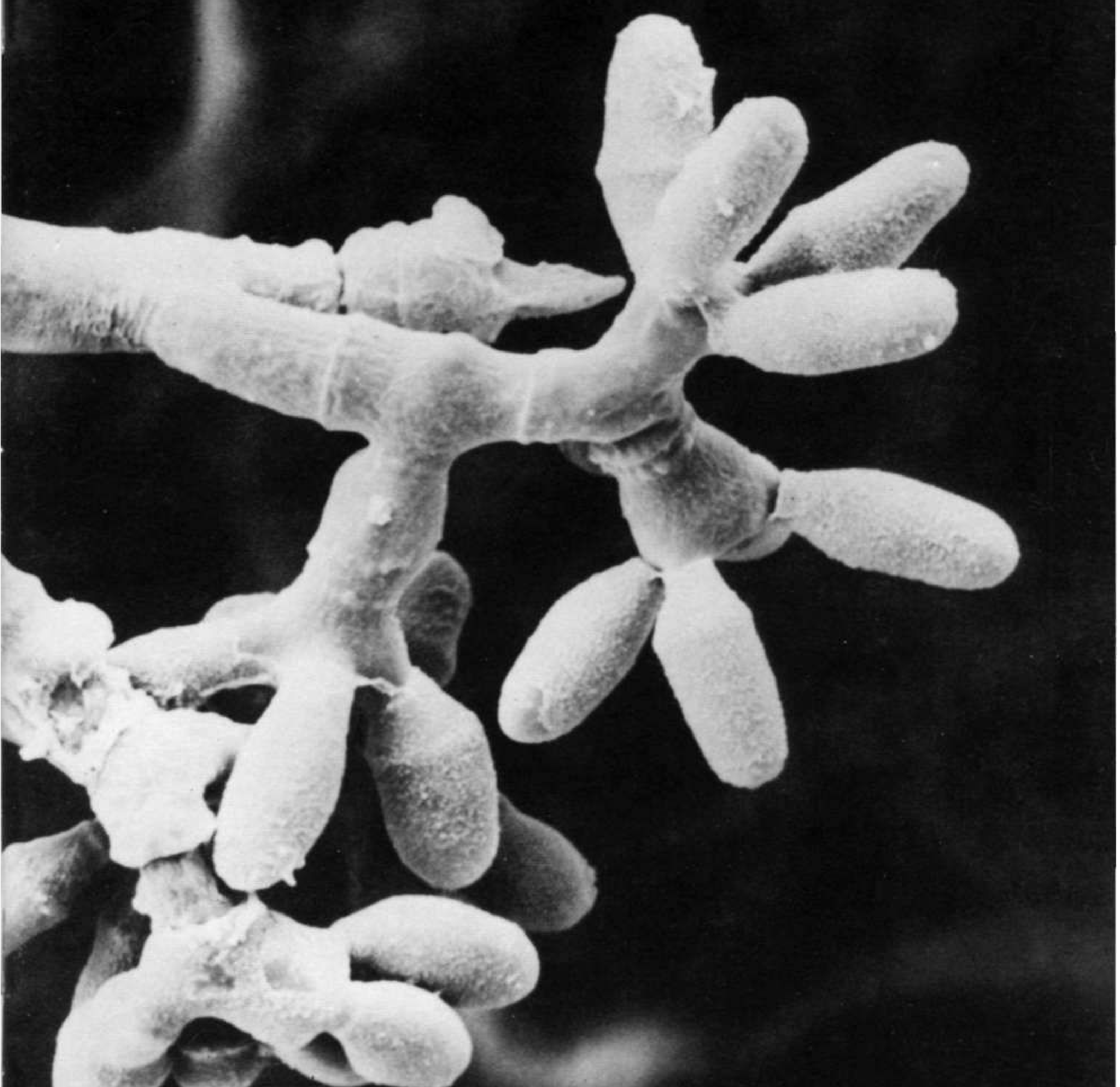
Botrytis Gray Mold of Chickpea

Recent Advances in Research



International Crops Research Institute
for the Semi-Arid Tropics

Abstract

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Botrytis gray mold (BGM) is a crucial biotic constraint to chickpea production in several South Asian countries. This publication contains summaries of the findings and recommendations made at the Second Working Group Meeting on BGM of chickpea (Rampur, Nepal, 14-17 Mar 1993). Research progress during the past two years in India, Bangladesh, Pakistan, and Nepal is reviewed. The present status of BGM management, and future research priorities, are discussed. Nine papers on BGM of chickpea are presented, dealing with such aspects as resistance screening and multilocational trials, breeding programs, disease management, and the role of crop microclimate. The discussions suggest that since high level resistance is presently unavailable, an integrated disease management program should be pursued, using a combination of moderately resistant cultivars, modified cultural methods, and judicious use of chemicals.

Résumé

Progrès récents de la recherche sur la pourriture grise du pois chiche due à botrytis: comptes rendus de la deuxième réunion du Groupe de travail pour discuter la recherche coopérative sur la pourriture grise du pois chiche due à botrytis, 14–17 mars, Rampur, Nepal. Dans plusieurs pays de l'Asie, la pourriture grise du pois chiche due à botrytis constitue une importante contrainte biotique à la production de cette culture. Cet ouvrage contient un compte rendu des résultats et des recommandations présentés à la Deuxième réunion du groupe de travail sur la pourriture grise du pois chiche due à botrytis (Rampur, Népal, 14–17 mars 1993), et la publication fait le point des progrès de recherche pendant les deux dernières années en Inde, au Bangladesh, au Pakistan et au Népal. L'état actuel de la gestion de cette maladie ainsi que les priorités de recherche future sont discutés. Sont incluses également, neuf communications sur la pourriture grise du pois chiche due à botrytis, traitant des aspects tels le criblage pour la résistance et des essais multilocaux, programmes de sélection, gestion de la maladie, ainsi que le rôle du microclimat de la culture. Etant donné la non disponibilité actuelle d'un haut niveau de résistance, les discussions laissent croire qu'un programme intégré de gestion de maladie doit être visé, faisant appel à des cultivars à résistance modérée, des méthodes culturales modifiées et l'usage judicieux des produits chimiques.

Resumen

Progresos redentes en la investigation del moho gris botritis de garbanzo: actas de la segunda reunion del Grupo de trabajo a discutir investigation colaborativa sobre el moho gris botritis de garbanzo, 14-17 de marzo de 1993, Rampur, Nepal. El moho gris botritis es una importante constriccion biotica a la producci6n de garbanzo en muchos paises de Asia. Esta publicacion contiene resumenes de las recomendaciones hechas en la segunda reunion del Grupo de trabajo sobre el moho gris botritis de garbanzo (Rampur, Nepal, 14-17 de marzo, 1993.) El progreso alcanzado en las investigaciones durante los ultimos dos anos en India, Bangladesh, Pakistan y Nepal y tambien se discuten las prioridades futuras de la investigacion asi como el estado presente del manejo del moho. Se presentan nueve comunicaciones sobre el moho gris de garbanzo tratando de aspectos como pruebas de resistencia y pruebas multilocacionales, programas de crianza, manejo de enfermedades y el papel que desempena el microclima de la cosecha. Las discusiones sugieren que dado que por el momento no se dispone de un alto nivel de resistencia, se debe seguir un programa integrado de manejo de enfermedades utilizando una combinaci6n de cultivares moderadamente resitentes, metodos modificados de cultivo y uso prudente de productos quimicos.

Cover: Clusters of conidia at the tips of *Botrytis cinerea* conidiophores (scanning electron micrograph, x 3500).

Recent Advances in Research on Botrytis Gray Mold of Chickpea

Summary Proceedings
of the Second Working Group Meeting
to discuss collaborative research on
Botrytis Gray Mold of Chickpea

14-17 March 1993
Rampur, Nepal

Edited by

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Contents

Introduction

Dr P. Amatya, Executive Director, Nepal Agricultural Research Council (NARC), in his opening address welcomed the participants to Nepal for the Second Botrytis Gray Mold of Chickpea Working Group Meeting. He pointed out that 90% of the population in Nepal depends on agriculture for its livelihood, and that chickpea is one of the most important grain legume crops in Nepal (cultivated on 28 000 ha, annual production 16 600 t). Botrytis gray mold (BGM) is the most important constraint to chickpea production in Nepal, and so it was fitting that the Working Group Meeting should be organized by the Cereals and Legumes Asia Network (CLAN) in collaboration with NARC. Dr Amatya expressed his hope that the coordinated research on BGM would eventually lead to increased chickpea production in Asia.

CLAN coordinates a number of working groups that have been set up to address specific problems of ICRISAT mandate crops in the Asia Region. BGM of chickpea is one such important problem in Bangladesh, Nepal, parts of Pakistan, and in the submontane regions of Uttar Pradesh and Bihar in India. The disease has also been recorded in Myanmar.

