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Recent Advances in Research on Botrytis Gray Mold of Chickpea

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Abstract

The Third Working Group Meeting on Botrytis Gray Mold of Chickpea reviewed research progress during the last 3 years, in Bangladesh, India, and Nepal. Summaries of these research findings are presented here. The preliminary report on the occurrence of botrytis gray mold of chickpea in Myanmar is noteworthy. Field trials conducted in Bangladesh, India, and Nepal indicate that an integrated disease management, if practised, can reduce disease intensity in chickpea fields, and increase chickpea production in disease-prone areas. Recommendations were made for future research priorities.

The research activities were partially supported by the Commission of the European Communities, the Government of Iran, and the Government of Spain.

Recent Advances in Research on Botrytis Gray Mold of Chickpea

Summary Proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea

15-17 Apr 1996
Pantnagar, Uttar Pradesh, India

Edited by
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Introduction

M P Haware[1]

Botrytis gray mold (BGM) of chickpea *(Cicer arietinum* L.) is important in Bangladesh, Nepal, and in the submontane regions of Bihar and Uttar Pradesh in India. Recently, BGM was also observed in Myanmar. The disease becomes serious following frequent winter rains that cause excessive vegetative growth and high humidity, which favor its spread and severity. Fortunately, these conditions do not occur every year.

ICRISAT developed a cooperative program with Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar, in Uttar Pradesh, India, for field screening of chickpea germplasm and breeding lines for BGM resistance. Limited screening has also been done at ICRISAT Asia Center (IAC) in controlled environment chambers. High level of resistance to BGM is not available in the existing chickpea germplasm. Although some lines do not show damage in the vegetative stage, they suffer severe flower infection, and do not set pods. In areas where disease pressure is high, there is good scope for integrated management of BGM. Erect, mid-tall, and compact chickpea genotypes, sown at wide interrow spacings, and limited use of appropriate fungicides must be incorporated into a disease management system. These components are presently being developed into a management strategy for transfer to farmers. This strategy will also be effective in the control of such other foliar diseases as stemphylium and alternaria blight, that occur in weather conditions similar to those for BGM.

In Bangladesh, large areas of chickpea are affected by BGM, and the regional agricultural research stations at Ishurdi and Jessore are the hot spots for BGM screening. The screening work being done at Jessore in Bangladesh and Parwanipur in Nepal needs to be strengthened. Artificial epiphytotics of BGM can be created if perfo-irrigation is made available. These stations also require facilities for the multiplication of disease inoculum. These locations are used to conduct trials on disease management. The disease is prevalent in Myanmar and Pakistan. However, there is a need to conduct a survey to assess the severity and importance of BGM, and to initiate research in these countries.

At present, screening for BGM host-plant resistance is being done at Ishurdi and Jessore in Bangladesh, at GBPUAT in Pantnagar, India, and at Parwanipur in Nepal. In the Indian subcontinent, the BGM problem is limited to specific agroclimatic areas. Unfortunately, not many breeders and pathologists are actively working on this problem.

ICRISAT's Chickpea Improvement Program has a project on the management of BGM of chickpea. The capacities of the national agricultural research systems

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(NARS, Bangladesh/Nepal) need to be strengthened to jointly tackle this problem. Training should be given to young scientists at IAC. Exchange of visits of scientists from NARS to IAC, and vice versa, to take part in collaborative research would be helpful.

The BGM of chickpea working group was established in a meeting held at Joydebpur, Bangladesh, during 4-8 Mar 1991. The second meeting was held at Rampur, Nepal, during 14-17 Mar 1993. In these group meetings, work plans were developed to organize and facilitate collaborative research at participating centers. The presentations made in these meetings were based on the work plans. Results were reviewed, and future plans recommended for collaborative research under the working group.

I thank Dr S C Modgal, Vice Chancellor, G B Pant University of Agriculture and Technology, for his support in organizing this meeting.

Inaugural Address

S C Modgal[1]

Dear participants, and staff from the press and media, I am happy to welcome you this morning to the inaugural function of the Third Working Group Meeting on Botrytis Gray Mold of Chickpea. This meeting is being attended by scientists from Bangladesh, Myanmar, Nepal, India (including scientists from ICRISAT Asia Center), and UK. We feel privileged to host this meeting, and I hope that the scientists who have assembled here will come up with a strategy to combat botrytis gray mold of chickpea in future.

Chickpea *(Cicer arietinum* L.) is one of the major grain legumes in the Indian subcontinent. Diseases are one of the most important constraints responsible for low yield. Of the major foliar diseases reported, botrytis gray mold (BGM), caused by *Botrytis cinerea* Pers. ex. Fr. is considered important, particularly in Bangladesh, some parts of India, and Nepal. This disease was first recorded in an epiphytotic form in the Terai region of Uttar Pradesh in 1969 by the pathologists at Pantnagar. Subsequently, heavy losses due to BGM were reported from various states of India: Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, and West Bengal.

Considering the importance of this disease in the Terai region of Uttar Pradesh, a project on BGM with major thrust on the management of the disease was started in Pantnagar in collaboration with ICRISAT, and I am happy to learn that good progress has been made in this project.

This group meeting is intended to review the work done at the collaborative centers in different countries, to discuss the research methodologies adopted, results obtained, and to exchange information and experiences, with a view to strengthen further collaboration. The ultimate beneficiaries of research are the farmers who look forward to resistant cultivars along with feasible management practices. Adequate attention should be paid to evolving resistant varieties and an ecofriendly integrated management strategy to combat not only this disease but others also.

I once again extend a very warm welcome, and wish every success to this Working Group Meeting. I look forward to continued cooperation between ICRISAT and various collaborative centers.

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Options for Disease Management of Botrytis Gray Mold of Chickpea

J M Lenne and M P Haware[1]

In Bangladesh, India, and Nepal, a considerable area sown to chickpea *(Cicer arietinum* L.) is prone to the ravages of botrytis gray mold (BGM), caused by *Botrytis cinerea* Pers. ex Fr.. The economic importance of BGM was first realized during the cropping season of 1980/81, when the disease destroyed 20 000 ha of chickpea in northern India. Since then, BGM has occurred in an epiphytotic form in most northern states of Bangladesh, India, and Nepal, causing serious losses during some years. Botrytis gray mold is also reported to cause significant losses in Pakistan, and has potential to do so in Myanmar. This is therefore one of the most important diseases affecting chickpea in South Asian countries, where the crop is grown primarily by resource-poor farmers.

Effective management of BGM is clearly a desirable objective. Considerable effort has been directed at trying to manage BGM on a range of crops worldwide, but this has been difficult to achieve, both in the developed and developing countries. Can we learn from experiences in other countries with other crops?

Most efforts in developed countries have focused on chemical control and host-plant resistance. During attempts to manage BGM in fruit crops in Europe, with few exceptions, fungicides (e.g., dichlofluanid) have been defeated by the production of resistant strains of *B. cinerea.* Current practice in fruit and vegetable crops in Europe relies on mixed spray programs and expensive repeated applications. Such reliance on fungicides for production of chickpea in South Asia is not possible because of the high cost. However, judicious use of fungicides as seed treatments or as foliar sprays in an integrated management program has merit. Attempts to breed for resistance to BGM in soft fruit crops in Europe (e.g., raspberry, strawberry) during the last 50 years have also been unsuccessful. Similarly, in chickpea, over 6000 lines have been screened for resistance to *B. cinerea,* with limited success. Some useful plant morphotypes have been identified, which rely primarily on open canopy architecture, to encourage air movement to allow rapid drying of foliage after rainfall. This escape mechanism reduces the rate of BGM development, because the water droplets and high humidity encourage B. *cinerea* infection in growing shoots, leaves, flowers, and

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developing fruits (pods). However, such a protection could be insufficient to manage BGM under high disease pressure. Antifungal compounds could be exploited as another resistance mechanism (Stevenson and Haware, these proceedings).

Although the prospects of developing cultivars with high levels of resistance by conventional approaches are still remote, biotechnology could hold more promise. Wild *Cicer* species, some of which are resistant to the pathogen, could help if improved transformation and regeneration methods are developed, so that their resistance can be transferred to chickpea. It has been recognized that the immature green fruit of raspberry is extremely resistant to invasion by the mycelium of *B. cinerea,* although the fungus resides in the attached floral organs, which it uses as a saprophytic base from which to invade the ripe fruit under conditions of high humidity. Recent work at the Scottish Crop Research Institute (SCRI), Scotland, UK, has shown that immature raspberry fruits contain a polygalacturonase-inhibiting protein (PGIP), effective against the endo-polygalacturonases produced constitutively by *B. cinerea.* The PGIP activity declines rapidly as the fruits ripen, and this decline is correlated with the onset of susceptibility to BGM.

Polygalacturonases are key enzymes in the invasion of plant tissues by many facultative fungal plant pathogens, and a strategy to enhance resistance of raspberry germplasm to B. *cinerea* has been devised at SCRI. The strategy relies on the isolation of the PGIP gene and the *Agrobacterium-mediated* transformation of leading cultivars and breeders' selections with constructs of the gene, using a constitutive promoter to ensure expression in all tissues. Another PGIP gene from kiwi fruit has been isolated and sequenced in collaborative studies between SCRI and the School of Biological Sciences, University of Auckland, New Zealand. Both genes will be used for the transformation of chickpea, with the objective of reducing the serious losses caused by BGM in South Asia. A 3-year collaborative project between ICRISAT and SCRI (funded by the Overseas Development Administration) will begin in October 1996.

In recent years, efforts have been focused at developing a range of such cultural control options for chickpea as time of sowing to avoid the main BGM risk period and plant spacing, to reduce canopy density (see Saxena and Johansen, these proceedings). These have been successful in reducing damage caused by BGM, but they are yet to be widely adopted by farmers.

Biological control by foliar applications of *Trichoderma* species on chickpea is presently being investigated in Bangladesh and India. Preliminary results are promising, but production technology, standardization procedures, and pilot programs will be needed. Similarly, such biological control as seed treatment with *Gliocladium roseum* (Link) Thorn is being field tested in Australia, where seedborne inoculum is the most important source that initiates epidemics in chickpea. There does not seem to be sufficient awareness of the role of seedborne inoculum in the epidemiology of the disease.

Many of the management options mentioned above are valuable and can be incorporated into an integrated management strategy, now in progress in Bangladesh, India, and Nepal. Work done, both by ICRISAT and in collaboration with other working group members, on the development of an integrated disease management (IDM) strategy for BGM of chickpea, has been summarized (Haware et al., these proceedings). The package involves the use of upright, erect varieties; wider spacing (both of which decrease humidity in the canopy); judicious use of fungicides or use of *Trichoderma* as a biocontrol agent. Manipulation of sowing dates is another option. Other options include the use of minimum foliar spray and plant spacing, which have been combined into a potential package (Bakr, et al., these proceedings). Adjustment of sowing dates, intercropping (e.g., with linseed in Bangladesh), and seed treatment are other components. Some others include time of spraying, detopping, and combinations of these treatments. It is now important to ask how much more of this work is needed. What are needed now are on-farm trials, to test methodologies in farmers' fields.

Our desired objective is effective management of BGM. We have identified several options that can be used individually, or in integrated packages. Some require further research. It is now important to evaluate these options for their utility in the farming system. Methodologies should be:

- Appropriate for the farming system: while intercropping with linseed is appropriate in Bangladesh it is not so in Nepal; while chemical control is appropriate in Europe, it is not so in South Asia. Integrated disease management should also be appropriate for each region.
- Practical for the farmer to use: neither chemical nor biological control is practical for resource-poor farmers; cultural control suited to the particular fanning system is a better option. However, host-plant resistance is the most practical option.
- Cost effective: it is more cost effective to choose the PGIP gene than to seek an unknown gene in *Cicer bijugum;* it is more cost effective to determine the basis of resistance in all presently known putative sources of resistance than to continue to use them without this knowledge; resistance is much more cost effective than chemical control.
- Adoptable: Adoption varies from region to region, and from country to country. Farmers are highly heterogeneous in their perceptions of the importance of BGM, and in their willingness to adopt management strategies per se, and types of management strategies. We need more information on this aspect.

Integrated Management of Botrytis Gray Mold of Chickpea: Cultural, Chemical, Biological, and Resistance Options

M P Haware[1], H S Tripathi[2], Y P S Rathi[2], J M Lenne[1], and S Jayanthi[1]

Chickpea *(Cicer arietinum* L.) is the third most important grain legume in the world. Though the yield potential of chickpea cultivars exceeds 5 t ha^{-1}, their actual yields are only 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) of chickpea, caused by *Botrytis cinerea* Pers. ex Fr., destroys chickpea crops in Bangladesh, northeastern India, and Nepal. The disease has been observed in Myanmar and Pakistan (Haware 1996, unpublished). In view of the destructive potential of the disease in southern Asia, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in collaboration with G B Pant University of Agriculture and Technology (GBPUAT), established a BGM nursery at Pantnagar, Uttar Pradesh, India, to screen germplasm and breeding material for resistance to the disease. Extensive screening of chickpea germplasm has not revealed any accession with a high level of resistance to BGM.

The spread and severity 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 bushy and spreading genotypes. This finding led to the consideration that integration of various methods of disease control may be a better approach to managing BGM. Two-to-three foliar sprays of vinclozolin (Ronilan® 0.2%) suppressed the disease. There was less damage in the fields with lower plant population. Therefore, with these findings, field trials on integrated management were conducted at Pantnagar from 1991/92 to 1994/95 seasons. Similar trials were also conducted at Ishurdi and Jessore in Bangladesh, and Parwanipur in Nepal, which are also hot spots for BGM of chickpea (results will be reported separately).

