Tarnab, Peshawar (NWFP)
4. Nazar Hussain Khilliji	Assistant Botanist (Oilseeds), Agricultural Research Institute, Sariab, Quetta.
5. Mohammed Illyas	Assistant Plant Pathologist, Agricultural Research Station, Bahawalpur.
6. Faqir Muhammed	Research Officer, Gram Project, University of Agriculture, Faisalabad.
7. Abdul Quddus	Research Assistant, Gram Project, University of Agriculture, Faisalabad.
8. Muhammed Iqbal Chohan	Assistant Plant Pathologist (Pulses), Ayub Agricultural Research Institute, Faisalabad.
9. Waqar Ahmed	Assistant Plant Pathologist (Pulses), Ayub Agricultural Research Institute, Faisalabad.
10. Abdel Ghafoor	Assistant Botanist (Pulses) Gram Breeding Sub-station, Kallurkot, Distt. Bhakkar.
11. Maqsood Ahmed Sheikh	Assistant Research Officer, Gram Breeding Sub-station, Attock.

12. Noor Mohammed Zafar	Assistant Botanist, (Cereals) BARI, Chakwal Distt. Jhelum.
13. Sonomal	Assistant Research Officer, Pulses Research Station, Dokri. Sind.
14. Muhammed Bashir	Scientific Officer (Pulses), NARC, Islamabad.
15. Mohammed Tahir	Scientific Officer (Pulses), NARC, Islamabad.
16. S.M.Sarwar Alam	Scientific Officer (Pulses), NARC, Islamabad.
17. Mohammed Zubair	Scientific Officer (Pulses), NARC, Islamabad.

LIST OF INSTRUCTORS

A. Instructors from Pakistan

1. Bashir Ahmed Malik, MSc (Plant breeding),
   National Coordinator (Food Legumes),
   National Agricultural Research Center,
   P.O. National Institute of Health,
   Islamabad.

2. Sajjad Hussain Qureshi, PhD (Plant pathology),
   Senior Scientific Officer (Plant Pathology),
   National Agricultural Research Center,
   P.O. National Institute of Health,
   Islamabad.

3. Akhlaq Hussain, PhD (Plant breeding),
   Senior Scientific Officer (Pulses),
   National Agricultural Research Center,
   P.O. National Institute of Health,
   Islamabad.

4. Mohammad Tufail, PhD (Plant breeding),
   Director (Pulses),
   Ayub Agricultural Research Institute,
   Faisalabad.

5. Mohammad Bashir Ilyas, PhD (Plant pathology),
   Assistant Professor,
   Department of Plant Pathology,
   University of Agriculture,
   Faisalabad.

6. Mohammad Ahsanul Haq, MSc (Plant breeding and genetics),
   Senior Scientific Officer,
   (Mutation Breeding),
   Nuclear Institute for Agriculture and Biology,
   Faisalabad.

7. Nazir Muhammed Merchant, BSc (Plant pathology),
   Plant Pathologist,
   Ayub Agricultural Research Institute,
   Faisalabad.

8. Ahmad Saleem, MSc (Plant pathology),
   Plant Pathologist,
   Ayub Agricultural Research Institute,
   Faisalabad.

9. Ghulam Ahmed Chaudary, MSc (Plant breeding),
   Director, Barani Agricultural Research Institute,
   Chakwal, Pakistan.

B. Instructors from ICARDA

1. M.V.Reddy, PhD (Plant pathology),
   Senior Chickpea Pathologist ICRISAT,
   ICARDA, P.O.BOX 5466,
   Aleppo, Syria.

2. K.B.Singh, PhD (Plant breeding),
   Principal Chickpea Breeder ICRISAT,
   ICARDA, P.O.Box 5466,
   Aleppo, Syria.

3. M.E.Habib Ibrahim, Senior Training Officer
   ICARDA, P.O.Box 5466,
   Aleppo, Syria.