BGM becomes serious following frequent rains that cause high humidity and excessive plant growth, factors which favor both spread and severity of the disease. Only low levels of resistance to BGM have been found so far in chickpea. Although some lines show little or no damage in the vegetative stage, they may suffer severe flower infection and do not set pods. An interdisciplinary, collaborative approach was considered to be necessary to find ways to manage the disease. In view of this, the first Working Group Meeting was held at Joydebpur, Bangladesh, during 4-8 Mar 1991, where participants agreed to create an informal network or 'Working Group' to coordinate research activities.

We wish to thank the Asian Development Bank (ADB) and ICRISAT for providing funds to hold this meeting, and NARC for hosting and organizing it.

At the first Working Group Meeting a work plan was developed to organize and facilitate collaborative research work at various research centers in Bangladesh, India, Nepal, and at ICRISAT. The work plan envisaged four major research components: surveys, genetic resistance, cultural practices, and epidemiology. The presentations made at this meeting are based essentially on the work plan. The research carried out to date was reviewed, and future plans were recommended for collaborative research under the Working Group.

Editors

Summaries

Botrytis Gray Mold of Chickpea

M.P. Haware and D. McDonald[1]

Chickpea (*Cicer arietinum* L.) is the third most important grain legume in the world after the common bean and the pea. It is particularly important as a source of protein to the largely vegetarian population of South Asia. Though the yield potential of present-day chickpea cultivars exceeds 5 t ha^{-1}, their actual yields are only in the region of 0.7 t ha^{-1}. The gap between actual and potential yields is mainly due to the depredations of diseases and pests. Botrytis gray mold (BGM) is an important disease affecting chickpea in South Asian countries. It has been reported from India, Pakistan, Nepal, and Bangladesh, and we recently noted its occurrence in Myanmar.

In view of the destructive potential of the disease in South Asia, a Working Group Meeting was held at Joydebpur, Bangladesh, during 4-8 Mar 1991 to discuss how best to address the problem. In this paper we endeavor to highlight the progress of research on BGM of chickpea during the last 2 years.

Host resistance

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in collaboration with G.B. Pant University of Agriculture and Technology, established a BGM nursery at Pantnagar, India, to screen germplasm and breeding materials for resistance to the disease. During the 1990/91 and 1991/92 postrainy seasons a large number of F_3, F_4, F_5, and F_6 progenies and bulk populations were screened in the nursery. Lines showing resistant reactions as measured on a 1-9 point scale (1 - free from disease, 9 - killed) were selected. High levels of resistance (3 or below) are not yet available.

We plan to systematically screen chickpea germplasm in a growth room under controlled conditions (25°C; RH 100% for 3 days and 70-80% for the next 7 days) for reaction to BGM.

BGM resistance in wild *Cicer*

Thirty-six accessions belonging to seven annual wild *Cicer* species were evaluated for their reaction to BGM in the controlled environment growth room at ICRISAT Center. All accessions of *Cicer judaicum, C. yamashitae, C. cuneatum, C. reticulation, C. echinospermum,* and C. *pinnatifidum* were susceptible. Three accessions of C. *bijugum* (ICCWs 41, 42, and 91) were resistant (a rating of <3 on a 1-9 scale) to the disease. Two of these (ICCW 41 and ICCW 42) were also resistant to ascochyta blight.

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Multilocational testing

Over 100 promising lines were screened in the BGM nurseries at Ishurdi (Bangladesh), Rampur (Nepal), and Pantnagar (India). Fourteen lines showed field resistance to BGM at Ishurdi and Pantnagar (Table 1).

Table 1. Reactions of 14 chickpea genotypes to botrytis gray mold at Ishurdi (Bangladesh) and Pantnagar (India), postrainy season 1991/92.

	Disease rating[1]		
Genotype	Ishurdi	Pantnagar	Mean
ICC 6304	3.0	3.5	3.2
ICC 7322	5.0	3.5	4.2
ICC 7568	5.0	4.5	4.7
ICC 7670	4.0	3.2	3.6
ICC 8529	5.0	4.7	4.8
ICC 12512	5.0	4.7	4.8
ICC 12961	3.5	3.2	3.3
ICC 13816	5.0	4.7	4.8
ICC 15980	5.0	5.0	5.0
ICC 15991	5.0	4.7	4.8
GG829	4.0	5.0	4.5
GL 85056	3.0	5.0	4.0
GL 85103	3.0	4.5	3.7
GL 85105	4.5	4.2	4.3
H 208 (control)	6.9	7.5	7.2
Location severity index (mean of 115 entries)	6.4	5.4	

1. Average of two replications scored on a 1-9 scale, where 1 - free from disease, 9 - killed.

Integrated disease management

Screening of chickpea germplasm has not revealed any accession with high levels of resistance to BGM. The spread of BGM is facilitated by high relative humidity in the crop canopy. Thus, in environments favorable to the disease, tall, erect genotypes of chickpea have less disease incidence than compact, spreading genotypes. Field trials on integrated disease management were conducted at Pantnagar in the 1991/92 postrainy season.

A tall, erect genotype, ICCL 87322, was sown on 30 Oct 1991 at four different plant row spacings: in single rows 30 cm and 60 cm apart, and in paired rows at 45:15:45 and 60:40:60 cm. Plant to plant spacing within rows was 10 cm. One set of plots at each spacing was sprayed with 0.2% vinclozolin (Ronilan®) on 14 and 28 Feb 1992.

ICCL 87322 had lower disease levels when sprayed. At wider spacings there was less disease and higher grain yields than at closer spacings in both fungicide-sprayed and nonsprayed plots. These results indicate that it is possible to manage BGM in chickpea by sowing tall and erect genotypes (moderately resistant) at wider spacing with judicious use of fungicides (Table 2).

Table 2. Effect of plant spacing and fungicide sprays on botrytis gray mold severity and grain yield in chickpea cultivar ICCL 87322, Pantnagar, postrainy season 1991/92.

Interrow spacing (cm)	Disease rating[1]		Yield (t ha^{-1})	
	Sprayed[2]	Nonsprayed	Sprayed	Nonsprayed
Single row				
30	5.0 (2.2)[3]	6.0 (2.7)	2.0	1.4
60	3.7(1.9)	5.0(2.2)	2.2	1.6
Paired row[4]				
45:15:45	4.0 (2.0)	5.0 (2.2)	2.1	1.4
60:40:60	3.0(1.7)	4.0(2.7)	1.9	1.5
SE				
Spacing	(±0.02)		±0.11	
Spraying	(±0.01)		±0.13	
Spacing x spraying	(±0.03)		±0.19	
CV (%)	2.7		16.5	

1. Final disease rating on a 1-9 scale, where 1 - free from disease, 9 - killed.
2. Fungicide vinclozolin (Ronilan®) (0.2%) sprayed on 14 and 28 Feb 1992.
3. Figures in parentheses are based on square root transformation.
4. Two plant row spacings were used: 45 cm alternating with 15 cm, and 60 cm alternating with 40 cm.

The effects of date of sowing and growth habit on BGM were studied in five chickpea genotypes at Pantnagar. The genotypes were sown on four dates at 2-week intervals from 31 Oct to 14 Dec 1991. Of the five genotypes tested, ICCL 87322 and ICCV 88510 were tall and erect, and moderately resistant. H 208 was semispreading and highly susceptible to BGM, Pant G 114 was semispreading, and K 850 was semierect. Date of sowing influenced the disease severity in all the genotypes. Delayed sowing in November-December resulted in low levels of disease, even in susceptible cultivars, probably because of reduced growth and canopy development. However, there was significant reduction in yield in late-sown plots (Table 3). It may be possible to manage BGM of chickpea by manipulating the date of sowing, but we need to identify chickpea genotypes that can perform better when sown late.

Table 3. Influence of date of sowing and growth habit of 5 chickpea genotypes on botrytis gray mold severity and grain yield, Pantnagar, postrainy season 1991/92.

	Disease rating[1]				Plot yield (kg)[2]			
Cultivar	31 Oct[3]	14 Nov	29 Nov	14 Dec	31 Oct	14 Nov	29 Nov	14 Dec
H 208	7.2 (2.0)[4]	7.0 (1.9)	5.2 (1.7)	4.2 (1.4)	1.0	1.1	1.0	0.9
Pant G 114	6.0 (1.9)	5.7 (1.7)	4.0 (1.4)	3.2 (1.2)	1.2	1.0	1.0	0.7
K 850	6.7 (1.9)	5.7 (1.8)	4.7 (1.6)	4.0 (1.4)	1.3	1.1	0.9	0.9
ICCV 88510	5.0 (1.6)	4.5 (1.5)	3.7 (1.3)	2.7 (1.0)	1.6	1.4	1.0	0.9
ICCL 87322	4.5 (1.5)	4.0 (1.4)	3.5 (1.2)	2.5 (0.9)	1.4	1.5	1.1	0.8
Mean	5.9 (1.8)	5.4 (1.7)	4.2 (1.4)	3.3 (1.2)	1.3	1.2	1.0	0.8
SE								
Cultivar		(±0.03)				±0.07r		
Sowing date		(±0.05)				±0.1C		
Cultivar x sowing date		(±0.07)				±0.15		
CV(%)		7.3				25.9		

1. Average of four replications scored on a 1-9 scale, where 1 - free from disease, 9 - killed.
2. Plot size: 2 x 4 m.
3. Denotes sowing dates.
4. Figures in parentheses are based on square root transformation.

