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PREFACE

This volume is the twenty-third in a publication series that documents the findings of researchers on common bean (*Phaseolus vulgaris*) in Africa. This series forms part of the activities of the pan-African bean research network, which serves to stimulate, focus, and co-ordinate research efforts on this crop.

The network is organized by the Centro Internacional de Agricultura Tropical (CIAT) through three interdependent regional projects in Eastern Africa, the Great Lakes region of Central Africa, and Southern Africa (with SADC).

Publications in this series include the proceedings of Workshops held to assess the status, methods, and future needs of research on selected topics that constrain production and productivity of this crop in Africa. This particular volume reports proceedings of the pan-African pathology working group meeting held at Thika, Kenya with the objective of developing coordinated pan-African research strategies and activities leading to the control of bean diseases.

Publications in this series currently comprise:

No. 1 Beanfly Workshop, Arusha, Tanzania, November 16-20, 1986.

No. 2 Bean Research in Eastern Africa, Mukono, Uganda, June 22-25, 1986.

No. 3 Soil Fertility Research for Bean Cropping Systems in Africa, Addis Abeba, Ethiopia, September 5-9, 1988.

No. 4 Bean Varietal Improvement in Africa, Maseru, Lesotho, January 30 - February 2, 1989.

No. 5 Troisième Seminaire Régional sur l'Amélioration du Haricot dans la Région des Grands Lacs, Kigali, Rwanda, 18-21 Novembre 1987.

No. 6 First SADCC/CIAT Regional Bean Research Workshop, Mbabane, Swaziland, October 4-7, 1989.

No. 7 Second Regional Workshop, on Bean Research in Eastern Africa, Nairobi, Kenya, March 5-8, 1990.

No. 8 Atelier sur la Fixation Biologique d'Azote du Haricot en Afrique, Rubona, Rwanda, Octobre 27-29, 1988.

No. 9 Quatrième Séminaire Régional sur l'Amélioration du Haricot dans la Région des Grands Lacs, Bukavu, Zaïre, 21-25 Novembre, 1988.

No. 10 National Research Planning for Bean Production in Uganda, Makerere University, Kampala, Uganda, January 28 - February 1, 1991.

No. 11 Proceedings of the First Meeting of the Pan-African Working Group on Bean Entomology, Nairobi, Kenya, August 6-9, 1989.

No. 12 Ninth SUA/CRSP Bean Research Workshop and Second SADCC/CIAT Regional Bean Research Workshop. Progress in Improvement of Common Beans in Eastern and Southern Africa, Sokoine University of Agriculture, Morogoro, Tanzania, September 17-22, 1990.

No. 13 Virus Diseases of Beans and Cowpea in Africa, Kampala, Uganda, January 17-21, 1990.

No. 14 First Meeting of the SADCC/CIAT Working Group on Drought in Beans, Harare, Zimbabwe, May 9-11, 1988.

No. 15 First Pan-African Working Group Meeting on Anthracnose of Beans, Ambo, Ethiopia, February 17-23, 1991.

No. 16 Cinquième Séminaire Régional sur l'Amélioration du Haricot dans la Région des Grands Lacs, Bujumbura, Burundi, 13-17 novembre 1989.

No. 17 Sixième Séminaire Régional sur l'Amélioration du Haricot dans la Région des Grands Lacs, Kigali, Rwanda, 21-25 janvier 1991.

No. 18 Conférence sur le Lancement des Variétés, la Production et la Distribution des Semences de Haricot dans la Région des Grands Lac, Goma, Zaïre, 2-4 Novembre 1989.

No. 19 Recommendations of Working Groups on Cropping Systems and Soil Fertility Research for Bean Production Systems, Nairobi, Kenya, 12-14 February 1990.

No. 20 First African Bean Pathology Workshop, Kigali, Rwanda, 14-16 November, 1987.

No. 21 Soil Fertility Research for Maize and Bean Production Systems of the Eastern African Highlands - Proceedings of a Working Group Meeting, Thika, Kenya, 1-4 September 1992.

No. 22 Actes de l'Atelier sur les Strategies de l'Amelioration Varietale dan la Region des Grands Lacs, Kigali, Rwanda, 17-20 Janvier 1991.

No. 23 Proceedings of the Pan-Africa Bean Pathology Working Group Meeting, Thika, Kenya, May 26-30, 1992.

Financial support for the regional bean projects and for this publication series come from the Canadian International Development Agency (CIDA), the Swiss Development Co-operation (SDC) and the United States Agency for International Development (USAID).

Further information on regional research activities on beans in Africa is available from:

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Regional Coordinator, SADC/CIAT Regional Programme on Beans in Southern Africa, P.O. Box 2704, Arusha, Tanzania.