A tall, erect genotype, ICCL 87322, was compared with a semi-erect, bushy genotype, H 208, at four different plant row spacings: in single rows 30 cm and

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Haware, M.P., Tripathi, H.S., Rathi, Y.P.S., Lenne, J.M., and Jayanthi, S. 1997. Integrated management of botrytis gray mold of chickpea: cultural, chemical, biological, and resistance options. Pages 9-12 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 19%, Pantnagar, Uttar Pradesh, India (Haware, M.P, Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Table 1. Effect of row spacing and Ronilan® sprays on the severity of botrytis gray mold, and grain yield in chickpea, Pantnagar, India, 1992/93.

Treatment	Cultivar	Spacing	Disease rating (1-9 scale)	Yield[1] (kg ha^{-1})
Sprayed[2]	ICCL 87322	30 x 10	4.3	1192
		60 x 10	3.3	1291
		45:15:45	4.3	1200
		60:40:60	3.3	1176
	H 208	30 x 10	5.7	1265
		60 x 10	4.7	1139
		45:15:45	4.7	1157
		60:40:60	4.7	1086
Nonsprayed	ICCL 87322	30 x 10	5.7	989
		60 x 10	4.3	989
		45:15:45	4.3	911
		60:40:60	4.0	1044
	H 208	30 x 10	8.0	459
		60 x 10	6.3	349
		45:15:45	6.3	392
		60:40:60	6.0	399
SE				
Cultivars			±0.124*	±85.1
Spacings			±0.175*	±120.4
Sprayings			±0.124*	±85.1*
Spacing x Sprayings			±0.248	±170.2
Cultivar x Spacing			±0.238	±170.2
Cultivar x Spraying			±0.175**	±120.4**
Cultivar x Spraying x Spacing			±0.350	±240.7
CV (%)			12.1	45.4

1. Mean of three replications.
2. Fungicide Ronilan® (0.2%).
* Significant at 1%; ** Significant at 5%.

60 cm apart, and in paired rows at 45:15:45 and 60:40:60 cm. Interplant spacing within rows was 10 cm. One set of plots at each spacing was sprayed with 0.2% Ronilan® at flowering. Seeds were sown during the first week of November, and the crop was harvested in April.

Another trial studied the effect of date of sowing and growth habit of genotypes on BGM in five chickpea genotypes: ICCL 87322, ICCV 88510, H 208, Pant G 114, and K 850. The genotypes were sown on four dates at a 5-d interval, starting 31 October, and the last date of sowing was 14 December. Of the five genotypes tested, ICCL 87322 and ICCV 88510 were tall and erect, and moderately resistant; H 208 was semi-spreading and highly susceptible; Pant G 114 was of the spreading type; and K 850 was semi-erect.

An isolate of *Trichoderma viride* obtained by selection on a fungicide (vinclozolin)-amended medium was found effective in disease control in the plant growth room at ICRISAT Asia Center. The same isolate was tested in a field trial at Pantnagar in 1994/95.

The tall erect genotype has less disease in sprayed and nonsprayed plots. In both the genotypes, wider row spacing reduced the disease severity. In H 208, one spray of Ronilan® reduced disease intensity significantly, as reflected in the yield. In ICCL 87322 and H 208, a wider row spacing, along with one fungicidal spray, significantly increased yield. However, under nonsprayed conditions, ICCL 87322, the tall, erect genotype, yielded twice as much as H 208 (Table 1). A preliminary investigation indicated that two sprays of biocontrol agent (T. *viride)* can effectively reduce BGM disease in the field (Table 2). This is being tested in the 1995/96 season in field experiments at Pantnagar (India) and Parwanipur (Nepal). In all the genotypes, date of sowing influenced disease severity. Delayed sowing resulted in low levels of disease, even in susceptible cultivars, because of reduced canopy development. However, there was a significant reduction in yield in late-sown plots (Table 3).

Table 2. Effect of *Trichoderma viride* on severity of botrytis gray mold (BGM), and yield in BGM nursery, G B Pant University of Agriculture and Technology, Pantnagar, India, 1994/95.

Treatment	Disease rating (1-9 scale)	Yield (t ha^{-1})
Control (no spray)	5.8	1.2
Three sprays of *Trichoderma* (10^7-10^8 spores mL^{-1}) at a 20-d interval	4.0	1.7
Three sprays of Ronilan® (0.2%) at a 20-d interval	4.0	1.8
First spray with *Trichoderma* (10^7-10^8 spore mL^{-1}) + Ronilan® 0.1%; second spray with *Trichoderma* (10^7-10^8 spores mL^{-1}); third spray with *Trichoderma* (10^7-10^8 spores mL^{-1}) + Ronilan® 0.1%	4.6	1.6
SE	±0.204	±0.079
CV (%)	9.1	10.1

Table 3. Influence of dates of sowing and growth habit of chickpea genotypes on severity of botrytis gray mold, and grain yield, G B Pant University of Agriculture and Technology, Pantnagar, India, 1992/93.

	DS I[1]		DS II		DS III		DSIV	
Cultivars	Disease rating[2]	Yield ($t\ ha^{-1}$)	Disease rating	Yield ($t\ ha^{-1}$)	Disease rating	Yield ($t\ ha^{-1}$)	Disease rating	Yield ($t\ ha^{-1}$)
H 208	7.7[3]	0.9	6.7	1.1	4.7	1.0	3.7	1.0
Pant G 114	6.3	0.9	5.7	1.0	3.3	0.9	3.3	1.3
K 850	6.0	1.0	6.0	1.1	4.3	0.9	3.3	1.3
ICCV 88510	5.3	1.2	5.0	1.0	4.0	0.7	2.3	1.2
ICCL 87322	4.7	1.2	4.7	1.1	3.3	0.9	2.3	1.1

SE	Disease rating	Yield
Cultivar	±0.169"	±0.086
Sowing	±0.152"	±0.077**
Cultivar x Sowing	±0.339	±0.173
CV (%)	12.6	31.6

1. Dates of sowing: DS I = 31 Oct 1992; DS II = 14 Nov 1992; DS III = 29 Nov 1992; DS IV = 14 Dec 1992.
2. Disease rating on 1-9 point scale, where 1 = free from disease, and 9 = killed.
3. Mean of three replications.
** Significant at 1%.

Botrytis gray mold of chickpea is strongly influenced by the environment. Chickpea cultivars with high levels of resistance to BGM are not available. The field trials conducted at Pantnagar, from 1991/92 to 1994/95 seasons indicated that BGM in chickpea can be managed by sowing a tall, erect genotype (moderately susceptible) at wide spacing, with judicious use of fungicide or an effective biocontrol agent. At present, these components, along with manipulation of sowing dates, are being developed into a management strategy for transfer to farmers.

Botrytis Gray Mold of Chickpea in Punjab, India

Gurdip Singh, Baljinder Kumar, and Y R Sharma[1]

Botrytis gray mold (BGM) appeared in an epidemic form along with ascochyta blight in Punjab and adjoining states of India from 1981-83, causing considerable damage to chickpea *(Cicer arietinum* L.) crop. Since then, BGM has been appearing every year in moderate-to-severe forms, depending upon the environmental conditions.

Since 1993/94, efforts have been made to develop options for integrated management of chickpea diseases at Punjab Agricultural University, Ludhiana and Gurdaspur.

Effect of Sowing Time

The effect of sowing time on the incidence of BGM was studied during 1993/94. An early-sown crop (10 October) showed the maximum disease incidence, whereas a late-sown crop (20 November) had low disease incidence. The BGM attack was significantly less severe on chickpea crop sown between 30 Oct and 20 Nov 1993.

Effect of Sowing and Seed Rate

A field experiment with three dates of sowing (25 Oct, 10 and 25 Nov), three seed rates (30, 40, and 50 kg ha^{1}), and two lines (PBG 1 and GL 88341) was conducted at Gurdaspur during 1994/95.

The crop sown on 25 Nov 1994 showed significantly less disease incidence than the crop sown on 25 Oct. A considerable reduction in disease incidence was also recorded on the crop sown on 10 Nov 1994. A lower seed rate of 30 and 40 kg ha^{1} also helped reduce BGM. No significant differences were observed between the two test varieties. The interaction between sowing time and cultivar, and between seed rate and cultivar was significant, whereas the effect of interaction of sowing time, seed rate, and variety was not significant.

Effect of Plant Population

Disease incidence was significantly less in wide row spacings of 45 and 60 cm, compared with close row spacings of 15 and 30 cm. The wide row spacing of 60 cm showed the least disease incidence. A plant spacing of 15 cm significantly reduced BGM incidence, compared with a closer plant spacing of 5 cm.

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Gurdip Singh, Baljinder Kumar, and **Sharma, Y.R.** 1997. Botrytis gray mold of chickpea in Punjab, India. Pages 13-14 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 1996, Pantnagar, Uttar Pradesh, India (Haware, M.P, Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Host-Plant Resistance

Germplasm and breeding material have been screened both in the field and in the growth room. A new screening technique called 'cut-twig' method was developed for use in a hybridization program. A high level of resistance to BGM has not been available in chickpea to date, but is available in some wild *Cicer* species. The cut-twig method proved reliable and efficient to screen breeding material derived from the hybridization program, particularly for backcrossing.

The cut-twig technique involved cutting with a razor, 10-15 cm long tender chickpea shoots in the evening. The lower portion of the single twigs were wrapped with a cotton plug and transferred to a test tube (15 x 100 mm) containing fresh tap water. The tubes were placed in a test tube stand and were inoculated by spraying spore suspension (50 000 spores mL^{-1}) of 10-days-old culture of *Botrytis cinerea* Pers. ex Fr.. Twigs of susceptible variety G 543 were used as susceptible controls. The inoculated twigs were immediately covered with moist polythene chambers supported by iron frames (18' x 18') for 144 h. During the incubation period, light was provided for 8 h d^{-1}. Disease symptoms, accompanied by fungal growth, appeared 24 h after inoculation. Complete mortality was noticed in the susceptible lines, 6 d after inoculation. The disease observations were recorded 6 d after inoculation, on a 1-9 rating scale. The results of this screening technique are comparable with that of the growth-room screening technique.

Screening of Wild *Cicer* Species

Sixteen accessions of eight wild *Cicer* species were screened for resistance to BGM in a growth chamber. *Cicer judaicum,* IWC 19-2, and three accessions of *Cicer pinnatifidum* (no. 188, no. 199, and JM 2123) were resistant to BGM.

Screening of Germplasm and Breeding Lines for Resistance to BGM

During 1992-95, 2550 chickpea lines were screened in a growth chamber. Five chickpea lines, PGL 700, GL 90159, GL 91040, KPG 70, and BG 439 were found resistant. Thirteen lines were found to be resistant-to-moderately resistant. It is necessary to confirm the resistance of these lines in multilocational testing.

Seed Treatment

Seed treatment with Bavistin® + Thiram® (1:1), Indofil M-45®, Thiabendazole®, Ronilan®, Rovral®, or Bavistin® at the rate of 3 g kg^{-1} seed controls the seedborne infection of *B. cinerea.*

Foliar Spray

Application of Indofil M-45®, Thiabendazole®, Bayton®, Bayleton®, and Thiram® during crop growth controls foliar infection in February-March.

Research on Botrytis Gray Mold of Chickpea in Bangladesh

M A Bakr[1], M S Hossain[2], and A U Ahmed[2]

Botrytis gray mold (BGM), caused by *Botrytis cinerea* Pers. ex Fr. is an important disease of chickpea *(Cicer arietinum* L.) in Bangladesh, India, and Nepal. This paper covers research work carried out during 1992-95 in Bangladesh.

Minimum Foliar Spray and Spacing Adjustment

Bushy and dense canopy, resulting from close spacing and spreading type of plants favors the development of BGM, because these conditions create high humidity. A field study was conducted at Ishurdi, Jessore, and Joydebpur in Bangladesh, to generate data on these observations. At Ishurdi, the study was conducted during 1992-95, while at Joydebpur, the study was conducted during 1994/95. Two genotypes, ICCL 87322 (upright branching) and H 208 (spreading type), were included in the study at four different plant row spacings: 60 x 10 cm, 60 x 10 cm, 45:15:45 cm (paired row), and 60:40:60 cm (paired row). The experiment was conducted in a split-plot design, with four replications of each treatment. The efficacy of a minimum of two sprays at a 14-day interval was assessed by applying and not applying the fungicide Ronilan® on the experimental plants. Foliar spray of Ronilan® significantly reduced the disease incidence in both the genotypes, and the grain yield also increased. It was also observed that wider row spacing reduced disease intensity. Disease development was significantly more at 30 x 10 cm spacing than at other spacings. However, grain yield was the highest at 60 x 10 cm spacing.

A wider row spacing resulted in higher yield in ICCL 87322 than in H 208, although the increase in the grain yield was not significant. Interaction effects of spray, genotype, and spacing were not significant in reducing the disease incidence. However, the yield difference between ICCL 87322 and H 208 was significant, the former producing higher yield. The highest grain yield was recorded in ICCL 87322, when sown at 60:40:60 cm spacing using Ronilan®.

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Bakr, M.A., Hossain, M.S., and Ahmed, A.U. 1997. Research on botrytis gray mold of chickpea in Bangladesh. Pages 15-18 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 19%, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Adjustment of Sowing Dates of Diverse Genotypes

Date of sowing could reduce disease incidence in a field. For example, early sowing of lentil in the first week of November in Bangladesh can avoid severe rust infection. Five chickpea genotypes with different growth habits were studied in a field experiment at Ishurdi and Jessore during 1992-95 with four dates of sowing. Genotypes Pant G 114, H 208, K 850, ICCL 87322, and ICCV 88510 were sown at four dates at an interval of 10 days, starting from 11 November to 18 December.