Conclusions

High level resistance to BGM is not yet available in chickpea. Germplasm enhancement by crossing among less susceptible lines, and by utilizing wild *Cicer* species are suggested as promising ways to improve resistance and thereby increase yields at the farm level.

Integrated disease management should be a regular practice in chickpea production. Indications are that judicious use of fungicides, manipulation of sowing date, use of wider row spacing, and growing tall and erect genotypes could increase yields of chickpea in BGM disease-prone areas.

How Important is Crop Microclimate in Chickpea Botrytis Gray Mold?

D.R. Butler[1]

Plant diseases are caused by microscopic organisms, which in turn are influenced by their immediate environment, the microclimate. What matters to a fungal spore on the surface of vegetation is the state of the surface; its temperature, whether it is wet or dry, and if it is dry, the humidity within the laminar boundary layer. The surface conditions in turn depend on the prevailing weather; the temperature and humidity of the bulk air, solar radiation, cloud cover, wind speed, and precipitation. In relating disease development to weather, we need to know whether it is satisfactory to use standard measurements of variables on a meteorological site or whether knowledge of the crop microclimate is important. There is no straightforward answer to this question, because the answer itself depends on the weather, the crop characteristics, and the pathogen behavior. In this paper I will attempt to illustrate conditions where the crop microclimate may or may not have a strong influence on disease.

Current knowledge

Many comments at the BARI/ICRISAT1991 Working Group Meeting to discuss collaborative research on botrytis gray mold (BGM) of chickpea indicate that weather is an important factor in BGM. In introducing the recommendations of the Working Group it was stated that 'incidence and severity of BGM is highly dependent on environmental factors' (Haware et al. 1992). Agronomic practices that minimized yield losses due to BGM were perceived to affect the disease mainly by 'creating a microenvironment less favorable to its development'. However, I wonder whether we have sufficient information to substantiate that statement.

Associations have been made between disease severity and canopy density after heavy or frequent rainfall early in the crop season (Tripathi and Rathi 1992, Bakr and Ahmed 1992). Rainfall would influence the disease in two ways: by its direct effect on the pathogen and by promoting vegetative crop growth early in the season, leading to a dense canopy. These two effects should be distinguished, since the role of microclimate is likely to be more important in the second case.

It is thought that conidia require free water on the plant surface for infection (Haware and McDonald 1992), although Rewal and Grewal (1989) observed germination of one strain of *Botrytis cinerea* at 75% relative humidity (RH) in vitro. Various strains of *B. cinerea* differ in the way that light, temperature, and RH affect conidial germination (Rewal and Grewal 1989).

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Disease symptoms are affected by weather. Flower drop and rotting of plant parts are conspicuous in cloudy weather. Discrete brown spots develop on leaflets with high humidity and low temperature; and chlorosis and defoliation occur at high temperature (Haware and McDonald 1992).

Required knowledge

To assess the importance of microclimate in disease, we need quantitative information on the crop microclimate and on the response of the pathogen to its environment. A typical relationship between infection and surface wetness duration is illustrated in Figure 1. The shape of the curve is similar for many foliar diseases, but the parameter values vary with different pathogen/host combinations. I do not know the parameter values for BGM so, for the purpose of this illustration, I have assumed that the minimum wetness period for infection is a little under 4 h, and that 90% infection occurs after 15 h of wetness.

Let us consider two crops, one dense and the other sparse. We would expect surface wetness to persist longer in the dense crop, and it is reasonable to assume that the dense crop remains wet 4 h longer than the sparse crop each time a wetting event occurs.

We first examine a situation where wetness persists on the dense crop for 8 h each day. There would be 4 h of wetness in the sparse crop, insufficient for substantial infection, but in the dense crop 8 h of wetness would be sufficient for 60% of the maximum possible infection (Fig. 1). In this case, therefore, the crop microclimate would have a dramatic effect on disease.

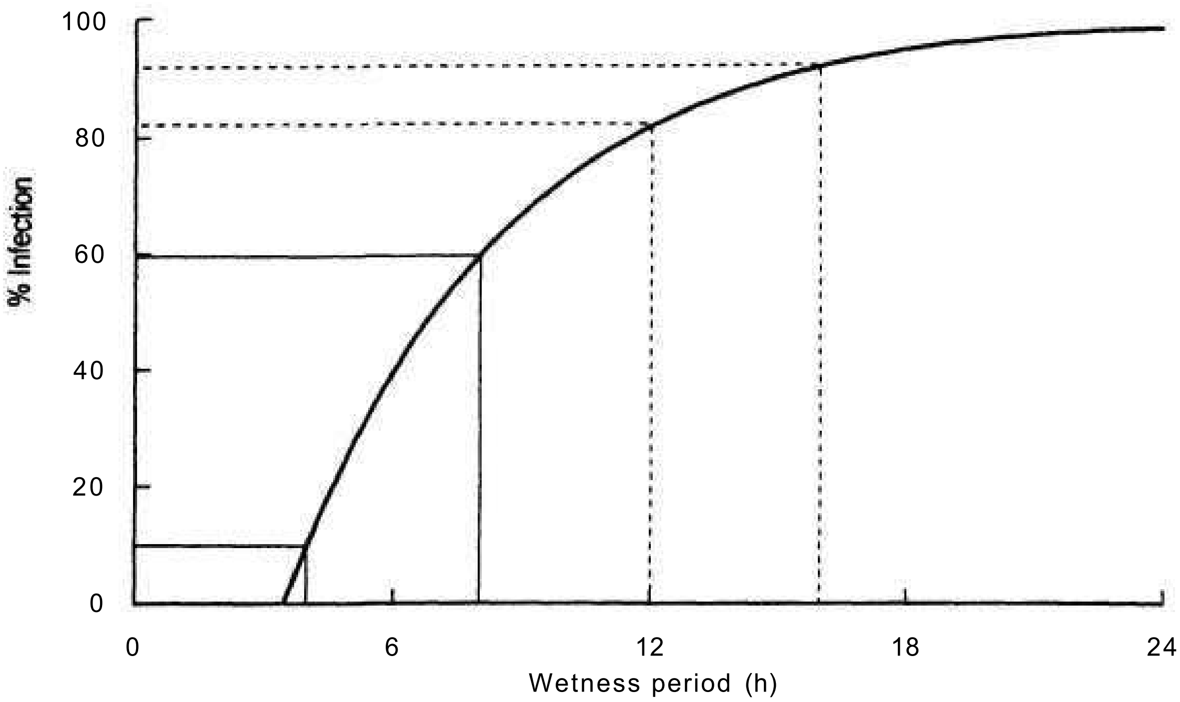

Figure 1. Relationship between leaf wetness duration and infection by foliar diseases.

Now consider a weather pattern in which wetness persists on the dense crop for 16 h each day. There would be sufficient wetness in the sparse crop (12 h) to cause 80% infection and this would increase to just over 90% in the dense crop (Fig. 1). In this case the effect of crop microclimate would be small and difficult to demonstrate experimentally.

The illustration above is hypothetical, but I have tried to make it realistic. The response curve to wetness is very similar to that which we have determined for groundnut rust (Butler and Jadhav 1990), and exposed leaves typically dry about 4 h earlier than do sheltered leaves within crop canopies.

The fact that I had to use a hypothetical illustration is an indication that we need more quantitative information about BGM. We need to determine the parameters for *B. cinerea* which would enable us to draw a response curve similar to Figure 1. We also need information on the crop microclimate, to quantify differences in wetness duration and humidity for crops of different growth habits and canopy densities. With this information it would be possible to assess the effectiveness of different agronomic practices such as choosing tall, erect genotypes, changing the time of sowing, and adjusting plant spacing in helping to control BGM.

For pathogens such as *B. cinerea* where airborne conidia are an important dispersal mechanism, sporulation commonly depends to a large extent on air humidity. Conidia are usually produced when the relative humidity exceeds a threshold and if this is the case for BGM, the crop microclimate could determine whether the threshold is passed. There are commonly consistent differences between air humidities measured in crops and on meteorological sites. A similar argument to that for infection would hold for sporulation; the microclimate becomes important when the effect of weather conditions is marginal.

I suspect that we are not yet in a position to predict disease outbreaks from the weather with certainty, so we are certainly not able to precisely assess the importance of microclimate to the disease. Our first priority should be to improve our understanding of how weather affects BGM. It might then be possible to identify situations where microclimate has a strong influence on disease.

Further studies

The following areas of research are suggested to improve our knowledge about the effect of weather on BGM. The information would allow us to develop forecasting systems, assess the effectiveness of microclimate manipulation in reducing BGM, and improve our interpretation of screening trials.

- Controlled environment experiments to determine the effects of wetness duration and temperature on infection, using different strains of *B. cinerea.*
- Controlled environment experiments to determine the effects of humidity and temperature on sporulation. Use different strains of *B. cinerea.*
- Comparison of disease development in dense and sparse canopies (using genotypes with different growth habits). Include observations on leaf wetness persistence in relation to weather.
- Analysis of weather patterns to see if there would be a consistent advantage in changing the sowing date.