Regional Coordinator, CIAT Regional Programme on Beans in Eastern Africa, P.O. Box 6247, Kampala, Uganda.

Coordinateur Régional, CIAT/RESAPAC [Réseau pour l'Amélioration du haricot (*Phaseolae*) dans la région de l'Afrique Centrale], B.P. 259, Butare, Rwanda.

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Official opening address by D.O. Michieka, Director of the National Horticultural Research Center, KARI, Thika, Kenya

Distinguished Guests, CIAT Officials, Participants, Ladies and Gentlemen,

It gives me great pleasure to be with you on this important occasion of the Pan-African Plant Pathology Working Group Meeting. On behalf of the Kenya Agricultural Research Institute, I have the honor to welcome all of you to Thika for the meeting.

Mr Chairman, I am informed that this workshop is the first of its kind addressing itself to pathological problems of beans to be held in Thika. We in Kenya feel privileged to be afforded the opportunity to host this important bean meeting.

The role of beans in human nutrition in the region is indeed very important. It provides total dietary protein in Burundi and Rwanda and forms a major supplement to the starch diets in Eastern Africa.

In Kenya, dry bean is the most important food legume and ranks second to maize as a food crop. Total area under bean cultivation is estimated at 500,000 ha with an average yield of 500 kg/ha. These yields are low considering the expected bean yield potential of 1500 kg/ha. The per capita consumption is 17 kg/year.

Mr Chairman, the CIAT Regional Bean Research Network in Africa, as most participants know, has three major objectives. These could be summarized as:

1) To increase productivity and production of the food bean through breeding and selection of higher yielding genotypes with resistance to major diseases and insect pests,

2) To develop more productive cropping systems and disease and insect pest management strategies,

3) To strengthen the National Research Programmes, and to make them appropriate and sustainable.

To meet these objectives, this research network has three separately funded regional programmes implemented in such a way that it exploits advantages of decentralization, supports the national programmes in planning, carrying out field research, and encourages and funds purposeful collaboration among national research programmes.

I would like to point out that KARI supports this collaborative work facilitated by CIAT, aimed at finding solutions to bean production problems.

Mr. Chairman, our national objectives as they relate to bean research are meant to contribute to the country's food security and foreign exchange earnings. These objectives include efforts to increase and stabilize yields through the development of appropriate bean varieties and improved technology in production, disease and insect pest management. The strategy for attaining the desired objectives involves pathologists, breeders, agronomists, economists and extension officers.

Ladies and Gentlemen, I have noted from the programme that many scientific papers will be presented in the course of this workshop, all attempting to provide answers to bean production constraints. In the course of this meeting, scientists from different countries will have the opportunity to know one another and exchange scientific views. This could auger well for bean research and development in the region and internationally, but we should bear in mind that our prime target is the farmer. In this respect, the results of your deliberations would have to be translated in a manner beneficial to the farmer.

Mr Chairman, I would like to request you to come out with firm affordable strategies on how to address major constraints facing food beans in various countries of this region, particularly concerning diseases.

There is also need to train the scientists in bean research as well as provide adequate facilities and infrastructure. This meeting should also address the issue of information exchange on research methodology, bean germplasm, literature and results between national programmes so that such information should reach not only bean researchers but also other scientists and policy makers.

Mr Chairman, I would wish to take this opportunity to express our gratitude to CIAT for facilitating this workshop and for the financial support.

Before I conclude my remarks, Ladies and Gentlemen, let me wish you very fruitful and successful deliberations in this workshop. I also wish our visitors a pleasant stay in Kenya.

Ladies and Gentlemen, it is now my very pleasant duty to declare this "Pan-African Plant Pathology Working Group Meeting" officially open.

Thank you.

Introduction

R.A. Buruchara

Several national research institutions in Africa, in collaboration with the Centro Internacional de Agricultura Tropical (CIAT) conduct research on beans aimed at increasing production. Bean pathology is one such area that receives considerable research attention with the aim of developing technologies that can be used in the management of local or regional key bean diseases. There are about 20 regional sub-projects on pathology or which have pathology components within the three bean networks in Africa. The sub-projects are led by scientists of different national research institutions working in collaboration with CIAT, and consider diseases and themes of national and regional importance. Leaders of these sub-projects were invited to this working group meeting. They represent an important group of scientists working with coordinated efforts to alleviate the deleterious effects of diseases on bean production in Africa. This First Pan-African Pathology Working Group Meeting was thus meant to provide a forum whereby past strategies, efforts, progress, failures and orientation of future research in bean pathology could be appraised and discussed at a pan-Africa level. This meeting focused on fungal bean diseases. Specific objectives of the meeting were:

a. To review past strategies and activities, and assess progress in bean pathology research (under sub-projects) on a pan-African level

b. To develop general and specific regional future research activities and priorities on bean diseases so as to increase effectiveness, efficiency and have impact at farm level

c. To formulate ways for greater collaboration, sharing of responsibilities and exchange of information and results on bean pathology research

d. To discuss the nature, testing and use of regional, pan-African and international disease nurseries

The meeting brought together scientists from national research institutions and universities of the main bean growing countries in Africa. Scientists from Britain and CIAT (Africa and Colombia) collaborating with national institutions in pathology in Africa also participated. Before the start of the meeting, participants were given an opportunity to indicate what their expectations were of the meeting. Their views are broadly grouped into three sections.