Disease severity was more in early-sown crops up to 27 November in both compact and spreading genotypes such as H 208, Pant G 114, and K 850, than in erect types. Disease rating was less in all genotypes when sown before 5-15 December. However, yield was reduced when they were sown after 10 December. Among the five genotypes, the disease rating was lowest in ICCL 87322 followed by ICCV 88510. The highest rating was recorded on H 208. Considering the interaction of genotypes and sowing dates, in ICCL 87322, at all sowing dates, disease incidence was less, and yield was comparatively high.

The present study reveals that ICCL 87322 performed better in the management of BGM. It also showed resistance to wilt root rot and collar rot diseases. Sowing time from end of November to 15 December is ideal for crops to escape BGM.

Integrated Management of BGM

A study on integrated management of BGM was conducted for three consecutive cropping seasons during 1992-95. The study was done at Ishurdi during the first two seasons, and in 1994/95, it was done at Ishurdi and Joydebpur. The treatments included:

- Presowing seed treatment with Bavistin 50wp®.
- Two foliar sprays of Bavistin 50wp® at 15 days interval starting from the flowering stage.
- Sowing a tolerant cultivar (ICCL 87322).
- Wide row spacing (60 cm).
- Intercropping with linseed.
- Seed treatment + foliar spray.
- Seed treatment + foliar spray + tolerant cultivar.
- Seed treatment + tolerant cultivar + wide spacing.
- Control, that is, no treatment of seed and plant, normal spacing (40 cm) of cultivar H 208.

Intercropping linseed with chickpea was found to be the best method of managing BGM. Wide spacing was effective after intercropping. The effectiveness of a combination of foliar spray and tolerant genotype, was similar to the use of wide spacing.

Facility for Field Screening at Ishurdi

Humidity is essential for the infection and spread of BGM in chickpea. Facilities for field screening have been available at the Bangladesh Agricultural Research Institute (BARI) at Ishurdi since 1993/94 cropping season. An area of 0.4 ha is supported with mist irrigation, which creates foggy and humid conditions [almost 100% relative humidity (RH)]. The system is operated generally four times a day for about half-an-hour, after every 3 hours, starting from 1000. The system is operated from 50% flowering (2nd week of February) to pod maturity (1st week of March).

Resistance Screening Efforts

Screening of chickpea genotypes under field conditions, for resistance to BGM, has been done since the 1990/91 cropping season, at the regional agricultural research station, Ishurdi. During the last three cropping seasons, 75 genotypes from the BGM observation nursery have been screened under field conditions at Ishurdi. The genotype GL 85103 showed tolerant reaction after repeated screening for 4 years. Ten out of 23 genotypes from the observation nursery, 5 out of 12 genotypes from the 2nd year of screening at Ishurdi, 9 genotypes from the BGM observation nursery at Joydebpur, and 6 genotypes from the nursery at Jessore were selected for further screening.

Leaf Wetness and Disease Development

The epidemiology of the disease should be properly understood in order to develop a successful management strategy. A study was conducted to understand the effect of leaf wetness on the development of BGM. Chickpea genotype H 208 was sown in field plots of 5 x 5 m. Leaf wetness data were recorded from 9 Feb to 15 Mar 1994. Data were recorded three times a day, at 1100, 1300, and 1500. Paper discs were cut from Whatman no. 50 filter paper with a punch machine, and oven-dried for 3 h at 60°C, and were kept at room temperature (20±5°C). While taking leaf wetness data, the discs were touched with the chickpea leaf inside the canopy with a gentle pressure, with the help of forceps. For each recording, 50 discs were kept inside a test tube, sealed with a rubber cork. The used discs were weighed in an analytical balance, and moisture content calculated. While recording leaf wetness data, temperature and RH inside the canopy were also recorded. Data on each of the factors were compiled and presented as weekly means. Data on the initiation and development of disease were also recorded.

The leaf wetness was more [16 mg (50 discs)$^{-1}$] during the 3rd week of February, and gradually decreased from the 4th week of February. In general, the quantity of water was more at 1100, and continued to increase up to 1300, and then decreased after mid-day The disease intensity (1-9 scale) increased with temperature. At the time of BGM initiation, the mean weekly temperature was 23°C (maximum), and 15.8°C (minimum), with a maximum RH of 93.6%, and a minimum RH of 74%. The intensity of incidence increased gradually. The highest incidence was attained during the 2nd week of March when the maximum temperature was 28°C, and the minimum around 20°C.

Future Outlook

For an effective disease management program, it is essential to know the host range and pathogen diversity. But the variability of *B. cinerea* in Bangladesh, its physiologic races (if any), its perpetuation, and host specificity are yet to be explored.

The management approaches reported here should be made to suit farmers' practices. Therefore, it is also necessary to disseminate this information to farmers, in order to minimize yield losses owing to BGM in chickpea.

Research on Botrytis Gray Mold of Chickpea in Nepal

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Chickpea *(Cicer arietinum* L.) is the most important grain legume crop in Nepal. It is widely grown as a sole or mixed crop in the Terai, inner Terai, and in the valley regions. The average chickpea yield is 0.6 t ha^{-1}, the area being 28 800 ha, and production 17 900 t. The prevalence of diseases is one of the main reasons for the low chickpea yield. Among them, botrytis gray mold (BGM) caused by *Botrytis cineria* Pers. ex Fr., is the most destructive.

Host Resistance

A nursery to screen germplasm material for resistance to BGM was established at Parwanipur during the 1994/95 season. The nursery was artificially inoculated, with inoculum multiplied on dried marygold flowers. Based on leaf and flower infection, none of the genotypes were rated resistant to BGM in the disease nursery. Such lines as ICCV 89302, ICCV 89332, and ICCL 80004 K were found moderately resistant. Flower drop, leading to poor pod setting was observed at some locations in Nepal. Similarly, entries from the national BGM nursery, ICCL 87305, ICCL 87322, ICCV 92501, and ICCV 88506 were rated as tolerant, both at Rampur and Tarahara. Chickpea lines ICCV 90143, ICCX 40508-40, ICCX 840511-26, and ICCX 840511-25 were moderately susceptible at Tarahara.

Integrated Disease Management

Disease development mainly depends on initial inoculum density, cropping period, genotypes, infection rate, plant population, growth stage of the plant, and sowing time. Taking such factors as genotype, fungicidal spraying, and spacing into consideration, studies on integrated disease management (IDM) of BGM in chickpea were conducted in a field at Parwanipur. One set of plots at each spacing was sprayed with vinclozolin (Ronilan®, 2 gm in 1 L of water) just after flowering. Chickpea genotypes ICCL 87322, a tall, and erect type, and H 208, a traditional bushy and spreading type were used. Two treatments were given to the subplots,

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that is, spraying and nonspraying with four different plant row spacings: 30 cm and 60 cm, and paired rows at 45:15:45 and 60:40:60 cm. Interplant distance within rows was 10 cm. Plot size was 24 m^2. Genotype ICCL 87322 had lower disease severity than H 208. However, in ICCL 87322, there was less disease and higher grain yield at wide row spacings than at close row spacings.

At Parwanipur, the effect of sowing dates was studied in five chickpea genotypes, Pant G 114, H 208, K 850, ICCL 87322, and ICCV 88510. The genotypes were sown on four dates: 12 Nov, 19 Nov, 26 Nov, and 3 Dec 1995. The trials were conducted in a split-plot design with four replications. There was significant difference in disease rating among the sowing dates. Delayed sowing (3 Dec) resulted in significantly low levels of disease. However, there was significantly higher yield reduction in late-sown plots. Significantly higher yield was found in genotype PG 114.

Future Work

Research work to control BGM of chickpea should concentrate on the following aspects.

- Regular monitoring of BGM in chickpea-growing areas, especially in the farmers' fields.
- Seed health testing.
- Screening of BGM-resistant lines.
- Integrated disease management, including the use of the biocontrol agent *Trichoderma viride.*

Integrated Management of Botrytis Gray Mold of Chickpea: Agronomic and Physiological Factors

N P Saxena and C Johansen[1]

Introduction

Botrytis gray mold (BGM) disease of chickpea *(Cicer arietinum* L.), caused by *Botrytis cineria* Pers. ex Fr., is common in areas where humidity and temperatures are high. There has been emphasis on the integrated management of BGM in recent years because of the nonavailability of germplasm sources with high levels of genetic resistance to the disease. Prospects of developing cultivars with high levels of resistance seem remote in the near future. Under these circumstances, there should be a greater emphasis on chemical, biological, and agronomic components of integrated management of the disease. These have proved effective in augmenting the low levels of genetic resistance under field conditions. In this paper, we describe agronomic management factors (e.g., sowing date, row spacing, and plant density), and plant characters (e.g., growth habit and open canopy structure), and the basis of these in ameliorating BGM incidence. We also suggest an ideotype, based on morphophysiological considerations, to reduce disease incidence, and point out the required genotypic variation in germplasm, to realize the proposed ideotype.

Climate in Relation to BGM Incidence

Relative humidity (RH), duration of leaf wetness (Butler 1993), and temperature of the ambient air in crop canopies seem to be the important factors in BGM disease incidence. Direct effects of temperature have been found on the epidemiology of the disease (Rewal and Grewal 1989), with possible indirect effects on duration of leaf wetness. Flow of air could modify humidity and temperature conditions in crop canopies, and through it, the leaf wetness and disease incidence, but these effects have not been examined in detail in the literature with respect to BGM incidence. Light (photoperiod) seems to affect the reproductive biology of the pathogen (Rewal and Grewal 1989), and foggy (Mahmood et al 1989) and cloudy conditions seem to favor disease development.

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Agronomic Management Factors

In the subtropics of South Asia where BGM is important, favorable soil moisture conditions, resulting from residual soil moisture from the rainy-season rains and winter rains, combined with mild winter temperatures result in profuse vegetative growth, if the crop is sown soon after the rainy-season rains (in October or early November). Higher seed rates and closer row spacings also contribute to the development of dense canopies. These conditions have been found to be conducive to the development of BGM.

Effects of Sowing Dates on Altered Climatic Conditions

Late sowing of chickpea crops, in which BGM incidence is low, seems to create a mismatch between the phases of crop growth most vulnerable to the disease and the climatic conditions most favorable for disease development. For example, at Gurdaspur in Punjab, a location where the disease occurred in an epidemic form during 1980/81 and 1981/82, sowing in October exposes the crop to periods of increasing RH and falling temperatures during the time when the crop is progressing towards flowering (Fig. 1). Sowing in late November or early December results in coinciding this phase of growth with periods of falling RH and increasing temperatures. This may be regarded as a macroclimate effect of sowing date. Efforts of macroclimate on the duration of leaf wetness have not been studied, but this is necessary to relate its effect with disease incidence.

A similar effect of climatic conditions on ascochyta blight (AB) disease incidence can be seen in Mediterranean types of environments in the West Asia and North Africa (WANA) region. Low AB in spring (Mar/Apr), compared with winter (Nov/Dec) chickpea seems to be because of unfavorable climatic conditions for AB incidence during spring. Although yields of spring chickpea are almost half those of winter chickpea (Saxena 1984), spring chickpea developed as a popular traditional practice because cultivars resistant to the disease and cold were not available in the past. These traits are essential if chickpea is to be grown as a winter crop in WANA.

Effects of Sowing Date on Plant Growth

Effects of early sowing on excessive vegetative growth and greater BGM incidence, and of late sowing on reduced dry matter production, both conditions reducing yield, were observed in Australia (Brinsmead 1992; Haware and McDonald 1993). Effects of sowing date on phenology, shoot mass, yield, and harvest index are also commonly observed in India. For example, in Hisar, Haryana, India (Fig. 2), a lower shoot mass and higher harvest index in late sowing shows that vegetative growth is inhibited in the late-sown crop. The crop growth is related to temperature, terminal heat, and a fall in RH (Fig. lb).