Screening for Botrytis Gray Mold Resistance in Chickpea in India

Y.P.S. Rathi and H.S. Tripathi[1]

Botrytis gray mold (BGM) caused by *Botrytis cinerea* is one of the most important foliar diseases of chickpea. Although preventive measures such as chemical sprays and wide row spacings help to reduce disease intensity, resistant cultivars offer the most economic control of the disease. Work on BGM of chickpea was taken up in 1984 at G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar (29°N, 79° 30'E), which is situated in the *Terai* region of Uttar Pradesh, India. The studies began through an Indian Council of Agricultural Research (ICAR) research project entitled 'Studies on survival and management aspects of gray mold of chickpea caused by *Botrytis cinerea'.* This project had the following objectives:

- to establish a BGM screening nursery;
- to develop an effective field screening technique;
- to carry out extensive screening of germplasm accessions to identify sources of resistance;
- to conduct epidemiological studies; and
- to develop an integrated disease management strategy.

The screening program was further strengthened in 1986 through a GBPUAT-ICRISAT collaborative project.

Since 1984, more than 8 500 germplasm accessions, including breeding materials (F_3, F_4, and F_5 populations) received through the All India Coordinated Pulses Improvement Project (AICPIP) of ICAR and from ICRISAT, have been screened. The test entries were sown in 2 m long rows (at 30 x 10 cm spacing) at the end of October every year. One row of the susceptible cultivar H 208 was sown after every two rows of test entries. All test entries were replicated twice. Inoculation with a fungal spore suspension was carried out when the plants were 80-90 days old (at onset of flowering), and repeated twice at 10-day intervals. To ensure high humidity in the screening nursery, a light irrigation was given prior to the first inoculation. After the second and third inoculations, high humidity was maintained in the crop through sprinkler irrigation every 2-3 days.

Observations on the disease were made thrice: in mid-February, and the first and last weeks of March. The disease severity/damage was rated visually by scoring individual rows on a 1-9 scale (1 - highly resistant, 9 - highly susceptible). Promising entries were selected on the basis of the final rating, and these were further tested in a greenhouse in the succeeding year.

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The results of germplasm screening indicated that none of the lines screened remained completely free from infection. However, 22 lines namely, ICCs 1069, 1609, 4107, 6250, 7574, 7670, 8919, 9689, 10302, 12961, 12963, 15938, and 15979, ICCL 87322, ICCV 88510 (all from ICRISAT); BGs 256, 261, and 306, H 86-73, H 86-96, E 100Y, and E 100Y(M) (from AICPIP) showed resistant reactions (severity score 3). Most of the entries that showed resistant reactions were of the erect/compact type.

Despite the considerable efforts of plant breeders and plant pathologists, no high degree *of* resistance to BGM has so far been found in chickpea. Further screening of germplasm and breeding material should be continued in the hope of identifying more resistant germplasm.

Studies on Botrytis Gray Mold of Chickpea in Nepal

P.B. Karki[1], S. Joshi[2], G. Chaudhary[1], and R.N. Chaudhary[1]

Chickpea is the third most important grain legume crop in Nepal, where it is widely grown as a sole or mixed crop in the *Terai* and inner *Terai* regions. Botrytis gray mold (BGM) caused by *Botrytis cinerea* is an important yield-limiting factor in chickpea in Nepal. The disease is endemic in Chitwan district.

Reasons for poor pod-setting

Flower drop leading to poor pod-setting has been observed at some locations in Nepal. Experiments were carried out at Rampur in 1990/91 and 1991/92 to determine the causes (suspected to be BGM and soil factors) of poor pod-setting. In 1991 a significant increase in pods per plant and seed yield was obtained following spraying with the fungicide Bavistin® (Table 1). The fungicide spraying x genotype interaction was significant. The increase in yield was higher in susceptible varieties than in the resistant cultivar Dhanush. In a pot experiment at Rampur, irrespective of genotype, plants grown in soil collected from Parwanipur produced more pods per plant than those grown in soil from Rampur. It is therefore thought that both BGM and soil factors (low pH and associated nutritional problems) are responsible for the poor pod-setting of chickpeas grown at Rampur.

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2. Plant Pathology Division, Nepal Agricultural Research Council, Kathmandu, Nepal.

Table 1. Effect of Bavistin® spray on pods per plant and seed yield in 13 chickpea genotypes at Rampur, Nepal, 1991/92 season.

	Pods per plant		Yield (kg ha^{-1})	
Genotype	Control	Sprayed	Control	Sprayed
Dhanush	35	51	508	817
Sita	11	32	269	662
Trishul	35	48	493	761
ICC 1894	7	31	142	891
ICCL 86237	5	16	111	488
ICCL 86313	12	29	120	325
ICCX 840508-21	17	45	367	1466
ICCX 840508-32	23	33	238	793
ICCX 840508-36	10	31	250	977
ICCX 840508-38	14	30	263	822
ICCX 840508-40	20	38	556	1334
ICCX 840508-41	19	29	263	980
ICCX 840511-25	18	52	261	1006
CV (%)	3.6	10.7	7.6	7.5
LSD (P - 0.05)	1.4	8.3	48.6	141.6

Host resistance

Breeding chickpea for resistance to BGM is a major objective of the varietal improvement program in Nepal. Chickpea germplasm and breeding lines from international and national programs have been screened at several locations in Nepal since 1985 to identify sources of resistance, and genotypes with moderate resistance and high yield potential.

A total of 201 chickpea lines from the International Chickpea BGM Nursery at Rampur were screened for resistance to BGM in 1990 and 1991. Based on leaf and/or flower infection, none of the genotypes was rated resistant/tolerant in either year. Entries from the national BGM nurseries at Tarahara, Parwanipur, and Rampur were screened during the 1990/91 and 1991/92 seasons. The disease incidence was very low at Tarahara and Parwanipur in 1991/92. Most of the genotypes tested in 1990/91 were rated 3 to 5 on a 1-9 scale (Table 2). Among these, three genotypes (Dhanush and its derivatives ICCX 840508-33 and ICCX 840508-41) were found resistant over locations and years. In 1991/92, 24 of the 244 lines tested at Rampur showed satisfactory levels of resistance to both leaf and flower infection. The reactions of these lines are being verified. Past results have indicated that the cultivar Dhanush, a locally adapted chickpea line, has field tolerance to BGM.

Table 2. Chickpea genotypes moderately resistant to botrytis gray mold at different locations in Nepal, 1990/91 season.

Location	Genotype
Parwanipur	ICCXs 840508-21, 840508-32, 840508-33', 840508-36, 840508-38, and 840508-41[1]; ICCs 1894, 86237, 87305, 87332, and 87333; ICCVs 89303, 89304, 89310, and 89328; Dhanush', Gaurav, and Kalika.
Tarahara	ICCXs 840508-26, 8404508-30, 840508-31, 840508-33[1], and 840508-41[1]; ICC 1894; ICCLs 86237, 87305, 87313, and 87333; ICCVs 89302, 89303, 89304, 89310, 89330, 89332, and 89333; Gaurav, and Dhanush[1].
Rampur	ICCXs 840508-21, 840508-25', 840508-31, 840508-32[1], 840508-33', 840508-36, 840508-38[1], 840508-40, and 840508-41[1]; and Dhanush'.

1. Had similar disease reactions during 2-3 years of testing at the specified locations.

Agronomic manipulation for BGM control

The low levels of resistance, and the changes in disease reactions of several chickpea lines over locations and years, have made breeding for BGM resistance a difficult task. Therefore, studies were conducted to identify agronomic practices that minimize BGM severity. Delay in sowing greatly suppressed BGM incidence. However, seed yields of genotypes so far tested in Nepal tend to be reduced by delayed sowing (NGLRP 1988, 1992). Two cultivars, Dhanush (field resistant to BGM) and Sita (BGM-susceptible), were sown at Rampur with different spacings and intercropping. The disease severity did not differ significantly whether genotypes were grown at 40 cm or 60 cm row spacing, or whether they were grown as a sole crop or as a mixed crop with mustard.

Effect of pH on different BGM isolates

Isolates of *Botrytis cinerea* from Janakpur (eastern Nepal), Parwanipur, Rampur (central Nepal), and Nepalgunj (western Nepal) were studied for their pH requirement in potato dextrose agar. A slightly acidic medium (pH 6) was most conducive to growth.

Two different types of isolates of BGM were identified: sporulating isolates from Janakpur and Rampur, and sclerotia-forming isolates from Parwanipur and Nepalgunj.

Conclusions

- Both BGM and soil-related problems are involved in poor pod-set in chickpea at Rampur.
- The released variety Dhanush has shown consistent field tolerance to BGM at Rampur.
- Delayed sowing suppresses BGM severity in Nepal. However, the varieties released so far are not suitable for late sowing.