1) On regional pathology sub-projects, participants expected:
   - Information on current research activities
   - Peer review of current research
   - Clear definition and prioritization of research areas and activities
   - Development of good and workable plans and timetables

- Development of strategies that will have impact at farm level

2) On exchange of information participants expected:
- Knowledge of current research on bean pathology
- Identification of knowledge gaps and problems
- Status of bean pathology research in Africa and scope
- Progress in pathology-breeder interface
- Knowledge on methodologies in certain aspects of pathology
- Informal interaction between scientists

3) On collaboration:
- Identification of areas of collaboration and/or cooperation
- Development of collaboration in common sub-projects or topics of research
- Interaction between researchers of the different bean networks

The meeting was structured into two main parts; presentations and working groups sessions. In the first part, presentation and discussion on the status of past and current research activities of on-going sub-projects were made basically to highlight objectives, research themes, achievements, failures, and future plans. Some invited papers were also presented. This formed a basis for the second part of working groups.

In the second part, participants worked in groups to consider in detail the diseases; anthracnose, angular leaf spot, rust, root rots, and ascochyta. All other fungal diseases and issues which are not specific to each disease were considered separately. The PPO method was used to analyze problems, set priorities and elaborate a research agenda. This part was intended to:

a. Bring out a global view of the problems associated with each disease and prioritize them

b. Make an inventory of, and prioritize both research and complementary non-research (non-pathology) areas and activities essential in the success of disease management. Identify future research areas.

c. Develop an approach for better collaboration and division of responsibilities for more efficient use of diminishing resources

The resulting planning matrix is meant to provide steering committees of the three bean research networks in Africa with guidelines, along which they may approve or re-orient proposals for sub-projects on bean diseases.

This document is a compilation of presentations that were made and results of the working group sessions.

Part 1:

Overview of current research on fungal bean diseases in Africa

SESSION I: ANGULAR LEAF SPOT

Pathogenic Variability of *Phaeoisariopsis griseola* in the Great Lakes Region

Mukishi M. Pyndji

Introduction

Angular leaf spot (ALS) of beans caused by *Phaeoisariopsis griseola* is one of the major diseases that reduce yield in most bean growing regions of the world, particularly in the Great Lakes region. Yield losses caused by ALS vary between 20 to 80% (Pyndji, 1987; Schwartz and Pastor-Corrales, 1989). Pathogenic variation of *P. griseola* has been reported and documented by different authors (Beebe and Pastor-Corrales, 1991; Buruchara, 1983; Correa-Victoria, 1987; Correa-Victoria *et al.*, 1989). Determination of pathogenic variability is considered important in the development of appropriate disease resistance strategies. Variation of ALS pathogen in the Great Lakes Region (GLR), was first reported by Correa-Victoria (1987) in studies where eight isolates collected from Burundi, Rwanda, and Zaire were included. The eight isolates could be classified into four different pathogenicity groups. Considering the diversity of ecological conditions in the region and the varieties grown, pathogenic variation of the ALS pathogen could be expected to be large, having implications on breeding for ALS resistance.

The main objective of this study was to determine pathogenic variability among isolates of *P. griseola* collected throughout the GLR so that selection and breeding for ALS resistance can be based on existing variability.

Materials and Methods

Pathogen isolation

P. griseola isolates were collected in different bean growing areas of Zaire, Rwanda and Burundi during different growing seasons. The techniques for isolation, inoculum production, and inoculation have been described by various workers (Correa-Victoria, 1987; Pyndji, 1991). Isolation of the pathogen is done from

sporulating lesions on either infected leaves or pods. Spore are picked from fungal synemma on infected tissues with a fine needle containing a small piece of agar. The latter is then placed in two drops of sterile water on water agar (WA) or acidified potato dextrose agar (APDA) medium, spread on the agar surface and incubated at 22-24°C for 24 to 48 hr for conidia germination to occur. Single spore isolation is made by picking a single germinated conidia by the aid of a stereomicroscope and then transferred to V-8 juice agar (200 ml V-8 juice, 3 g of calcium carbonate, 15 g of agar, and 800 ml distilled water) plates. Five or six transfers of single spores are made into each 9 cm diameter petri dish. The plates are then wrapped in aluminum foil or Kraft paper and incubated at 22-24°C for 14 to 21 days or until cultures reach a diameter of 5 to 10 mm.