It is generally presumed that excessive vegetative growth in early sowing causes microclimate differences in dense crop canopies that are favorable to

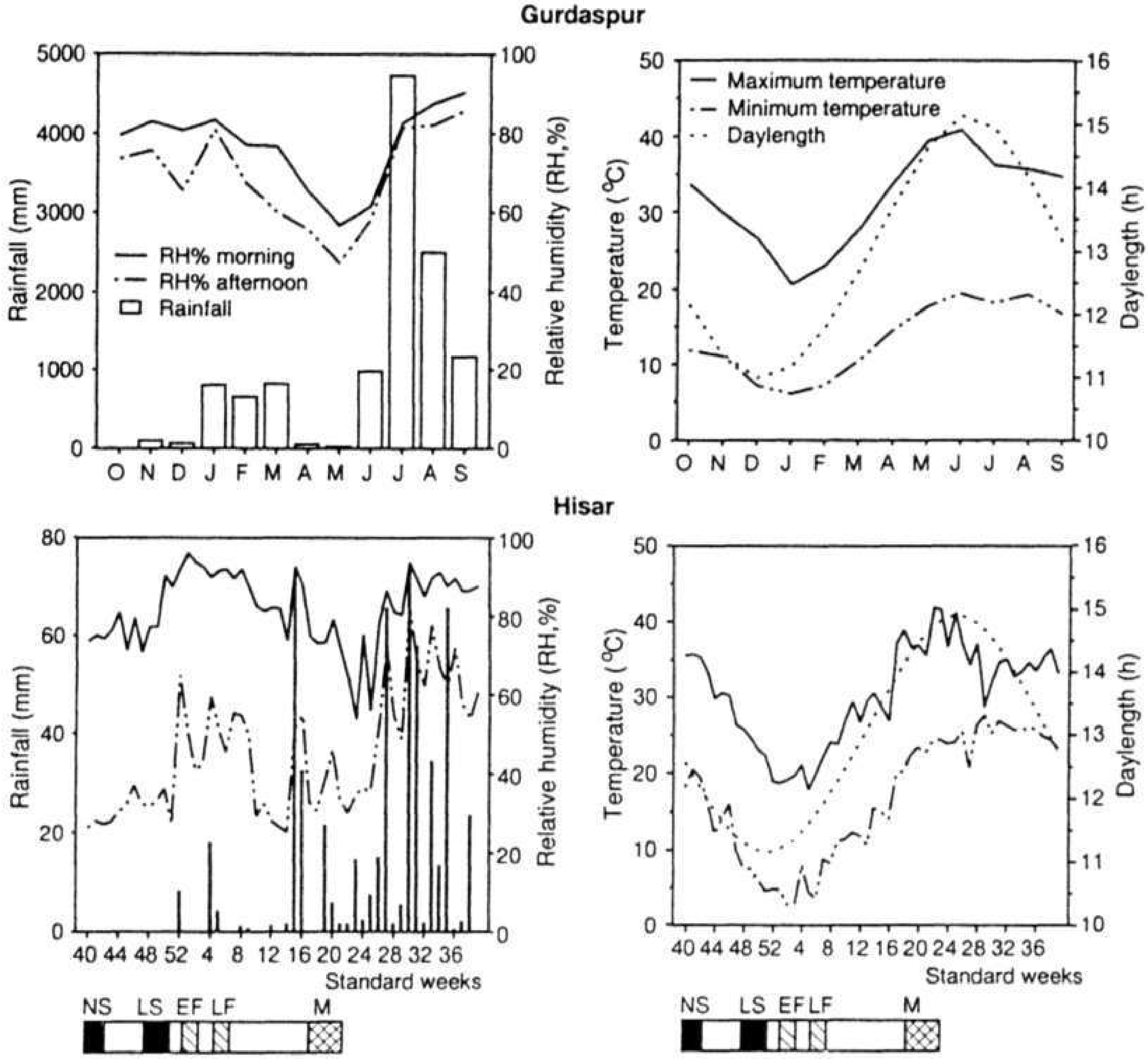

Figure 1. Weather conditions at Gurdaspur (mean of 1992-94), and Hisar (1982/83 chickpea cropping season), Haryana, India. (NS = normal sowing, LS = late sowing, EF = early flowering, LF = late flowering, and M m maturity).

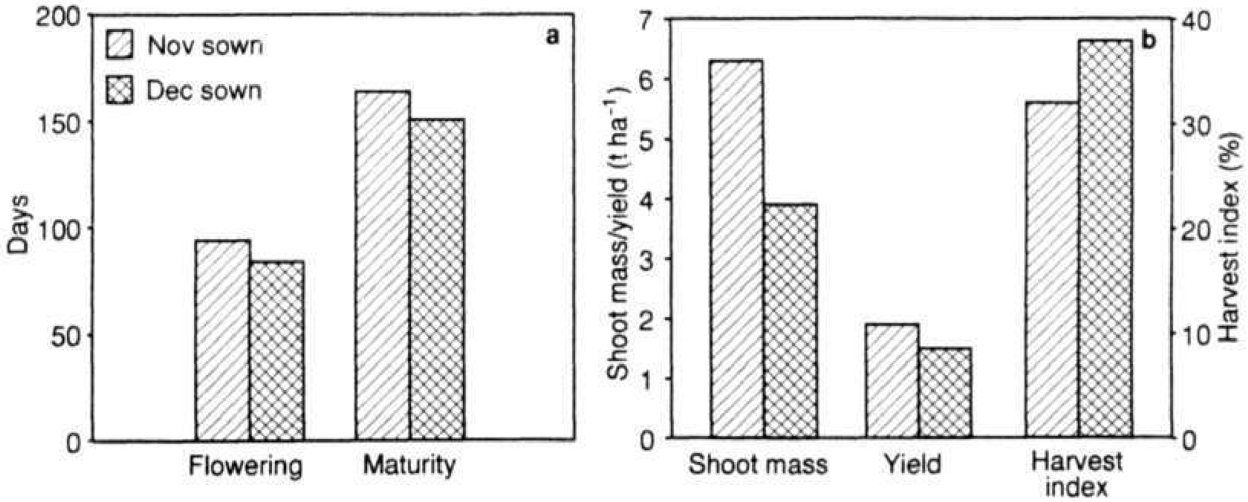

Figure 2. Effect of sowing date on (a) days to flowering and days to maturity, and (b) on shoot mass, yield, and harvest index (HI%). ICRISAT cooperative research center, Hisar, 1982/83.

disease incidence. The reverse is expected to be true in late sowing, which inhibits crop growth. However, there are no data to verify these supposed effects. In the absence of such data, it is difficult to infer which of the two effects of sowing dates, between macro- and microclimates, is more important for reduced BGM disease. This knowledge is necessary to refine this component in the integrated management of BGM.

A great disadvantage of adopting late sowing as an agronomic component of BGM management is the penalty in yield (Fig. 2). If experimental evidence shows that the macroclimate effects of late sowing are more dominant than microclimate effects, which are likely to occur when plant density is increased in late-sown conditions, the penalty in yield can easily be overcome.

Effects of Sowing Geometry

A wide row spacing reduces disease incidence at a constant plant density (Reddy et al. 1993), perhaps because of improved ventilation in the crop canopy brought about by spatial rearrangement of crop ground cover. The advantages of sowing in paired rows, compared with uniform row spacing (ICRISAT 1995), combine the positive effects of wide spacing, and the scope of increasing plant densities. This, however, needs to be confirmed.

There are not many studies on the effects of sowing geometry, row spacing, and row orientation, with respect to natural wind direction, and their effects on the flow of air through crop canopies, leaf wetness, and disease incidence. Information on these aspects would be useful to further improve the agronomic management of this disease.

Detopping of Shoots

Detopping (nipping) of young shoots, and the top portion of branches with three to four terminal leaves, is a practice in some areas where crop growth is profuse, as in parts of India (Saxena and Yadav 1975) and also in Bangladesh. The detopped shoots are a preferred vegetable (called 'Shag'), in the Barind tract of Bangladesh. This also reduces subsequent vegetative growth.

Another method adopted by farmers, to reduce excessive vegetative growth, is to drive goats and sheep quickly through their chickpea fields, to lightly graze the standing chickpea crops. This practice has been adopted in some regions (western parts of Rajasthan, India, and Dera Ismail Khan, Attak, and Thal in Pakistan), where sheep and goats are an integral part of the production system.

Detopping of shoots and animal grazing, apart from providing economic value as food and feed, also arrest subsequent vegetative growth and possibly increase yield. In addition to these, they also help in reducing BGM disease. These two practices thus merit consideration as components in the integrated management option.

Effects of Plant Type

Chickpea genotypes with erect and compact growth habit have less BGM compared with genotypes with bushy and spreading growth habit (Reddy et al. 1993). This effect of compact plant type on BGM disease is attributed to the differences in microclimate conditions that this trait could cause. However, no data are available to verify this effect of plant type on microclimate under field conditions.

Compact plant type is an aggregate effect of one or more such morphological traits as branch number (primary secondary and tertiary), branch angle, number of nodes and therefore leaves per plant, and number and size of pinnules in a compound leaf. An analysis of growth of compact and bushy growth habits could help identify morphological components of these plants that are related to the gross differences in morphology, and their associated effects in modifying the microclimate.

Ideotype Approach: Effects of Plant Architecture and Functions

The expression of the effects of erect and compact plant habit on reducing BGM disease incidence can be further enhanced by incorporating morphological traits that could reduce foliage growth. We propose that an ideotype, likely to have low BGM incidence, should have the following morphological and functional traits:

- Erect and compact growth habit.
- Few leaves.
- Few and narrow pinnules.
- Ability to set pods at high soil moisture regimes and high humidity.
- An early and rapid rate of dry matter partitioning into seeds through large seeds or twin-pod character.

Variability for these traits is available in chickpea germplasm collection, as pointed out below. We suggest that the proposed ideotype can be realized as a genotype by the multidisciplinary team in the BGM working group.

Morphological Traits

Reduction in leaf number

A large variation in the number of leaves or nodes per plant exists in the germplasm. This variation in leaf number is generally associated with differences in seed size, large-seeded types having fewer leaves. For example, K 850 [28 g (100 seed)$^{-1}$] has fewer nodes and therefore, leaves per plant (129 nodes plant^{-1}), than Annigeri (145 nodes plant^{-1}) [(18 g (100 seed)$^{-1}$], when grown at ICRISAT Asia Center (IAC). K 850, a genotype with semi-compact growth habit, has lesser disease incidence than the bushy types (M P Haware, IAC, personal communication). However, large-seeded types have the disadvantage of having large pinnule size.

Reduction in area per leaf

In chickpea germplasm, accessions with fewer pinnules (ICC 5680) or with narrow pinnules (ICC 14330) are available. Both these traits could be useful in reducing the pinnule size of large-seeded types, provided the two traits are not closely linked.

Compact growth habit

In chickpea, not many studies have been done on the angle and different order of branches, and their relationship with canopy spread and structure. A study in germplasm for variation of this trait and to establish a causal relationship between plant architecture and foliar disease would be useful.

Functional Traits

Rapid rate of dry matter partitioning into seeds

Large-seeded and twin-podded genotypes have a rapid rate of seed filling, compared with small-seeded types (Saxena and Sheldrake 1975). A rapid rate of partitioning of dry matter into seed as sinks could inhibit concurrent vegetative growth. This can be inferred from the fact that removal of flowers and pods as competitive sinks results in continued growth of vegetative structure, both of the shoot and root, including nodules in chickpea (Sheldrake and Saxena 1979). Large variation in seed size is available in germplasm.

Continued pod set at high soil moisture regimes

In chickpea, high soil moisture during the reproductive period (flowering and early pod set), e.g., frequent irrigation or rainfall during flowering, has been found to make plants revert into a vegetative growth phase. High humidity could also have similar effects. This response could induce effects similar to flower removal (Sheldrake and Saxena 1979), or of failure of pod set at chilling temperature (Saxena and Johansen 1990), causing excessive growth. ICC 5810 behaves differently in this respect by continuing to flower and set pods at high soil moisture, when the crop is irrigated regularly during the flowering period. It also produces less shoot mass.

Future Thrust

It seems unlikely that high levels of host-plant resistance to BGM will be found in the near future. However, evidence to date indicates that there is good scope of improving BGM management through targeted refining of agronomic management practices, and improvement of plant type. Thrust areas of research that are important in the agronomic management of BGM are:

- Validation of the integrated management packages in on-farm trials.

- Effects of agronomic management practices and of plant type on the macro- and microclimate parameters, and relating them to disease incidence.
- Identification of components of morphology that contribute to erect and compact growth habit.
- Realization of the proposed ideotype as a genotype by the multidisciplinary team of scientists in the working group on BGM of chickpea.

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Breeding for Resistance to Botrytis Gray Mold of Chickpea in Pantnagar, India

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Chickpea *(Cicer arietinum* L.) breeding research at G B Pant University of Agriculture and Technology (GBPUAT), Pantnagar, Uttar Pradesh, India, was initiated in 1966/67, with the objective of developing high-yielding chickpea cultivars with wider adaptability, resistance to major diseases, and with acceptable seed quality. As a result of these efforts, a small-seeded [12-13 g (100 seeds)$^{-1}$] cultivar, Pant G 114, was developed from G 130 x 1540 cross. A program was initiated recently to develop cultivars suitable to the late-sown conditions in Uttar Pradesh.

Pantnagar is located at the foothills of the Himalayas, and falls in the humid subtropical climate zone (29°N latitude, 79.3°E longitude, and an altitude of 243.8 m). It is a hot spot for botrytis gray mold (BGM) disease of chickpea. The major activities of the chickpea breeding program during the last 3 years are described below.

Screening of Diverse Lines/Cultivars

Over 100 lines were grown under normal and late-sown conditions, and were scored for BGM reaction on a 1-9 scale. Of these, ICCL 87322 showed resistant reaction to BGM. This line has also been observed to be moderately resistant to BGM under artificial screening at GBPUAT.

Hybridization Program

To develop higher-yielding varieties with wider adaptability, along with resistance/tolerance to major diseases, the following cultivars/lines were frequently used in the hybridization program. These were: Pant G 114, C 235, Radhey, Avrodhi, PBG 1, ICC 1069, ICC 10302, ICCL 87322, KPG 59, and BG 329.

Selection in Segregating Generations

The segregating generations (F_2-F_4), emanating from the crosses of BGM-tolerant lines (ICC 1069, ICC 10302, ICCL 87322) and high-yielding cultivars (C 235, T 3,

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Radhey, Avrodhi, PBG 1, and BG 329) were grown in normal and late-sown conditions in 1992/93 and 1993/94. The normal crop was sown after the harvest of maize (in October) and the late-sown crop, after the harvest of rice (in November). Individual plants were selected in the F_3/F_4 generations, and progenies were selected in the F_4/F_5 generations. Selection was for tolerance to diseases (under natural epiphytotic conditions), good podding, and seed size [15-25 g (100 seeds)$^{-1}$]. More than 50 elite lines have been developed; of these 11 combine high level of resistance to BGM.

Evaluation of Elite Lines

Selected F_4/F_5 progenies were evaluated in an augmented design. Later, their promising progenies were tested in replicated trials, where Pant G 114, Avrodhi, and Pusa 256 were included as controls. One of the elite lines, PG 92-2 (ICC 1069 x T 3), is being tested in coordinated trials. Other lines with BGM resistance are: PG 95-9, PG 95-22, PG 95-23, PG 95-24, PG 95-29, PG 95-30, PG 95-31, PG 95-32, PG 95-33, and PG 95-34.