Multilocational Screening for Botrytis Gray Mold Resistance in India

Vishwa Dhar[1], Y.P.S. Rathi[2], H.S. Tripathi[2], Mahendra Pal[3], Gurdip Singh[4], M.P. Haware[5], and J.P. Upadhyay[6]

Botrytis gray mold (BGM) is an important foliar disease affecting chickpea in northern India. During the last three decades several epiphytotics of this disease have caused heavy yield losses in parts of the Indo-Gangetic plains and the northwest plains zone. After major outbreaks in Haryana and Punjab in the 1979/80 and 1980/81 seasons, the disease has occurred only sporadically in these states. However, in the *Terai* regions of western Uttar Pradesh, BGM has occurred regularly throughout the last decade.

In order to identify BGM-resistant varieties, chickpea lines bred by various centers under the All India Coordinated Pulses Improvement Project (AICPIP) were extensively screened at New Delhi, Ludhiana (Punjab), Pantnagar (Uttar Pradesh), Dholi (Bihar) and ICRISAT Center, Patancheru. The results of screening during the 7 years from 1985/86 to 1991/92 are summarized in this paper.

Most of the genotypes screened were entries from the coordinated varietal trials (CVT) contributed by the cooperating centers of AICPIP. The screening was done in the field at Pantnagar and Dholi and in the greenhouse at New Delhi, Ludhiana, and Patancheru.

In field screening, the reactions of test entries to the disease were recorded when the disease intensity reached a maximum on the susceptible control lines (H 208 or L 550). In greenhouse tests, observations were recorded 5-7 days after inoculation, when the disease development was maximum. Test entries were graded on a 1-9 scale (1 - no disease, 2-3 - resistant, 4-5 - moderately resistant, 6 - moderately susceptible, 7-9 - susceptible).

The location severity index (LSI) values under field screening at Pantnagar and Dholi ranged between 3.2 and 6.1, indicating that disease pressure was moderate at these locations during all years of screening. Under artificial inoculation screening in the greenhouse, the disease pressure was higher as evidenced by the high LSI range of 5.8-7.1 at New Delhi, 7.0-8.8 at Ludhiana, and 7.6-8.9 at Patancheru. This permitted effective screening for resistance against BGM. None of the test entries exhibited a high level of resistance under artificial screening. While the majority were found to be susceptible, a few showed moderate resistance/tolerance (4-5 on a 1-9 scale) to BGM. Under field screening a relatively large number of entries exhibited moderate levels of resistance.

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Screening was done during all the 7 years (1985/86 to 1991/92) at Pantnagar, for 6 years at New Delhi, 3 years at Ludhiana, 2 years at Patancheru, and for only 1 year at Dholi. The results of screening at the different locations are shown in Table 1.

Table 1. Chickpea coordinated varietal trial entries moderately resistant to botrytis gray mold in multilocational testing under the All India Coordinated Pulses Improvement Project, India, 1985-1992.

Location	Total entries screened	No. of moderately resistant entries		
		1 year	2 years	3 years
New Delhi	1095	48	BGs 240, 257, 276, 297, 298, and 318; BGM 405, BGM 424, GNG 158, GL 83119, Hs 86-18, 86-156, and 86-158; ICCC 10, ICCC42, ICCV 88103, KPG 59, KPG 143-1, PDGs 83-33, 83-34, and 84-10 (21 entries)	BGs 212, 244, 256, and 267; GL 769, Gaurav (6 entries)
Ludhiana	518	27	BG 209, GL 86051, H 86-39, H 86-156, ICC 1069, ICC 7574, ICCV 88102 (7 entries)	Not tested
ICRISAT Center	368	4	Not tested	Not tested
Pantnagar	1265	105	BGs 209, 240, 261, 267, 276, 297, 298, 299, 321, 329, and 344;BGMs413, 417,and431;GBGs 158, 426, and 432; GG 715, GL 86152, Hs 86-18, 86-39, 86-72, and 86-156; ICC 1032, ICC 1069, ICCV 89445, K 3256, NDG 8605, PDG 83-34, PDG 84-5 (30 entries)	BGs 212, 244, and 256; GCP 6, PDG 83-33, Gaurav (6 entries)
Dholi	187	7	Not tested	Not tested

At Pantnagar, where 1265 entries were tested during the 7 years, 105 exhibited moderate resistance for one season, and 30 for two seasons. Six entries (BGs 212,244, and 256, GCP 6, PDG 83-33, and Gaurav) showed fairly stable but moderate levels of resistance for three seasons. At Dholi, where entries were screened for one season only, BG 212, BG 256, GCP 6, Gaurav, GG 715, H 86-156, and GL 83119 were identified as moderately resistant. Among 1095 entries screened in the greenhouse at New Delhi, 48 exhibited moderate resistance for one season, 21 for two seasons, and 6 for three seasons. At Ludhiana seven entries were found to be moderately resistant to BGM for two seasons, but these were not tested during the third season.

At Patancheru only four entries (H 86-18, H 86-232, HK 88-209, and Gaurav) showed moderate resistance during 1990/91, when the disease pressure was rather low (LSI 7.6). In 1988/89 (LSI 8.9) all the test entries were rated as susceptible. However, the four entries found to be moderately resistant in 1990/91 were not included in the 1988/89 trial.

In addition to the CVT entries, 858 breeding lines developed at Ludhiana were screened for BGM resistance under artificial inoculation tests during the 1990/91 and 1991/92 seasons. Of these, GL 90159 and GL 91040 showed resistance and 30 others were moderately resistant (Table 2).

Table 2. Breeding lines showing resistance to botrytis gray mold at Ludhiana, 1990-92.

Total lines screened	Disease rating[1]	
	3	4-5
858	GL 90159, GL 91040	GFs 89-26, 89-28, 89-40, 89-62, 89-118, 89-120, 89-121, and 89-177; GLs 84147, 84190, 84297, 85018, 85059, 85090, 86015, 87049, 87053, 88202, 88225, 88358, 88393, 88395, 89025, 89026, 89027, 90048, 90062, 90160, 91035, and 91039.

1. Scored on a 1-9 scale, where 3 - resistant, 4-5 = moderately resistant.

Nineteen entries which exhibited stable and broadbased, moderate levels of resistance to BGM were identified at the test locations under field and greenhouse screening. These are: BGs 209, 212, 240, 244, 256, 267, 276, 297, and 298, GCP 6, GNG 158, GL 769, GL 83119, Hs 86-18, 86-39, and 86-156, ICC 1069, PDG 83-33, and Gaurav.

Three lines have been earlier identified as resistant to BGM: ICC 1069 at Pantnagar (Chaube et al. 1980), and BG 276 and BG 298 at New Delhi (Yadav 1992). The cultivar Gaurav is also moderately resistant to ascochyta blight and thus appears to possess multiple resistance against two very important diseases. Chickpea lines reported resistant to BGM in India should be evaluated under high disease pressure at locations like Rampur in Nepal to confirm their resistance before they are recommended as donor parents for resistance breeding programs in India.

Progress in the Management of Botrytis Gray Mold of Chickpea in Bangladesh

M.A. Bakr[1], M.M. Rahman[1], F. Ahmed[1], and J. Kumar[2]

Widespread occurrence of diseases is the most important constraint to chickpea production in Bangladesh. Among the diseases, botrytis gray mold (BGM) is considered to be the most damaging. It may cause total crop loss in years of epidemics (Bakr and Ahmed 1992). In recent years the disease has occurred regularly in Bangladesh due to rains in February, which caused excessive vegetative growth. Efforts are being made to contain the damage caused by BGM, and there has been collaborative work between the Bangladesh Agricultural Research Institute (BARI) and ICRISAT since 1990. The first BARI/ICRISAT BGM Working Group Meeting was held in Bangladesh, during 4-8 Mar 1991. The work plan developed at the meeting included four components: surveys, genetic resistance, cultural practices, and epidemiology. Research on BGM done in Bangladesh is described.

Surveys

Farmers' fields in Bangladesh were surveyed jointly by the Crop Diversification Programme (CDP) of Bangladesh and ICRISAT from 23 Feb to 3 Mar 1992. The major objectives included assessment of biotic and abiotic constraints to the production of rabi pulses like chickpea, lentil, and lathyrus. During the 1991/92 season the overwhelming biotic constraint to chickpea production was BGM. The major chickpea-growing regions of west Bangladesh (e.g., Faridpur, Kushtia, Jessore, Jhenaidah, and Magura) were badly affected by the disease, especially where crop canopies were dense. The only region where the disease was not a major problem was the Barind tract. Thus, there were clear indications that BGM infection was less intense in more open crop canopies and in canopies with lower relative humidity (RH) (ICRISAT 1992). During the survey we also identified a local germplasm line which was relatively free from BGM.

Genetic resistance

Screening for BGM resistance was initiated at Ishurdi during the 1990/91 postrainy season, in collaboration with ICRISAT. Eighty-six chickpea lines were screened in that season and 115 more (received from ICRISAT) in the 1991/92 season, under natural field conditions. The highly susceptible control entry ICC 4954 was sown as a disease 'spreader' after every four test entries. High RH was created by irrigation and by spraying the plants with water using knapsack sprayers.

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1. Pulses Research Centre, Regional Agricultural Research Station, BARI, Ishurdi. Bangladesh.
2. Crop Diversification Programme, Dhaka, Bangladesh.

Of the 86 chickpea lines screened in both 1990/91 and 1991/92, the following 10 lines showed resistance/tolerance to BGM during both years: ICCs 5035, 6304, 12963, 14911, 14912,15973,15978, and 15982, ICCL 15986, and ICCL 85086. Of the 115 lines screened in 1991/92, 13 were rated as resistant/tolerant. In the 1992/93 season, we are retesting all these lines, plus 30 more sent from ICRISAT, and results of 3 years of testing will be available at the end of the season. We shall use the most resistant lines in the breeding program in future.

Cultural control

Wide spacing between plants and application of fungicidal sprays can effectively reduce BGM-related losses. A study was undertaken to integrate such disease management practices as seed treatment (carbendazim 25% + thiram 50%, 1:1), foliar spray of carbendazim and wide row spacing (75 cm). Two foliar sprays were applied at a 14-day interval. Foliar spray combined with seed treatment was found to be more effective than foliar spray alone. Seed treatment, by itself, was ineffective. The disease was also reduced significantly by wide spacing alone, but the yield was lower than that obtained with the seed treatment/ foliar spray combination. The experiment is being repeated during the 1992/93 season with two additional treatments namely, intercropping with linseed and use of the BGM-tolerant line ICCL 87322.

Epidemiology

Studies on the development of BGM in different chickpea genotypes were conducted during the years 1989-91, and physical factors were monitored. The results were documented in the summary proceedings of the first BGM Working Group Meeting (Haware et al. 1992). The temperature and RH at the onset of the disease were 14°C and 89%, recorded at 0700 h, and 26°C and 77% at 1300 h. Maximum infection was observed from 13-26 Feb, during which period the mean temperature ranged from 17 to 28°C, and RH from 70 to 97%.

Ongoing studies

During the 1992/93 cropping season the following four experiments are being conducted:

- Screening of chickpea lines for resistance to BGM.
- Integrated management of BGM in chickpea, using wide row spacing (60 cm), seed treatment (Bavistin® + thiram), foliar spray (Bavistin®), use of tolerant variety ICCL 87322, intercropping with linseed, and a combination of these treatments.
- Effect of date of sowing and growth habit on the incidence of BGM. This includes four dates of sowing at 10-day intervals, starting in early November, as main treatments and five cultivars as subtreatments.
- Effect of plant spacing and foliar sprays with fungicide in BGM control. This includes no spray/foliar spray of Ronilan® on one tolerant and one susceptible cultivar as main treatments. Subtreatments include two spacings (60 and 40 cm) and two paired rows at 45:15:45 and 60:40:60 cm.

Future prospects

Recently, research on pulses has received excellent support through the CDP, and facilities for breeding for disease resistance are being strengthened. A mist irrigation system is being installed in the BGM nursery. These developments will enhance our capability for effective screening against BGM and other diseases. We hope to increase the breeding and management efforts to minimize the threat from this disease to the production of chickpea.

Present Status and Future Research Outlook for Botrytis Gray Mold - a Potential Threat to Chickpea in Pakistan

B.A. Malik, S.M. Iqbal, and M. Bashir[1]

Chickpea occupies 72% of the area under pulse crops in Pakistan. Although improved chickpea cultivars have yield potentials of 4-5 t ha^{-1}, the actual yield is only about 0.5 t ha^{-1}. The gap between potential and actual yield is due to biotic and abiotic constraints. Among the fungal diseases, ascochyta blight and botrytis gray mold (BGM) are potentially important.

Occurrence of disease

Botrytis gray mold of chickpea occurs sporadically in chickpea growing areas, particularly in the early-sown crop. An epidemic during 1980/81 in Punjab state resulted in substantial losses (NARC 1981), but since then no severe outbreak has been observed. The disease was also observed on chickpea and lentil in off-season nurseries in the Kaghan valley (2200 m).

Survival of the pathogen

The pathogen has a wide host range. Under natural climatic conditions in Pakistan, BGM is more serious on lentil than on chickpea. *Botrytis cinerea* survives in the seed and on infected crop debris.

1. National Agricultural Research Centre, Islamabad, Pakistan.

Importance of climate

The disease requires higher temperatures (24-26°C) and humidity (90%) than does ascochyta blight, which appears earlier in the season. It has generally been observed at the National Agricultural Research Center (NARC), Islamabad, that ascochyta blight starts appearing in chickpea and lentil in the last week of February or first week of March, whereas BGM starts appearing in mid-March or April, and causes serious crop damage when humid conditions prevail for a long period.

Host resistance

At present BGM is not considered a serious problem on chickpea in Pakistan, and so only very limited work has been done to identify sources of resistance. During 1980/81 (NARC 1981), 104 chickpea genotypes were sown at Islamabad, Tarnab, Faisalabad, and Lahore for screening against foliar diseases (ascochyta blight and BGM). None was resistant, but NEC 138-2 was tolerant to the disease. Erect type chickpea genotypes appear to be less susceptible than spreading types.

Chemical control

Preliminary in vitro evaluation of 14 fungicides against *B. cinerea* was carried out using poisoned food techniques (Nene and Thapliyal 1979). Most of the fungicides significantly inhibited growth of the fungus; complete inhibition was observed with Benlate® and Tecto-60®. Promising fungicides will be evaluated under field conditions.

Future outlook

No chickpea cultivar with high level resistance to BGM is as yet available. Integration of such disease management strategies as reducing plant density, modifying moisture levels in the crop canopy, intercropping, changing sowing date, seed treatment, crop rotation, and removal of debris should help reduce the disease in the field. Therefore, agronomists, climatologists, breeders, and pathologists must work together to develop appropriate disease management strategies.

Breeding for Botrytis Gray Mold Resistance at ICRISAT

S.C. Sethi, Onkar Singh, and H.A. van Rheenen[1]

At ICRISAT, breeding for botrytis gray mold (BGM) resistance in chickpea started after the disease epidemics of 1979/80 and 1980/81 in Pakistan and northern India. We have been collaborating since 1985 with G.B. Pant University of Agriculture and Technology, Pantnagar, in screening for BGM resistance. Segregating populations, single plant progenies, and advanced breeding lines have been screened at Pantnagar. This has enabled us to incorporate field resistance in the adapted backgrounds, although high levels of resistance have not so far been achieved. The following approaches are suggested for the improvement of BGM resistance in cultivated *Cicer.*

Breeding

After the initial crossing among adapted and disease-resistant parents, F_2 populations are screened in wilt-sick plots at ICRISAT Center, Patancheru. Thereafter, F_3/F_4 bulks are screened in the BGM screening nursery at Pantnagar. Single plant progenies are further screened in the F_4/F_5 generations in this nursery. The F_5/F_6 progeny bulks are evaluated for yield in normal fields using appropriate controls. Superior breeding lines are evaluated in regular yield trials and their disease reaction is further confirmed in the BGM nursery. Details of breeding materials screened at Pantnagar from 1989/90 to 1992/93 are given in Table 1.

Table 1. ICRISAT breeding materials screened in the Collaborative Botrytis Gray Mold Screening Nursery at G.B. Pant University of Agriculture and Technology, Pantnagar, 1989-1993.

	Number of lines screened			
Breeding materials	1989/90	1990/91	1991/92	1992/93
F_3 bulks	25	14	17	
F_4/F_5 bulks	1		1	1
F_4 progenies	98	71	87	367
F_4/F_6 progeny bulks		114	53	
F_5 progenies	104		10	38
F_6 progenies	34			33
Advanced lines			12	37

1. ICRISAT, Patancheru, Andhra Pradesh 502 324, India.

Two hundred and sixty-eight progeny bulks selected after screening at Pantnagar were tested in normal fields at Hisar in the 1991/92 season. Only 24 progeny bulks exceeded the average yield of the best control. Of 23 entries tested in replicated yield trials, 16 entries exceeded the control yield.

ICRISAT scientists have collaborated closely with national scientists in Nepal, Bangladesh, and India in developing lines resistant to BGM. Some of the moderately resistant lines identified in India are ICCVs 88101, 88103, 88510, 89307, and 89445, and ICCL 87322. We have recently developed a controlled-environment growth room facility at ICRISAT Center, in which chickpea materials will be screened in future. We will be able to screen large numbers of plants in quick succession, thus supplementing the field screening at Pantnagar.

Germplasm enhancement

A scheme to pyramid BGM-resistant genes from different sources to increase the overall level of resistance is presented in Table 2. It involves crossing various moderately resistant genotypes, screening large F_2/F_3 populations, selecting resistant types, and intercrossing the resistant types to enhance resistance levels. We have generated F_2 populations of four single crosses (ICC 5035 x ICC 6306, ICC 11874 x ICC 12961, ICC 12963 x ICC 15973, and ICC 15993 x ICCL 87322) and two double crosses among these. These will be screened in the growth room in 1993/94. Resistant plants will be utilized in making further crosses to generate material for further cycles of selection.