Collaborative Breeding

A collaborative project titled 'Polygon Breeding' involves ICRISAT Asia Center (IAC), Punjab Agricultural University, Ludhiana, and GBPUAT, and aims to develop high-yielding cultivars with resistance to BGM. Crosses were made at IAC, and the F_3 populations were shared equally. The following F_3 populations were grown in the BGM screening nursery during 1995/96 postrainy season: Radhey x ICC 14303, GL 91026 x ICCV 90201, GF 89-36 x ICC 11324, and Radhey x GL 91026.

In addition, five BGM-tolerant lines were increased in the station trial, along with other material developed at GBPUAT.

Genetics of Resistance to Botrytis Gray Mold of Chickpea

I S Singh[1]

Botrytis gray mold (BGM) is one of the most important diseases of chickpea *(Cicer arietinum* L.) in northeastern India. Development of resistant cultivars is an effective method of controlling the disease. However, incorporation of resistance into high-yielding cultivars is hampered owing to lack of information on the genetics of resistance to BGM.

Three chickpea lines (P 349-2, P 919, and NEC 2451), showing field resistance (5 on a 1-9 point scale) to BGM, and two lines (JG 62, T 3) showing susceptibility were used as parents. Two resistant x susceptible (P 919 x JG 62, NEC 2451 x T 3), two resistant x resistant (P 919 x NEC 2451, P 919 x P 349-2), and one susceptible x susceptible (JG 62 x T 3) crosses were made. The parents, F_1, F_2, and F_3 generations were screened under field epiphytotic conditions. Three rows of a highly susceptible cv JG 62 were sown around the experimental plot as spreader rows. The entire experimental plot was sprayed with a spore suspension (25 000 spores mL^{-1}) of *Botrytis cinerea* Pers. ex Fr. (which causes BGM) in the evenings at 40, 50, and 60 days after sowing (DAS), to increase disease incidence.

Disease reaction was recorded on individual plants at 50, 65, 80, and 90 DAS. In order to confirm the results from the field screening, a second set of material was screened in a greenhouse. The experimental material consisted of the parents, F_1 and F_2 generations. Spore suspension containing 25 000 spores mL^{-1} was used to inoculate the test material at three stages, starting from 40 DAS at 10-day intervals. After inoculation, the plants were covered with moist polyethylene bags for 48 h, and kept in the greenhouse at 25±2°C. During this period, water was sprayed on to the plants to maintain high humidity. Observations on disease reaction on single plants were recorded 10 days after inoculation. Chi-square was used for testing of goodness of fit to different genetic ratios in F_2 and F_3 generations.

Three lines of chickpea, P 919, P 349-2, and NEC 2451, were identified as resistant, while JG 62 and T 3 were identified as susceptible. The F_1 plants from two crosses involving resistant and susceptible parents were resistant. The segregation pattern in the F_2 and F_3 generations under field conditions, and in F_2

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Singh, I.S. 1997. Genetics of resistance to botrytis gray mold of chickpea. Pages 31-32 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 19%, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

in the greenhouse revealed resistance to BGM to be under the control of a single dominant gene in P 919 and NEC 2451 parental lines. The F_2 and F_3 segregation ratios of the cross P 919 x P 349-2 (between two resistant parents) indicated the presence of duplicate dominance for resistance. Overall results indicated that resistance against BGM in chickpea follows major gene resistance (Table 1).

The set of experimental material included in the present report has indicated a monogenic mode of inheritance for resistance to BGM of chickpea. However, the intermediate reaction of test plants in F_1, F_2, and F_3 generations does not point to the possibility of polygenic inheritance. The mode of inheritance may be both Mendelian and polygenic, as in the case of resistance to helminthosporium blight of corn.

Table 1. Reaction of parents, their F_1s, F_2s, and F_3s to botrytis gray mold in the field.

Cross	Generation	Observed frequency[1] R	Observed frequency[1] S	Total	Expected ratio[1] R	Expected ratio[1] S	P value
P 919 x JG 62	P_1	50	-	50	-	-	-
	P_2	-	38	38	-	-	-
	F_1	17	-	17	-	-	-
	F_2	196	62	258	3	1	0.80-0.70
	F_3	298	182	480	5	3	0.90-0.80
NEC 2451 x T 3	P_1	36	-	36	-	-	-
	P_2	-	32	32	-	-	-
	F_1	27	-	27	-	-	-
	F_2	90	28	118	3	1	0.80-0.70
	F_3	238	145	383	5	3	0.90-0.80
P 919 x NEC 2451	P_1	40	-	40	-	-	-
	P_2	-	48	48	-	-	-
	F_1	10	-	10	-	-	-
	F_2	218	-	218	-	-	-
	F_3	268	-	268	-	-	-
P 919 x P 349-2	P_1	30	-	30	-	-	-
	P_2	45	-	45	-	-	-
	F_1	21	-	21	-	-	-
	F_2	185	14	199	15	1	0.70-0.50
	F_3	226	30	256	55	9	0.30-0.20
JG 62 x T 3	P_1	-	52	52	-	-	-
	P_2	-	47	47	-	-	-
	F_1	-	22	22	-	-	-
	F_2	-	185	185	-	-	-
	F_3	-	210	210	-	-	-

1. R = Resistant and S = Susceptible.

Screening Chickpea Genotypes for Botrytis Gray Mold Resistance in Bangladesh

M S Hossain, M Motiur Rahman, and M A Bakr[1]

Chickpea *(Cicer arietinum* L.) is the third most important pulse crop in Bangladesh in area and production. Among the major diseases of chickpea, botrytis gray mold (BGM), caused by *Botrytis cinerea* pers. ex Fr. is the most serious, and causes yield instability. Resistance sources are not available among the local cultivars in Bangladesh. Therefore, screening of germplasm under natural conditions was initiated at the regional agricultural research station, Ishurdi, Bangladesh, in 1990. In 1993, a mist irrigation system was installed in the BGM disease nurseries at Ishurdi, to create uniform humidity in the field. The germplasm and breeding material were then screened under uniform and heavy disease pressure.

During 1990-94, 276 entries were received from ICRISAT, to be included in the BGM nurseries. Each entry of each nursery was sown in a 4-m long single row, with 40 cm x 10 cm spacing in two replications. The susceptible control, ICC 4954, was sown after every two test entries. Plant stand was recorded 20 days after sowing. Mist irrigation was applied four times daily, for 20 min (at 1000, 1200, 1400, and 1600) starting from the 50% flowering stage to the pod-filling stage. Disease development was recorded at 10-day intervals on a 1-9 scale. Promising lines were screened for a second year, for confirmation of tolerance.

Out of the 86 entries screened during 1990/91, 19 entries were selected initially, and were further screened for the next 4 years. Most of the entries died due to disease complex. Out of the 115 entries screened during 1991/92, 14 entries were selected. These were screened for three consecutive cropping seasons, and GL 85103 was selected (scoring 5 on a 1-9 scale) as promising. None of the entries screened during 1992/93 screening was resistant.

Five entries (scoring 5 on a 1-9 scale) from the 1993/94 screening nursery will be screened again to confirm their resistance. During 1994/95, 10 entries (with score of 4-5 on a 1-9 scale) were selected, out of 23 entries.

During the 5 years of screening, the intensity of disease varied from year to year. Out of the 276 entries tested, only one entry, GL 85103, showed tolerance reaction. Although this entry initially had a rating of 3, in the fourth year of screening, it was rated 5 on a 1-9 scale.

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Future Work

- Work on screening of BGM should be continued.
- To date, sources of resistance to BGM have not been identified among the cultivated species of chickpea. Efforts should, therefore, be devoted to transferring resistant genes from the wild species. ICRISAT can take the lead role, and we can support the program through field screening.

Breeding Chickpea for Resistance to Botrytis Gray Mold: Problems and Progress

H A van Rheenen[1], H S Tripathi[2], M P Haware[1], B V Rao[1], and S Jayanthi[1]

Introduction

Attempts to manage botrytis gray mold (BGM) of chickpea *(Cicer arietinum* L.), caused by *Botrytis cinerea* Pers. ex Fr., have been made since as recently as 1980. Globally, the disease is of limited significance, but regionally it is important, as in eastern Asia. In this paper, we give a brief inventory of the main literature available on BGM, and then update the paper presented by Sethi et al. (1993) at the Second Working Group Meeting at Rampur, Nepal in 1993, on breeding for BGM resistance at ICR1SAT. We also present selected data obtained during recent research in breeding and screening for BGM resistance, and discuss the results of data analyses and the consequences for further research.

Literature on BGM in Chickpea

The literature on BGM in chickpea is limited (Table 1).

Table 1. Results of a literature search of the Semi-Arid Tropical Crops Information Service database using key words: chickpea + botrytis.

Source	Articles
Proceedings of BGM Working Group Meetings	
Haware et al. 1993	10
Haware et al. 1991	8
International Chickpea Newsletter 1987-1996	8
Various Indian Journals	7
Legumes Program	
Progress Reports, ICRISAT 1987-1996	4
Miscellaneous	4
Total	41

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The results presented in the literature are mainly on:

- Characteristics of the pathogen, its variability and symptomatology.
- Screening for disease resistance and its results.
- Preliminary observations on epidemiology and crop damage.
- Management by cultural practices.

Literature on *Botrytis* spp., *Botrytis cinerea* included, in crops other than chickpea, is fairly extensive, but it is again very limited on sources of resistance and breeding for resistance (Table 2). Subjects most frequently addressed, as indicated in Review of Plant Pathology (RPP) 1991-1995, include control, environmental factors, host range, enzymes, antagonists, and storage. In the 1993 and 1994 volumes of RPP, chickpea as a crop takes a good share, among other crops, for BGM references, because of the 1991 and 1993 Working Group Meetings. For chickpea, there is a comprehensive listing of varieties at one place or another, that have been reported to show resistance to BGM. It appears from Table 2 that grape, strawberry, and faba bean have more references than the other crops.

Table 2. World literature on *Botrytis* spp. varietal differences, breeding, and selection in various crops.

	No. of articles					
Crop	1991	1992	1993	1994	1995	Total
Grape	2	2	3	-	3+0.3	10.3
Strawberry	1	1	1	1	2	6
Faba bean	2	0.5	1	2	-	5.5
Rape seed	-	2	-	0.5	-	2.5
Sunflower	-	1	-	1	-	2
Linseed	-	1	-	0.5	-	1.5
Tobacco	-	-	1	-	0.3	1.3
French bean	-	1	-	-	-	1
Onion	1	-	-	-	-	1
Pea	-	0.5	-	-	0.5	1.0
Pear	-	-	-	-	1	-
Pistachio	1	-	-	-	-	1
Rose	1	-	-	-	-	1
Kohlrabi	-	-	-	-	0.5	0.5
Tomato	-	-	-	-	0.3	0.3
Total	8	9	6	5	8	36

1. Source: Review of Plant Pathology 1991-1995, volumes 70-74.

Table 3. Breeding material screened in the collaborative botrytis gray mold screening nursery at G B Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh, India, 1993-96.

	No. screened		
Breeding material	1993/94	1994/95	1995/96
F_3 bulks	6		4
F_4 progenies		20	72
F_5 bulks	1		
F_6 progenies			32
Advanced lines	283	198	192

- = Not screened.

Breeding Chickpea for BGM Resistance

Sethi et al. (1993) presented a table on breeding material screened for BGM resistance from 1989 to 1993 in the collaborative BGM Screening Nursery at G B Pant University of Agriculture and Technology (GBPUAT), Pantnagar, Uttar Pradesh, India. Table 3 gives an update of the information.

Thirty-six entries, selected from the BGM nursery at Pantnagar, were also evaluated in replicated yield trials during 1993/94, and 13 were selected for inclusion in the International nurseries the same year, while one was entered in the All India Coordinated Pulses Improvement Project (AICPIP) trials. To give an example of performance: ICCX 860031-BP-BP-4PN-BG-B, included in the AICPIP trials, ranked second out of 18, tested at Hisar and Gwalior, with a mean yield of 2.2 t ha^{-1}, compared with 1.4 t ha^{-1} for Pant G 114, and 1579 for Gaurav.

Forty-two entries, selected from the BGM nursery at Pantnagar, were selected for testing in replicated yield trials during 1994/95. ICCX 890365-BP-3PN-BPN-BP ranked first out of 25 tested at Gwalior, Hisar, and Patancheru, with a mean yield of 1.8 t ha^{-1}, compared with 1 t ha^{-1} for Pant G 114 and 0.1 t ha^{-1} for Annigeri. Out of the 42, seven were selected and included in international nurseries during 1995/96, and 14 are being tested in advanced yield trials during 1995/96. Eighty-four entries, selected from the BGM nursery and ICRISAT Asia Center (IAC) Growth Room, are being multiplied during 1995/1996, for possible further testing during 1996/97.

Analysis of Selected Data

Some questions that need to be asked when considering the scope for breeding for BGM resistance are:

- Is the disease rating scale sufficiently concise and clear?
  - Do different researchers arrive at comparable ratings when scoring disease damage?

- Is the screening technique adequate?
  - Are results sufficiently consistent over replications, scoring dates, years, and over environments?
- Do we have satisfactory sources of resistance?

To formulate preliminary answers to the above questions, several BGM data sets from Pantnagar and IAC, established over several years, were studied but only one was selected for presentation here, as it shows the salient features required for the purpose (Table 4).

Table 4. Botrytis gray mold disease (BGM) rating in experiments PN002/00488R and PN00689R, conducted at Pantnagar in the BGM screening nursery during 1988 and 1989 postrainy seasons. (Rating scale: 1 = no symptoms, 9 = killed by disease).