Interspecific crosses

Three accessions of the wild species C. *bijugum* (ICCWs 41, 42, and 91) are resistant to BGM. As crossing between chickpea and *C. bijugum* is difficult, biotechnology must be used to transfer genes from wild *Cicer* to *Cicer arietinum.*

Plant type

Genotypes with erect habit (e.g., ICCL 86237, ICCL 87322, and H 89-167) are less vulnerable to BGM because of their open canopy. Therefore, selection for such types with high yield potential may help to overcome the problem.

Cold tolerance

Cold-tolerant genotypes that can flower early and set pods through the cold season may escape BGM damage. Tolerance to cold coupled with early flowering could check excessive vegetative growth and lead to early completion of podding. A number of cold-tolerant lines have been developed and these should be tested in BGM-endemic areas.

Mutation breeding

Seed of chickpea variety ICCV 6 was irradiated and the M_2 and M_3 populations were screened in BGM screening nurseries at Pantnagar (India) and Rampur (Nepal). These

Table 2. Scheme for enhancement of resistance to botrytis gray mold in chickpea germplasm.

Season	Activity[1]						
1	$P_1 x P_2$		P_3 x P_4		P_5 x P_6		$P_7 x P_8$
2	F_1 (80)[2]	X	F, (80)		F, (80)	X	F, (80)
3	F_2 (4000)	F_1' (160)	F_2 (4000)	x -	F_2 (4000)	F_1' (160)	F_2 (4000)
4	F_3 (400)	F_2 (8000)	F, (400)	F_1" (320)	F_3 (400)	F_2 (8000)	F_3 (400)
5	F_4 (8)	F_3 (400)	F_4 (8)	F_2 (16000)	F_4 (8)	F_3 (400)	F_4 (8)
6	8-x	F_4 (8)	8-x	F_3 (400)	8-x	F_4 (8)	8-x
7		8-x		F_4 (8)		8-x	
8				8-x			

1. F_1 = Single cross, F,' - 4-way cross, F_1" = 8-way cross.
   8-x : these 8 selected lines are inducted into the breeding scheme, corresponding to the parents P_1...P_8.
   This scheme results in 7 main streams; 4 single crosses, 2 double crosses, 1 eight-way cross.
   At any time after the first screening, parents can be selected from segregating populations for conventional breeding or to initiate another cycle under this scheme.
2. Figures in parentheses refer to number of plants in respective generations.

first efforts to use mutation breeding for BGM resistance improvement were not successful, but we suggest that they be continued.

Late sowing

Late sowing checks excessive vegetative growth, and consequently BGM incidence/severity. Genotypes with specific adaptation to late sowing are being bred in various programs, and can be tested for tolerance to, or escape from BGM.

Botrytis Gray Mold of Chickpea: Progress on Breeding for Resistance at Pantnagar, India

I.S. Singh[1]

Chickpea is the most important grain legume in India, both in area cropped and in production. Botrytis gray mold (BGM) disease can be quite devastating to chickpea crops in northern India, Bangladesh, and Nepal. In the last few years, research collaboration between G.B. Pant University of Agriculture and Technology (GBPUAT) and ICRISAT has helped to develop reliable field techniques to screen chickpea germplasm for resistance to BGM. Studies involving crosses with BGM-resistance donors have also enabled us to determine the mode of inheritance of resistance. Disease reaction to BGM in F_1, F_2, and F_3 generations has been shown to be under monogenic control, resistance being dominant over susceptibility (Chaturvedi and Singh 1991). What follows here is an account of the BGM resistance research work carried out at Pantnagar during the 1990/91 and 1991/92 seasons.

In 1989/90, F_1s of two crosses (C 235 x ICC 10302 and C 235 x ICC 1069) were made. These were space-sown in 1990/91 to obtain sufficient F_2 seed, which was then space-sown in the BGM nursery at Pantnagar. Only resistant plants were retained and advanced to further generations. BGM resistance being monogenic dominant, it was simple to discard susceptible plants. Resistant plants were individually harvested to be grown as plant progenies during the 1992/93 season in the BGM nursery.

In addition, in 1990/91 F_1s of six crosses were made between three high-yielding varieties (Avrodhi, Pb G1, and BG 239) and two BGM-resistance donors (ICC 10302 and ICC 1069). These were space-sown in 1991/92 for advancement to F_2.

The variety ICCL 87322 was identified as a BGM-resistance donor in the ICRISAT-GBPUAT BGM nursery at Pantnagar. This was crossed in 1991/92 with three agronomically elite varieties, BG 329, KPG 59, and PDG 84-10.

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Future strategy

With the availability of moderately BGM-resistant chickpea lines, it is now possible, using the reliable field screening facility at Pantnagar, to identify resistant plants in the breeding nursery. ICCV 88510, which has moderate resistance to BGM, is being crossed with newer high-yielding lines during the postrainy season 1992/93. Segregants from these crosses are expected to combine adequate levels of BGM resistance with good yielding ability.

References

Bakr, M.A. and Ahmed, F. 1992. Botrytis gray mold of chickpea in Bangladesh. Pages 10-12 *in* Botrytis gray mold of chickpea: summary proceedings of the BARI/ICRISAT Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 4-8 Mar 1991, Joydebpur, Bangladesh (Haware, M.P., Faris, D.G., and Gowda, C.L.L., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Butler, D.R. and Jadhav, D.R. 1990. Requirements of leaf wetness temperature for infection of groundnut by rust. Plant Pathology 40:395-400.

Chaturvedi, R. and Singh, I.S. 1991. Genetics of resistance to botrytis gray mold in chickpea *(Cicer arietinum* L.). Pages 215-217 *in* Proceedings of Golden Jubilee Symposium on Grain Legumes, 9-11 Feb 1991, New Delhi, India. New Delhi 110 012, India: Indian Agricultural Research Institute.

Chaube, H.S., Tripathi, H.S., and Upadhyay, R.N. 1980. Research on rabi pulses at Pantnagar, 1980-81. Pantnagar, Uttar Pradesh 263 145, India: G.B. Pant University of Agriculture and Technology.

Haware, M.P., Faris, D.G., and Gowda, C.L.L. (eds.) 1992. Botrytis gray mold of chickpea: summary proceedings of the BARI/ICRISAT Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 4-8 Mar 1991, Joydebpur, Bangladesh. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 23 pp.

Haware, M.P. and McDonald, D. 1992. Integrated management of botrytis gray mold of chickpea. Pages 3-6 *in* Botrytis gray mold of chickpea: summary proceedings of the BARI/ ICRISAT Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 4-8 Mar 1991, Joydebpur, Bangladesh (Haware, M.P, Faris, D.G., and Gowda, C.L.L., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1992. Farmers' field survey of constraints to production of rabi pulses in Bangladesh, Feb-Mar 1992. Crop Diversification Programme, Bangladesh and Legumes Program, ICRISAT. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

NARC (National Agricultural Research Centre). 1981. Annual Report of Food Legumes Programme for 1980/81. Islamabad, Pakistan: NARC.

Nene, Y.L. and Thapliyal, N.S. 1979. Fungicides, their action and application. New Delhi, India: IBH & Oxford Publishing Co.

NGLRP (National Grain Legume Research Programme). 1988. Annual report for 1986/87. Rampur, Chitwan, Nepal: NGLRP.

NGLRP (National Grain Legume Research Programme). 1992. Annual report of NGLRP for 1990/91. Rampur, Chitwan, Nepal: NGLRP.

Rewal, N. and Grewal, J.S. 1989. Effect of temperature, light and relative humidity on conidial germination of three strains of *Botrytis cinerea* infecting chickpea. Indian Phytopathology 42:79-83.

Tripathi, H.S. and Rathi, Y.P.S. 1992. Epidemiology of botrytis gray mold of chickpea. Pages 8-9 *in* Botrytis gray mold of chickpea: summary proceedings of the BARI/ICRISAT Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 4-8 Mar 1991, Joydebpur, Bangladesh (Haware, M.P., Faris, D.G., and Gowda, C.L.L., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Yadav, S.S. 1992. Botrytis Gray Mold Resistance in Chickpea. Pages 9-10 *in* Botrytis gray mold of chickpea: summary proceedings of the BARI/ICRISAT Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 4-8 Mar 1991, Joydebpur, Bangladesh (Haware, M.P., Faris, D.G., and Gowda, C.L.L., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Recommendations

The present work plan for the Botrytis Gray Mold of Chickpea Working Group was developed during the Second Working Group Meeting, held at Rampur, Nepal, during 14-17 Mar 1993. The discussions took into account the earlier work plan prepared at the Bangladesh meeting in 1991, and the progress made since then.

Appropriate research centers were identified for each area of research.

Surveys

In Bangladesh, a survey of farmers' fields was undertaken from 23 Feb to 3 Mar 1992, to identify constraints to the production of postrainy season pulses (chickpea, lentil, and lathyrus). A systematic survey is needed to obtain information on BGM distribution in Pakistan. Scientists were requested to organize surveys to determine the extent of losses caused by BGM in their countries.