Entry no.	BGM disease rating							
	1988		1989					
	A1	A2	BI	BII	CI	CII	B	C
01	3	3	8	8	6	6	8.0	6.0
02	3	5	7	7	7	6	7.0	6.5
03	5	3	6	7	6	6	6.5	6.0
04	3	3	5	8	5	6	6.5	5.5
05	3	3	8	6	6	5	7.0	5.5
06	5	3	7	6	7	6	6.5	6.5
07	5	5	6	6	5	6	6.0	5.5
08	5	3	7	6	7	7	6.5	7.0
09	5	3	8	8	7	7	8.0	7.0
10	3	3	5	6	5	5	5.5	5.0
11	5	3	6	7	5	8	6.5	6.5
12	3	3	7	7	6	7	7.0	6.5
13	3	5	8	7	6	6	7.5	6.0
14	5	5	6	7	6	6	6.5	6.0
15	3	3	7	8	6	8	7.5	7.0
16	5	3	8	8	7	7	8.0	7.0
17	5	5	8	9	7	7	8.5	7.0
18	5	5	5	7	6	6	6.0	6.0
19	5	5	7	8	6	6	7.5	6.0
20	7	7	7	9	6	9	8.0	7.5
SE							0.60	0.72
Mean							7.03	6.25
CV (%)							11.99	16.21

1. A1: Scoring date: February B I, B II: Rating team B, Rep 1,II
   A2 : Scoring date: March C I, CII: Rating team C, Rep I, II

Table 5. Correlation coefficients for the various disease rating combinations as shown in Table 3.

Entry no.		1988			1989					
		A1	A2	$\bar{A}$	B I	B II	C I	C II	$\bar{B}$	$\bar{C}$
1988	A1	-	0.47	0.85	-0.03	0.26	0.09	0.49	0.13	0.43
	A2	0.47	—	0.86	0.02	0.34	0.09	0.22	0.19	0.22
	$\bar{A}$	0.85	0.86	-	-0.03	0.35	0.11	0.41	0.19	0.38
1989	BI	0.03	-0.02	-0.03	—	0.31	0.56	0.20	0.83	0.55
	BII	0.26	0.34	0.35	0.31	-	0.17	0.57	0.79	0.54
	C I	0.09	0.09	0.11	0.56	0.17	-	-0.05	0.46	0.68
	C II	0.49	0.22	0.41	0.20	0.57	-0.05	—	0.47	0.70
	$\bar{B}$	0.13	0.19	0.19	0.83	0.79	0.46	0.47	-	0.67
	$\bar{C}$	0.43	0.22	0.38	0.55	0.54	0.68	0.70	0.67	-

Correlations between the various columns are shown in Table 5.
Table 5 enables us to give preliminary answers to the questions raised.

- Disease rating scale.

Correlation $F_{\bar{B}\,\bar{C}}$ = 0.67
The relatively low R-value suggests that the rating scale needs more precise definition.

- Screening technique.

\- Consistency over replications:
Correlation $R_{BI.BII}$ = 0.31
$K_{CI.CII}$ = -0.05
The R-values are alarmingly low, which suggests that the screening nursery lacks uniformity, and needs improved environmental control.

\- Consistency over scoring dates:
Correlation $R_{A1 \cdot A2}$ = 0.47
The low R-value suggests that the most relevant scoring date needs to be identified in such a way that data from different experiments are comparable.

\- Consistency over years:
The correlations: $R'_{\bar{A}\cdot\bar{B}}$ = 0.19
$R'_{\bar{A}\cdot\bar{C}}$ = 0.38
$R'_{\bar{B}\cdot\bar{C}}$ = 0.67
The low correlations between years suggest that uniformity over years needs to be improved.

- Sources of resistance

Several varieties have been listed by various authors, and some varieties have shown resistance over more years at more than one location (Vishwa Dhar et al. 1993). However, the observations presented above under 'Analysis of Selected

Table 6. Disease ratings, and their square roots (in parentheses), obtained for three environments: Pantnagar Screening Nursery 1993 and 1994, and ICRISAT Asia Center (IAC) Growth Room 1995. Rating scale: 1 = no symptoms, 9 = killed by disease.

	Environment					
Entry no.	Pantnagar 1993		Pantnagar 1994		IAC Growth Room 1995	
01	3.0	(1.7)	5.8	(2.4)	4.0	(2.0)
02	4.0	(2.0)	5.3	(2.3)	7.3	(2.7)
03	4.5	(2.1)	5.0	(2.2)	5.3	(2.3)
04	3.0	(1.7)	5.8	(2.4)	4.5	(2.1)
05	6.0	(2.4)	6.0	(2.4)	5.5	(2.3)
06	3.5	(1.9)	5.8	(2.4)	4.8	(2.2)
07	4.0	(2.0)	5.8	(2.4)	5.0	(2.2)
08	4.0	(2.0)	6.5	(2.5)	4.8	(2.2)
09	4.0	(2.0)	4.8	(2.2)	5.8	(2.4)
10	4.0	(2.0)	6.0	(2.4)	5.3	(2.3)
11	4.5	(2.1)	5.0	(2.2)	6.5	(2.5)
12	4.0	(2.0)	4.5	(2.1)	5.3	(2.3)
13	4.5	(2.1)	6.3	(2.5)	5.3	(2.3)
14	4.0	(2.0)	5.3	(2.3)	5.0	(2.2)
15	4.0	(2.0)	5.8	(2.4)	5.3	(2.3)
16	4.0	(2.0)	6.5	(2.5)	5.5	(2.3)
17	4.0	(2.0)	7.0	(2.6)	5.0	(2.2)
18	3.0	(1.7)	6.5	(2.5)	5.8	(2.4)
19	4.0	(2.0)	6.8	(2.6)	5.3	(2.3)
20	4.0	(2.0)	5.5	(2.3)	5.0	(2.2)
21	4.5	(2.1)	6.3	(2.5)	4.8	(2.2)
22	4.0	(2.0)	5.3	(2.3)	5.8	(2.4)
23	6.0	(2.4)	6.8	(2.6)	5.5	(2.3)
24	4.5	(2.1)	7.0	(2.6)	5.0	(2.2)
25	4.0	(2.0)	6.3	(2.5)	4.5	(2.1)
26	3.0	(1.7)	6.5	(2.5)	5.0	(2.2)
SE	0.828	(0.204)	0.435	(0.092)	0.339	(0.075)
Mean	4.08	(2.00)	5.90	(2.42)	5.24	(2.23)
CV (%)	28.7	(14.4)	14.7	(7.6)	12.9	(6.6)

Data' suggest that caution is required, when using the lists of resistant varieties to select parents for crossing programs.

Genetic Advance

The genetic advance expected from breeding for BGM resistance is estimated by the equation:

$$G_s = (k)\,(\sigma_A)\,(H)$$

where:

G_8 = expected genetic advance under selection

k = selection differential (2.06)

σ_A = phenotypic variation

H = heritability coefficient

The critical factors here are: σ_A and H, and in our screening nurseries, H seems to be most critical.

$$H = \frac{\sigma_a}{\sigma_A}$$

where:

σ_a = genotypic variation

From a data set presented in Table 6, obtained from three environments [Pantnagar 1993 and 1994; Growth Room (GR) 1995], we calculated:

H = 0

σ_a = 0

σ_A = 0.955(0.007)

G_8 = 0

For the material under test, and using the above facilities and techniques, the expected genetic advance was nil. The data of Table 6 were also used to estimate the consistency over environments mentioned under 'Analysis of Selected Data':

$R_{(\text{Growth Room, Pantnagar 1993})} = 0.28$

$R_{(\text{Growth Room, Pantnagar 1994})} = -0.30$

The R-values suggest that factors that may cause such discrepancies are carefully studied.

In general, the chickpea BGM host-pathosystem seems very sensitive to fluctuations in environmental factors, which cause problems in breeding for resistance. Developing a well-defined rating scale and reducing the variation in screening conditions with respect to humidity, soil, and other microclimatic parameters, may all contribute to improved consistency and a more effective screening methodology. This is especially desirable in the case of chickpea and BGM, where the resistance levels are still relatively low.

Prospects for Integrated BGM Control

The identification and use of different sources of resistance, including those from related species and of exotic origins, will enable breeders and plant pathologists to apply the method of germplasm enhancement and gene-pyramiding in a partial resistance breeding program, as recommended by Parlevliet (1993).

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Accumulation of Phytoalexins in the Foliage of Wild and Cultivated Chickpea Species, Associated with Resistance to Botrytis Gray Mold

P C Stevenson[1] and M P Haware[2]

Although not a constraint worldwide, botrytis gray mold (BGM), caused by *Botrytis cinerea* Pers. ex Fr., is a major production constraint in Bangladesh, Pakistan, and the submontane regions of Uttar Pradesh and Bihar in India. The onset of the disease, to a large extent, depends upon climatic conditions, and frequent winter rains cause heavy yield losses. Extensive screening for resistance to BGM has been carried out, but no cultivars of chickpea *(Cicer arietinum* L.) have expressed high levels of resistance, although some cultivars expressed moderate resistance showing no damage, at least in the vegetative stage. One wild species, *Cicer bijugum* (ICCW 41), however, appears to express good resistance to BGM.

The production of the anti-fungal pterocarpans, medicarpin and maackiain, in response to infection (phytoalexin response) by another pathogen of chickpea, fusarium wilt is known to occur. Further, an increased phytoalexin response by chickpea is associated with wilt resistance. There is also evidence from cell cultures that the same response is associated with resistance to blight caused by *Aschochyta rabiei.* More recently, wild species including C. *bijugum,* have been shown to express a phytoalexin response to fusarium wilt.

In a preliminary study, we investigated the possibility that this phytoalexin defence response could also be important in the natural defence of BGM-resistant and -tolerant varieties. A susceptible cultivar (H 208), a cultivar resistant in the vegetative stage (ICCL 87322), and a resistant wild species (C. *bijugum* ICCW 41) were grown in a greenhouse in sterile soil. After 7 days, the plants were transferred to the ICRISAT BGM growth room, and maintained at 100% relative humidity to provide artificial conditions most suitable for the germination and growth of BGM spores. The plants were sprayed with a 1 x 106 spore suspension in water, and maintained in the growth room for a further 4 days. Some plants were not inoculated, but were maintained in the same environment as controls.

After 4 days, the foliage of all plants was macerated and extracted in hot methanol for 24 h. Hot methanol prevents further enzyme activity, so extracts

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Stevenson, P.C, and Haware, M.P. 1997. Accumulation of phytoalexins in the foliage of wild and cultivated chickpea species, associated with resistance to botrytis gray mold. Pages 43-45 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 1996, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

contain a true chemical profile of the plant at the time of sampling. The resultant slurry was filtered through Whatman Grade 1 filter paper, and the filtrate evaporated under reduced pressure. The dry extracts were redissolved in a known quantity of methanol to give extracts equivalent to 1 g fresh mass of foliage mL^{-1} methanol.

Foliar extracts were analyzed by high performance liquid chromatography using a Waters L.C. 600 pump, Waters 717 autosampler, and a Waters 996 Photodiode array detector. Samples were injected on to a Spherisorb ODS column (25cm x 4.6mm i.d.; 5 µm particle size), and were separated using a 2% acetic acid in water (A), and 2% acetic acid in acetonitrile (B) gradient program: time = 0 min, A = 50%; time = 20 min A = 40%, using a convex gradient (Waters L.C. 600 pump curve 4). Peaks were identified and quantified by co-chromatographic comparison of retention times and UV spectra with genuine standards (Plantech UK Ltd.). The anti-fungal effects of medicarpin and maackiain are similar, so the concentration of total anti-fungal pterocarpans was combined to give a more clear comparison between varieties.

The concentration of total pterocarpans in the foliage of H 208 and ICCL 87322 was not significantly different in nontreated plants, and was shown to be approximately 45 µg g^{-1} foliage. The concentration of pterocarpans in the nontreated foliage of ICCW 41 was only 25 µg g^{-1} foliage, although this value was not significantly lower than those recorded for the cultivated species.

The concentration of pterocarpans in the foliage of both resistant and susceptible plants increased significantly after treatment and incubation with BGM spores (Fig. 1). This shows that chickpea exhibits a phytoalexin response to the BGM spores. However, the concentration of pterocarpans in treated foliage varied considerably between the plants. While the concentration increased from 45 µg g^{-1} to 138 µg g^{-1} in the susceptible variety H 208, the concentration increased to almost 400 µg g^{-1} in the treated foliage of ICCL 87322. In addition, the concentration in the foliage of the resistant wild species increased to 270 µg g^{-1} (Fig. 1).

Medicarpin and maackiain are generalist anti-fungal agents, and among other fungi less important to chickpea, have been shown to severely inhibit spore germination and hyphal growth of *Fusarium oxysporum* f. sp. *ciceri* and *Aschochyta rabiei.* If, as is likely, these compounds are also inhibitory to the BGM spores, the phytoalexin responses of the two resistant plants shown here could explain why these plants are tolerant of the disease. One observation supports this conclusion. The concentration of pterocarpans required to give optimum inhibition of spore germination of *F. oxysporum* is 250 µg mL^{-1}, and the concentration of phytoalexins in both the resistant plants was greater than this. A concentration of 138 µg g^{-1} recorded in the susceptible variety causes only 40% inhibition of spore germination in F. *oxysporum.* It is conceivable, therefore, that cv H 208 is susceptible because this cultivar produces a significantly lower phytoalexin

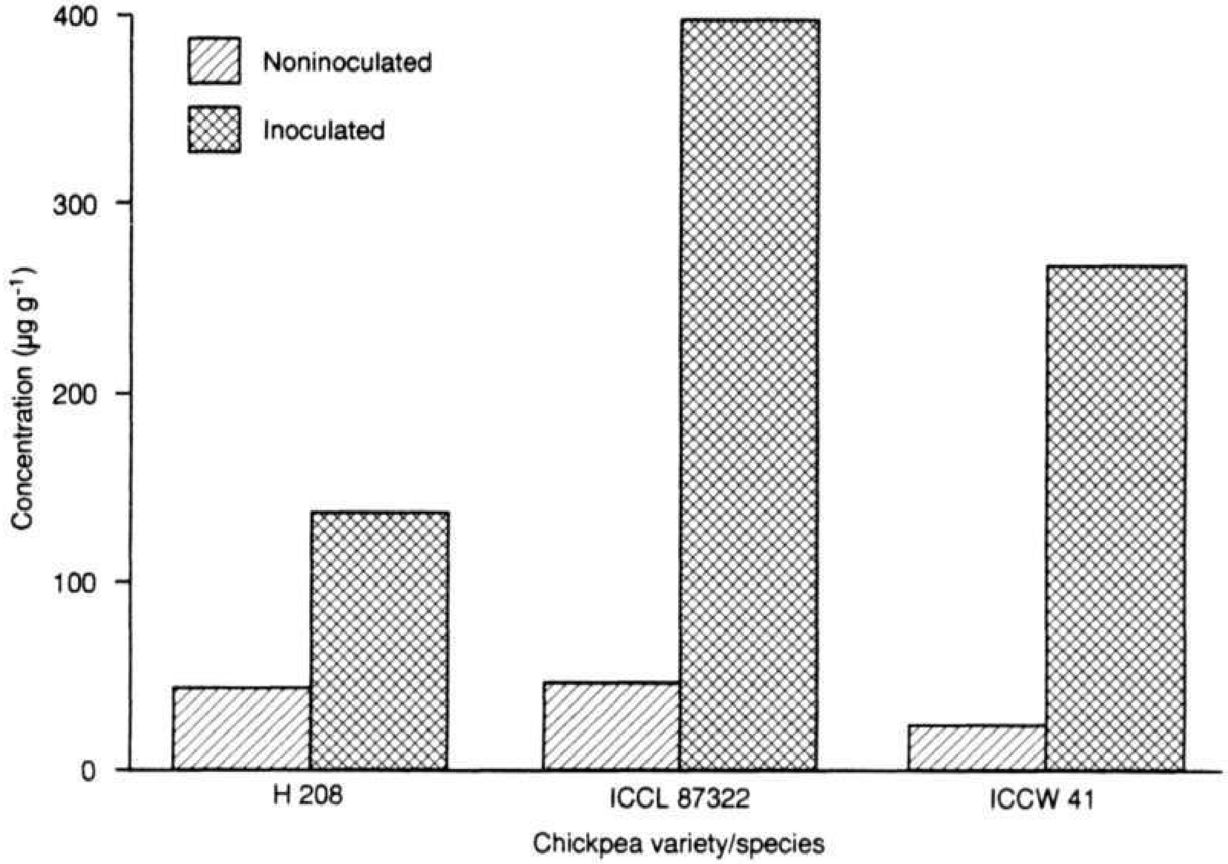

Figure* 2. *Total concentration of pterocarpans in the foliage of three chickpea varieties/ species, nontreated or inoculated with botrytis gray mold (BGM).

response to BGM than the two resistant plants, and the response is too low to have an optimum inhibitory effect on BGM.

While this is only a preliminary study, the results presented here identify a possible resistance mechanism in chickpea to BGM. The analysis could be modified and developed to use as a screening method for chickpea in early growth stages. A more detailed study is necessary to show whether any other mechanisms were expressed, and whether this response was uniform throughout the life cycle of the plant. This is because, under optimum BGM growth conditions, even the tolerant cultivar ICC 87322 succumbs to the disease in the later growth stages.

Epidemiology of Botrytis Gray Mold of Chickpea

Gurdip Singh[1]

Botrytis gray mold (BGM) of chickpea *(Cicer arietinum* L.), caused by *Botrytis cinerea* Pers. ex Fr., is an important disease in South Asian countries. There are several gaps in our knowledge of the disease, particularly factors relating to its epidemiology, and biology of the pathogen. This paper deals with such aspects of the epidemiology of BGM, as pathogen, source of inoculum, survival, spread of the disease, variability, host range, and environmental factors that favor infection and disease development.

Pathogen

The pathogen produces both imperfect or asexual (B. *cinerea),* and perfect stages *(Botryotinia fuckeliana)* (Groves and Loveland 1953). Both these stages are important in the epidemiology of the disease.

Imperfect stage

The fungus in the imperfect or asexual stage infects all the foliar parts of the plant. *Botrytis cinerea* grows profusely on potato-dextrose agar (PDA). Initially, the growth is white and cottony, and it later becomes gray with age. The fungus produces conidia and sporodochia on artificial media and on the host surface. Round, oval, unicellular microconidia are produced on the sporodochia. The sporodochia soon become nonsporiferous and change into hard sclerotial masses.

Perfect stage

The occurrence of the perfect stage (B. *fuckeliana)* has not been reported earlier on chickpea. However, it has been reported from other crops. The teleomorph stage of B. *cinerea* from chickpea was produced in the laboratory at Punjab Agricultural University, Ludhiana. Sclerotia were taken from 30-days-old culture of B. *cinerea,* and dormancy induced in the deep freezer of a refrigerator for 48 h. The sclerotia were surface-sterilized with 0.01% mercuric chloride, and kept for germination as per the technique described by Kapila (1992). The sclerotia of B. *cinerea* started germinating after 60 days of incubation, and maximum germination was

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Gurdip Singh 1997. Epidemiology of botrytis gray mold of chickpea. Pages 47-50 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 1996, Pantnagar, Uttar Pradesh, India (Ha ware, M.P, Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

achieved up to 68 days. Optimum time for apothecial formation was 67-73 days. These studies indicated that the teleomorph stage of *B. cinerea* of chickpea could be present in nature, particularly in the cooler areas of Kashmir and Himachal Pradesh, India.

Physiological Variation

There are variations in the morphological and cultural characters of different isolates of B. *cinerea.* The isolates were designated into four pathotypes, 232, 494, 508, and 510, based on their reactions on 12 chickpea lines in a growth chamber. Pathotype 232 was the least virulent, and pathotype 510 was the most virulent (Singh and Bhan 1986). Rewal and Grewal (1989) identified five pathotypes on the basis of their reaction to five chickpea lines.

Perpetuation

Botrytis cinerea can survive on crop debris and on infected seed as a saprophyte, and has a wide host range.

Infected Seeds

Infected seeds may carry the pathogen to new areas. Survival for long periods, up to 5 years, on infected seeds stored at 18°C has been recorded (Rathi and Tripathi 1993). The seed samples collected from Faisalabad (Pakistan) showed 56% infection of *B. cinerea* (Haware et al. 1986). However, the role of seedborne infection in the epidemiology of this disease is not well understood.

Plant Debris

Botrytis cinerea can survive in the soil in the form of mycelia and sclerotia from one crop season to the next. The infected plant debris and infested soil are the main sources of primary inoculum (Mahmood and Sinha 1990). Recovery of the pathogen on chickpea-infected plant debris stored under laboratory conditions was influenced by the prevailing temperature. Recovery was higher at temperatures below 10°C, and lower at 40°C, after 8 months of storage (Rathi and Tripathi, 1993). Small infected plant debris mixed in the seed as admixture also play a role in the survival of the pathogen (Grewal 1988).

Host Range

Botrytis cinerea is a facultative parasite, having a very wide host range. It infects over 100 plant species, including vegetable and fruit crops, ornamental plants, field crops, and several weeds. Rathi and Tripathi (1991) reported that B. *cinerea* infects 8 cultivated species and 21 weeds. Inoculum is available throughout the year.

Environmental Factors

Among the environmental factors, high relative humidity and free moisture on the surface of the leaf are critical in the development of the disease. Singh and Kapoor (1984) reported that there was a sharp increase in disease intensity with the increase in leaf wetness period beyond 12 h. One hundred percent mortality of chickpea plants was observed after 144 h of leaf wetness. A study conducted in Bangladesh indicated that the incidence of the disease was much higher when the mean temperature ranged from 17 to 28°C, and relative humidity from 70% to 97% (Bakr et al. 1993). The disease spreads rapidly in February-March, when the plant canopy becomes dense, and temperature is favorable. Under such conditions, there is abundant sporulation on the diseased and dead plant parts, particularly on flowers and pods. These spores are disseminated by air and rain to neighboring plants, and may travel long distances.

The relative importance of microclimate, seedborne inoculum, and other inocula has not been elucidated for BGM (Haware and McDonald 1993). The fungus grows on a wide range of temperatures. However, the optimum temperature for fungal growth and sporulation is 25°C (Mahmood and Sinha 1990). This temperature level is also favorable for the development of disease in the field and in the growth chamber. Higher disease intensity was observed when the dark period varied from 4 to 12 h. Further, the disease is more severe on plant parts hidden under the canopy than on the upper parts (Singh and Kapoor, 1984).

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Botrytis Gray Mold of Chickpea in Myanmar

Daw Myint Nu Thwin[1]

Myanmar's economy is highly dependent on its agriculture, which generates about 40.6% of the gross national income and employs 66% of the total labor force. At present, the population is about 42 million, and it is expected to reach 50 million by 2000. In order to meet the increasing needs of food and other requirements, the Ministry of Agriculture aims to grow surplus paddy, be self sufficient in edible oil, and increase production of such export commodities as pulses and industrial crops.

In recent years, the production of peas and beans increased because of market demand. Since 1992/93, areas growing pulses under multiple-cropping system have been increased owing to the rise in their price. Pulses are important not only for local consumption, but also for export. Moreover, they are relatively easy and less expensive to produce.

As the area of chickpea *(Cicer arietinum* L.) expands, the damage by pests and diseases has become more prominent. Chickpea is attacked by more than 50 pathogens, and some of them are economically important. Out of them, dry root rot and fusarium wilt were found to be major diseases in Myanmar. According to a survey carried out under a cooperative work plan between Myanma Agriculture Service of Myanmar and ICRISAT in 1990, fusarium wilt and dry root rot were found to be the main pathogens occurring in Myanmar. Other major diseases occurring at a low frequency were stunt, phyllody (mycoplasma), mosaic (alfalfa mosaic virus), and root-knot *(Meloidogyne* sp.).

Present Status of Botrytis Gray Mold of Chickpea

There has been no information yet from farmers, regarding botrytis gray mold (BGM) of chickpea. This disease is the major constraint to chickpea production in Bangladesh, Nepal, parts of Pakistan and India, all neighboring countries of Myanmar. Recently, BGM was found in some areas of Pyinmana and Monywa townships. (M P Haware, ICRISAT, personal communication 1996).

Future Plans

No systematic surveys on BGM have been made so far, and a planned program to explore the disease incidence in Myanmar is urgently needed. Therefore, with the

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Daw Myint Nu Thwin 1997. Botrytis gray mold of chickpea in Myanmar. Page 51-52 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 1996, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

assistance of, and in collaboration with the Cereals and Legumes Asia Network, ICRISAT, and plant protection working groups, four major areas of activities have been prepared: surveys, identification of diseases, screening for disease resistance, and prevention and control.

Occurrence of Botrytis Gray Mold of Chickpea in Haryana, India

Harichand, A S Rathi, and B L Jalali[1]

Botrytis gray mold (BGM), caused by *Botrytis cineria* Pers. ex Fr. is an important disease of chickpea *(Cicer arietinum* L.) in northern India. In 1980/81, it appeared in an epiphytotic form in several parts of Bihar, Haryana, Himachal Pradesh, Punjab, Rajasthan, Uttar Pradesh, and West Bengal states, causing serious losses. In Hisar (Haryana), the disease caused 70-100% grain yield losses.

From 1981/82 to 1993/94, BGM occurred regularly in some parts of Haryana, but its intensity was very low. However, during 1994/95, it occurred in a severe form in the chickpea breeding block at Chaudhary Charan Singh Haryana Agricultural University Research Farm, Hisar. In a survey conducted during 1995/96, BGM was found to occur in Bhiwani, Hisar, and Rohtak districts of Haryana. In each district, the disease was noticed at several locations and at each location, large areas were severely affected.

The cultivars H 208, H 86-18, and HC 1 (H 82-2) exhibited susceptible reaction to BGM under natural conditions. Among these, cv H 208 was highly susceptible. Cultivars Avrodhi, HC 2 (H 86-143), WR 315, and Pb 7 were less affected by the disease.

In Haryana, BGM usually occurs during the end of February or early March. During the 1995/96 cropping season, it appeared in early March, when the maximum temperature was 28.8°C and minimum temperature 11.8°C, with 68.5% relative humidity. The intensity of the disease was directly related to crop canopy. It occurred in a more severe form in areas affected by flood during the rainy season. The disease was also found to affect lentil crop.

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Harichand, Rathi, A.S., and Jalali, B.L. 1997. Occurrence of botrytis gray mold of chickpea in Haryana, India. Page 53 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 1996, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Role of Working Groups in Network Collaborative Research

A Ramakrishna and C L L Gowda[1]

Agricultural research is facing severe funding crisis globally, and research administrators and scientists are being requested to cut costs and maximize the efficiency of research output. Many laboratories and/or institutes are unable to conduct comprehensive studies due to scarcity of funds, facilities, and expertise. Therefore, the need for collaborative research for the effective utilization of the scarce financial and human resources, to achieve goals and find solutions to important production constraints, is increasingly being realized.

An agricultural research network is a group of individuals or institutions linked together by a commitment to collaborate in solving or addressing a common agricultural problem, or set of problems, and to use existing resources more effectively Collaborative research networks involve joint planning and conduct of research to address common research interests.

Working Groups

A Working Group, also called a subnetwork, consists of a group of scientists who share a common interest, and are committed to collectively address a high priority regional problem, and to share their research results with others. Working Groups coordinate and stimulate cooperative research by pooling expertise from both developing and developed countries, international research centers, and specialized research laboratories and institutions, to work together on a common platform as equal partners to find quick answers. Working Groups use existing staff and facilities, and avoid duplication of effort.