The need for funds and manpower (expertise) was identified to allow disease surveys to be conducted in Nepal, Pakistan, Myanmar, and India.

Screening for resistance

Field screening of chickpea for BGM resistance has been standardized, and disease screening nurseries are in operation at Pantnagar (India) and Ishurdi (Bangladesh). The present location (Rampur) in Nepal was felt to be unsuitable for BGM screening because of soil acidity and associated nutritional problems. It was recommended that a suitable location (Bhairahwa/Parwanipur) in Nepal should be identified.

Jessore (Bangladesh) and Dholi (India) were identified as sites for field screening.

Facilities for screening under controlled conditions are available at ICRISAT Center, Patancheru. ICRISAT should take up systematic screening of chickpea germplasm and should facilitate the exchange of promising material among members of the Working Group. However, there is a need to correlate the disease reactions in the field with results *from* screening and plant growthrooms/greenhouses.

Wild species

Three accessions of *Cicer bijugum* were found resistant to BGM. Attempts should be made to transfer genes from wild *Cicer* to *Cicer arietinum.* (Location: ICRISAT Center.)

Muitilocational testing

ICRISAT has formulated a chickpea BGM nursery. Other centers were requested to contribute promising lines to the nursery for muitilocational screening. (Locations: Pantnagar, Dholi, Ludhiana, Ishurdi, Jessore, Rampur (Bhairahwa), and Parwanipur; locations for screening are to be identified in Pakistan and Myanmar.)

Plant type

Plant habit appears to be important for disease escape. In erect plants the flowers are formed above the microclimate of the leaf canopy. Such escape mechanisms should be exploited. (Locations: ICRISAT Center, Pantnagar, Rampur, and Ishurdi.)

Time of sowing

Field experiments at Pantnagar and Ishurdi indicated that late sowing of chickpea reduces disease intensity, but also reduces yield significantly in normal years. Therefore, chickpea varieties suitable for late sowing should be identified and screened. (Locations: Pantnagar, Ishurdi, Rampur, and Islamabad.)

Spacing

Normal or early sowing results in a thick canopy which may provide a suitable microclimate for infection and buildup of the inoculum. Wider spacing between rows could effectively reduce disease intensity and increase yield. With wider spacing, plants have less shelter/shade from wind and sun. Leaves dry more quickly and leaf wetness periods are reduced. Appropriate spacings (interrow and plant to plant) for chickpea cultivation in disease-endemic areas need to be worked out. (Locations: Pantnagar and Ishurdi.)

Chemical control

Several fungicides (Ronilan®, Bavistin®, etc.) were reported to be effective in controlling BGM of chickpea. However, the use of chemicals alone is not economical and their use should be integrated into an overall disease management program. (Locations: Ishurdi and Pantnagar.)

Epidemiology

A beginning has been made on some aspects of basic epidemiology research.

Survival. *Botrytis cinerea* can survive in the seed and on host debris for at least one year. However, the role of infected seed and debris in epiphytotics is not known. Sources of primary inoculum should be investigated. (Locations: Pantnagar, Ishurdi, Rampur, and Islamabad.)

Microclimatic studies. It was recommended that wherever instruments were unavailable to monitor variables such as leaf wetness and canopy temperature, simple experiments should be planned. A susceptible chickpea line should be sown at different dates, and leaf wetness period and progress of the disease monitored every morning. Minimum and maximum temperatures, RH, rainfall, and hours of sunshine from meteorological sites should be helpful in our efforts to understand disease development. Environment x genotype x pathogen (E x G x P) interaction studies may be conducted in controlled environment at ICRISAT Center. ICRISAT microclimatologists should be requested to associate with pathologists to plan these studies. (Locations: Pantnagar, Ishurdi, and Rampur.)

Pathogenic variability

There are both sclerotia- and nonsclerotia-producing isolates of *B. cinerea* in nature. Work initiated in Nepal should be continued to understand the pathogenic variability among these isolates. (Locations: Khumaltar and Pantnagar.)

Disease rating scale

At present a 1-9 point scale is used to measure the disease in the field. This scale needs to be modified for epidemiological studies (quantitative measurement).

Training

ICRISAT was requested to conduct in-country training programs on BGM of chickpea in Nepal and Bangladesh. The training programs should cover loss assessment studies, screening techniques, and measurement of incidence/severity of the disease in greenhouses and in the field.

Botrytis Gray Mold of Chickpea Working Group

The Group felt that other scientists working on BGM of chickpea should be identified and kept informed about the activities of the Working Group. It was felt that the Working Group would be most effective with regular meetings and continuity in attendance.

It was also agreed that research work should be strengthened in the countries concerned. The Cereals and Legumes Asia Network (CLAN) was requested to identify funding sources for laboratory equipment and field supplies (Rampur and Ishurdi) and training (Nepal, Pakistan, Bangladesh, and Myanmar), to support research on BGM of chickpea.

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Ishurdi, Bangladesh, May 1991. Participants at the first meeting of the BGM of Chickpea Working Group. The ongoing resistance screening/breeding program at Ishurdi is being strengthened with additional funding and new equipment (such as a mist irrigation system for the BGM nursery).

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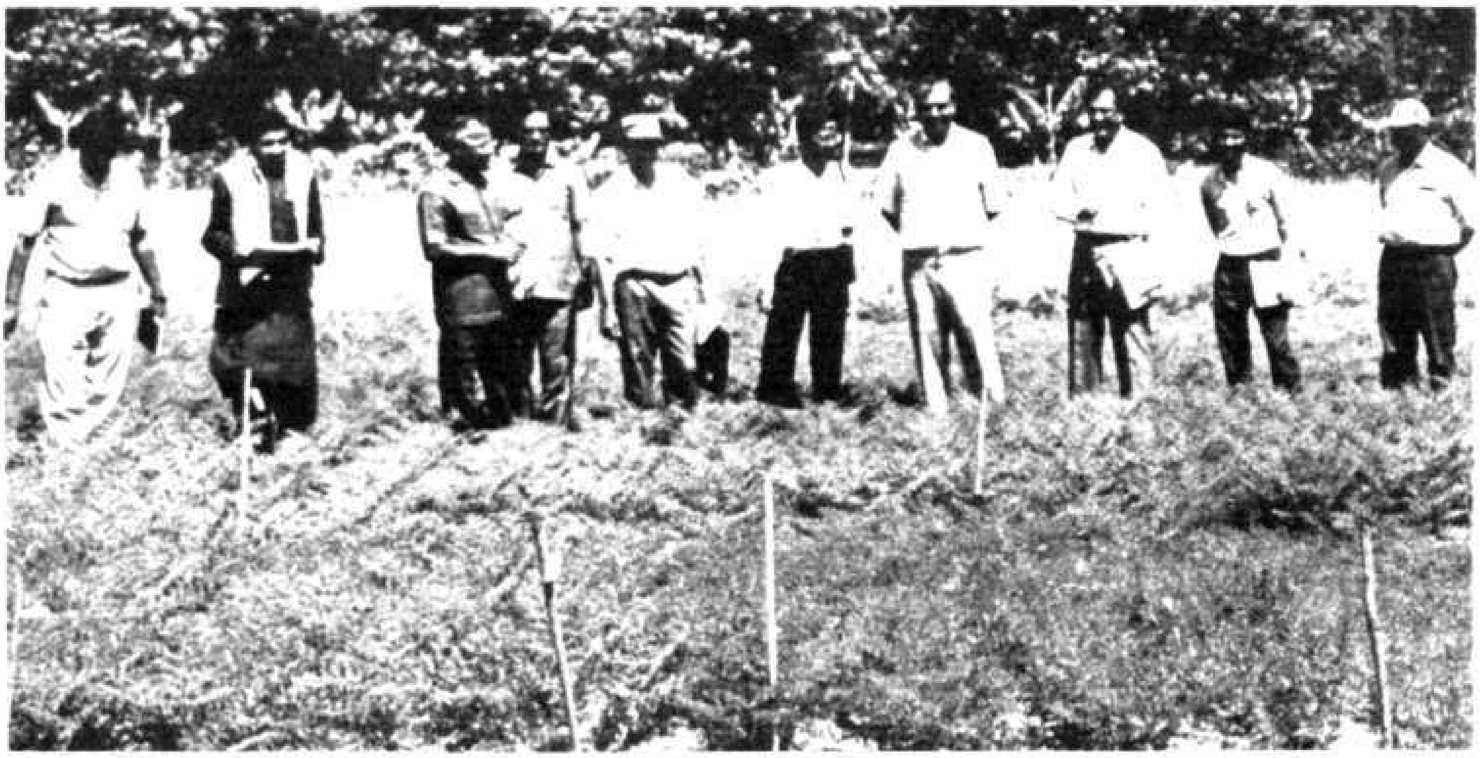

Field evaluation of the BGM nursery by delegates at the Second Working Group meeting, Rampur, Nepal, March 1993. Researchers have worked at Rampur since 1990 on various aspects of BGM of chickpea. Additional studies have now been proposed, specifically on epidemiology and disease management.

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 18 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).

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