Advantages of Working Groups

Working Groups (WG) have several advantages in terms of their ability to carry out collaborative research within a network, for e.g., the Cereals and Legumes Asia Network (CLAN):

- Working Groups identify, address, and solve problems that are of high priority to a region more quickly than do institutions or researchers working independently.

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Ramakrishna, A., and Gowda, C.L.L. 1997. Role of working groups in network collaborative research. Pages 55-58 *in* Recent advances in research on botrytis gray mold of chickpea: summary proceedings of the Third Working Group Meeting to Discuss Collaborative Research on Botrytis Gray Mold of Chickpea, 15-17 Apr 19%, Pantnagar, Uttar Pradesh, India (Haware, M.P., Lenne, J.M., and Gowda, C.L.L., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

- The WG approach allows scientists to initiate a series of discrete research topics when priority problems are identified. These can be terminated once the problem is solved.
- The small size of a WG makes it cost-effective and easy to operate.
- In a network such as CLAN, WGs can share facilities and support one another in such overlapping areas as training, meetings, and workshops.
- The parent network can be used to identify research targets, disseminate results quickly, and provide feedback.

Organization and Structure of Working Groups

The members of a WG include scientists from national programs, international and regional institutions, and advanced research laboratories (Fig.1). Each WG nominates a Technical Coordinator (TC), who is normally an expert on the subject, to liaise, coordinate, and harmonize joint research. The TC is usually supported by a network or institution that provides the necessary administrative and logistic support. The Cereals and Legumes Asia Network supports and coordinates several WGs set up to address specific problems of CLAN's priority crops in the Asia region. Botrytis Gray Mold (BGM) of Chickpea Working Group is one of them.

Botrytis gray mold of chickpea Working Group

Botrytis gray mold (BGM) of chickpea *(Cicer arietinum* L.) is an important problem in Bangladesh, Nepal, parts of Pakistan, and in the submontane regions of India. This disease has also been recorded in Myanmar. To date, only low levels of resistance to BGM have been found in chickpea. Therefore, an interdisciplinary, collaborative approach was considered necessary to find ways to manage the disease. At the first Working Group Meeting held at Joydebpur, Bangladesh, during 4-8 Mar 1991, participants agreed to join collaborative research activities on BGM (Haware et al. 1992). The work plan envisaged four major research components: surveys, genetic resistance, cultural practices, and epidemiology. A second Working Group Meeting held at Rampur, Nepal, during 14-17 Mar 1993, reviewed the research carried out and developed future research plans for collaborative research under the WG (Haware et al. 1993). This is the third meeting of the WG. The collaborative research carried out under WG over the past 5 years has helped to develop field screening methods and management options for the control of BGM. Research on biological control has been initiated.

Conclusion

In addition to encouraging research collaboration among scientists, WGs help strengthen national programs' capabilities to improve basic and strategic research, and provide answers that can be quickly channelled to farmers for enhanced impact. The critical mass of scientists in a WG address and solve problems at a much faster pace, and thus considerably reduce the 'research lag'.

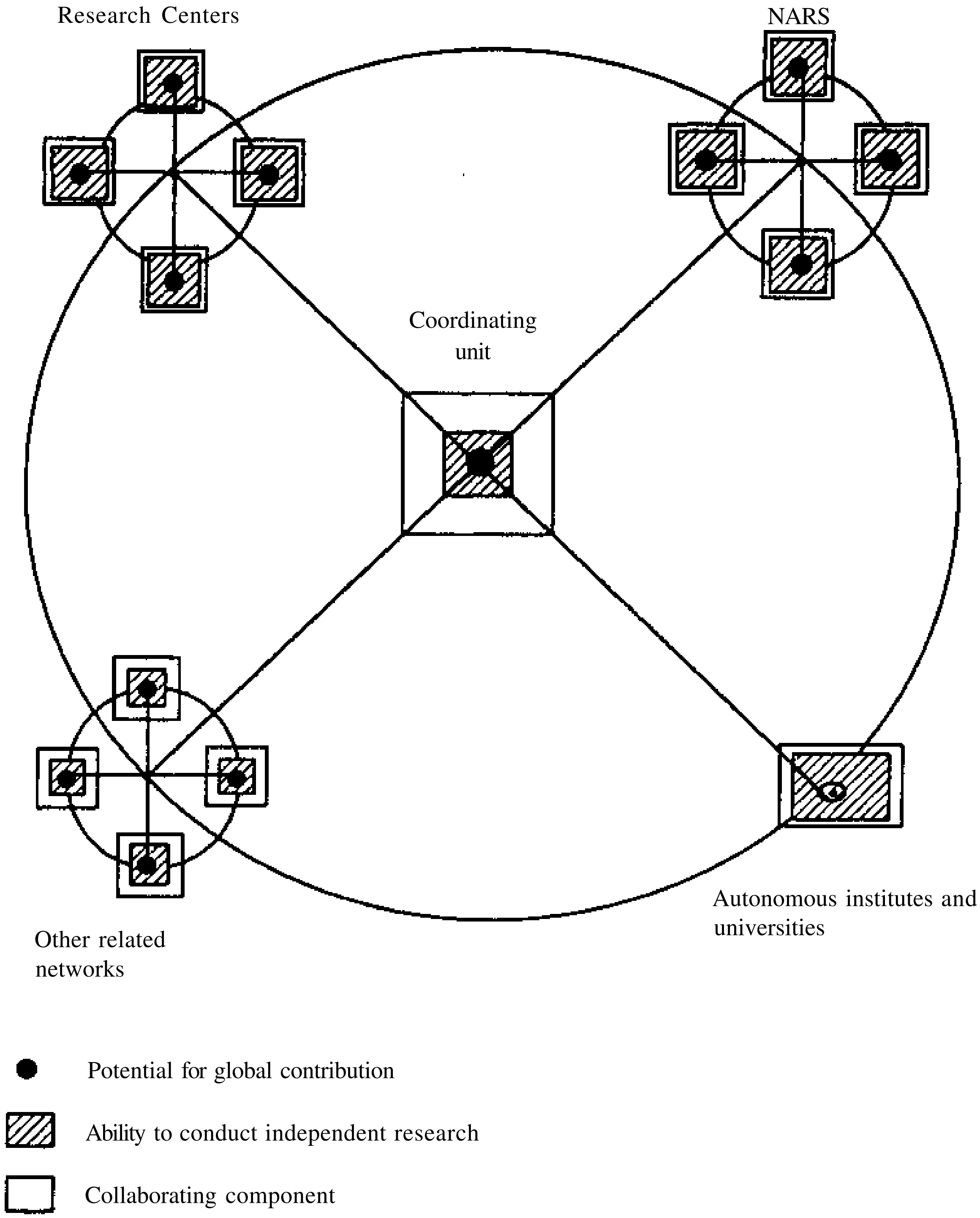

Figure 1. Structure of a Working Group.

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Recommendations

The following recommendations for the Botrytis Gray Mold (BGM) of Chickpea Working Group were developed during the Third Working Group Meeting held at Pantnagar, India, during 15-17 Apr 1996. The Group reviewed the recommendations made at the Second Meeting in 1993, and the progress made since then. Recommendations were made for followup action and appropriate research centres were identified for each area of research.

Surveys

Disease surveys have been made in Bangladesh, India, and Nepal. It was recommended that these annual surveys should continue in all countries, and information gathered to date should be summarized to better target future surveys. National programs were asked to take the lead. A systematic survey is needed to get information on distribution of BGM and its importance in Myanmar and Pakistan. Commitments were made by members of the Working Group from Bangladesh, Myanmar, and Nepal. It was agreed that there is need for coordination of surveys in India between the Indian Institute of Pulses Research (IIPR) and ICRISAT, the latter facilitating the surveys in India, depending on availability of staff and resources.

Screening for Resistance

Field screening

Pantnagar (India) and Ishurdi (Bangladesh) were identified as the key sites for field screening of BGM of chickpea. It was recommended that as far as possible, the site used for the BGM nursery should be used exclusively for germplasm and breeding material screening, and not mixed with other trials. Resistant and susceptible controls should represent both erect and bushy morphotypes of chickpea. The details of the field screening methodology at the above two sites should be compared and modified, if necessary, to ensure standardization and further refinement of methods.

Growth room screening

It was recommended that ICRISAT should evaluate and standardize the present methodology, and seek improvements if necessary.

Correlation between field and growth room screening

It was recommended that attempts should be made to assess the effect of plant age on BGM development. Correlation between disease ratings in the field and in the growth room could then be assessed. It was also recommended that additional understanding of BGM could be gained through an assessment of the reaction of seedlings to BGM in the field. This may form the basis of a more realistic correlation with seedling screening in the growth room and adult-plant performance in the field. It was strongly suggested that the seedlings should be screened in the field in February/March, coinciding with the environmental conditions most conducive to BGM development. Pantnagar and ICRISAT were assigned the responsibility for this activity.

Sources of resistance

Attempts should be made to bring together all sources of resistance from all locations for field screening at Pantnagar, and growth room screening at ICRISAT, which was assigned the responsibility for this activity.

Rating scale

It was recommended that ICRISAT scientists review the existing rating scales for field and growth room evaluations, seek further input from other members of the Working Group, and make necessary improvements. As far as possible, the scale should be made less subjective, either through photographic keys (for growth room) or quantification (for field).

Multilocational Screening

The international BGM nursery has been evaluated successfully at various locations in Bangladesh, India, and Nepal. It was agreed that some chosen locations were suitable, while others were not. The following locations were identified as the best for continued field screening: Nepal - Parwanipur and Tarhara; Bangladesh - Ishurdi and Jessore; India - Pantnagar and Ludhiana.

Basis of Resistance

It was recommended that the contribution of genetic resistance and escape in reducing BGM severity needs to be understood, to strengthen breeding efforts. Elucidation of the morpho-physio-chemical bases of resistance should be given priority. Attention should be given to understanding the role of phytoalexins in resistance to BGM, in the light of recent data from Natural Resources Institute (NRI), UK. Efforts should be focused on the production of phytoalexins at different ages of the chickpea plant, and by different plant parts. Such information is essential to evaluate the potential of enhancing the contribution of phytoalexins to disease reduction through breeding or biotechnology. The responsibility for these activities was assigned to NRI, UK, Pantnagar, and ICRISAT.

Agronomic Management

Available information on the contribution of agronomic (cultural) practices to reduce BGM incidence needs to be brought together and synthesized. This includes a wide range of practices including date of sowing, spacing, nutrition, intercropping, mixed cropping, detopping, etc. Gaps in our current knowledge should be identified, and priority areas for further research targeted. The lead role in carrying out this activity was assigned to ICRISAT, in collaboration with all the other Working Group members. As a result, it is hoped that recommendations will be made for both field screening onstation (to achieve **high** BGM pressure) and for farmers (to achieve **low** BGM pressure).

Integrated Disease Management

On-station research should continue in the development of integrated disease management (IDM) of BGM at Ishurdi (Bangladesh), Pantnagar (India), and Tarhara (Nepal). It was recommended that seed treatment with fungicides should be included as an additional component in the IDM package. Further work is needed on the potential contribution of intercropping to reduce BGM. Bangladesh, India, and Nepal were assigned responsibility for these activities.

Additional work is needed to develop an optimum methodology for the application of *Trichoderma* to chickpea. The need to summarize available information on chemical control, and the economics of such control measures was also identified. ICRISAT will take the lead in these two activities.

Epidemiology

Seedborne infection

The need to quantify the role of seedborne infection in disease development, especially in India, was recommended. Pantnagar, IIPR (Kanpur), and ICRISAT will take necessary followup action. Nepal will take the responsibility to quantify seedborne infection by BGM in Nepal.

Microclimate studies

Further work is needed to understand the effect of microclimatological variables on disease development. Some attention should be given to the role of leaf wetness vs relative humidity (RH%). Available literature on BGM in relation to microclimate in other crops should be consulted. This responsibility was assigned to ICRISAT.

Biology of the fungus

The study of biology of the fungus on the leaf surface could help our understanding of the disease development. This would best be done through student-research projects between Pantnagar and ICRISAT. This is to be finalized by ICRISAT, after discussions with Pantnagar scientists.

Pathogenic Variability

Work has been initiated in India and Nepal on understanding pathogenic variability among a range of isolates. It was recommended that this work should continue in both these countries. It was also recommended that a third country (that does not grow chickpea) should be identified for comparative studies of isolates from all countries in the region. A collaborator will be identified at the International Botrytis Meeting in Netherlands in June 1996.

Novel Approaches to Resistance

An Overseas Development Administration Holdback project will be initiated by the Scottish Crop Research Institute, Scotland, UK, and ICRISAT in October 1996, to explore the possibility of using polygalacturonase-inhibiting protein genes for resistance to BGM. The possibilities of developing additional collaborative linkages with other institutes presently involved in biotechnology research on chickpea should be explored. These include Indian Agricultural Research Institute, New Delhi; G B Pant University of Agriculture and Technology, Pantnagar; National Chemical Laboratory, Pune; and ICRISAT. Although potential sources of resistance have been found in the wild *Cicer* species, these are not yet directly usable due to cross-incompatibility problems. It was recommended that the basis of resistance in wild *Cicer* species should be determined to assess their utility and application at a later stage. This responsibility was assigned to ICRISAT, in collaboration with the institutes listed above.

Training

A training program at ICRISAT on chickpea diseases is scheduled for early 1997 with 10-15 participants from the region. Individual training programs can also be arranged at ICRISAT on request by the national agricultural research systems.

Next Meeting

It was agreed that the next meeting of the Botrytis Gray Mold of Chickpea Working Group will be held in December 1997 or March 1998, in Bangladesh. This will be followed by one at Nepal.

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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 16 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 United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.

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