Inoculum production

The surface of 14-21 days old single spore cultures are scrapped or ground in a sterilized petri dish cover with some drops of sterile distilled water. A conidial suspension obtained is spread on the surface of V-8 agar using a bent glass rod and plates are then incubated as previously described for 10 to 14 days.

Inoculation and differential varieties

A set of 22 differential varieties (including A 285 found resistant in Mulungu research center by the Bean Pathology section) recommended by CIAT (Correa-Victoria, 1987) were used (Table 1). Each differential variety was sown in two (sometimes four or six) 15 cm diameter pots containing a mixture of sterilized soil and sand (5:1, v/v). Each pot containing three plants constituted a replication. Inoculation was done when seedlings were 19 to 24 days old (1 to 3 trifoliate leaves) with a conidial suspension at a concentration of 2.0×10^4 conidia/ml. A one litre hand sprayer was used to apply the spores on the leaves. Inoculated plants were covered with a plastic bag to maintain a high (saturated) relative humidity and then placed under greenhouse benches on the ground kept moist with running water for 72 to 96 hours. After this period, plants were kept on greenhouse benches at temperatures varying between 21 to 38°C.

Disease evaluation

Eleven days after inoculation, disease severity was evaluated according to a CIAT nine-point scale (CIAT, 1989) where 1 = no visible symptoms, 3 = 2% , 5 = 5%, 7 = 10%, and 9 = 25% or more of leaf area covered with lesions. Evaluation was done at 11, 14, 17, and 20 days of inoculation (or until defoliation occurred). Disease reaction was classified in three categories: R = resistant (1-3), I = intermediate (4-6), S = susceptible (7-9). To differentiate pathotypes 11 host varieties were used (Table 2). A variety with a disease severity less than 2% was considered resistant; one with more than 2% (from 3.1 to 9) as susceptible.

Other activities

The bean pathology section in collaboration with the breeding section also carries out inoculations of various lines or populations from different crosses. A mixture of identified isolates has been used in the inoculations which are done in the greenhouse and data taken as described above. The Great Lakes regional trials (ERGL) of bush and climbing beans were also inoculated with a mixture of four isolates namely; Cyangugu, Kidote, Bugarama, and Burhale.

Salient Results

A reaction of a variety was scored resistant, intermediate, or susceptible on the basis of the mean disease severity scores recorded after four evaluations. These reactions varied among the differential varieties. Montcalm and Calima were the only differentials which showed a susceptible or an intermediate reaction to all 21 isolates. A 285 was highly resistant to all isolates, while Seafarer and Cornell 49-242 were resistant to 3 and 5 isolates respectively. A 339 and BAT 1647 gave a resistant reaction to 19 and 16 isolates, respectively. BAT 332 and Caraota 260 were moderately resistant. Comparing field reaction of the differentials during two growing seasons to greenhouse reactions, results show that bean varieties BAT 76, Caraota 260, Jalo EEP 558, BAT 1647, A 235, A 212, A 339, and A 285 remained resistant under field conditions (Table 1).

Moso isolate from Burundi was the most pathogenic one causing susceptible reaction to all differentials except for A 285. Tshirumbi isolate was pathogenic to 19 varieties, while Bukavu and Kavumu from Zaire and UNR-1 from Rwanda were each pathogenic to 18 varieties.

From the results in Table 2, 17 pathogenicity groups could be distinguished out of the 21 isolates on the basis of 11 differentials. Isolates in groups 14 to 17 were the least pathogenic; in fact, they caused susceptible or intermediate reaction only to less than 3 cultivars, while most of the differential varieties were resistant. Four groups among the seventeen were composed of two isolates each, causing the same reaction.

According to Beebe and Pastor-Corrales (1991), reaction of some differentials to different Brazilian and Colombian isolates was demonstrated during the 1983 BALSIT. BAT 332 had been found to express high degree of resistance in Popayán, Colombia. In greenhouse tests the same variety was found to have resistant or intermediate reaction to different isolates. No susceptible reaction was observed. On the other hand, BAT 76, Caraota 260, and Jalo EEP 558 have shown an intermediate or resistant reaction in two locations of Brazil and Colombia. In the present study, the same varieties were also shown to give the same reaction to different isolates; however, Jalo EEP 558 was susceptible to the isolate from Moso (results not shown here).

Table 1: Field reaction of differential cultivars to *Phaeoisariopsis griseola* during two seasons (1991A and 1992B)

Cultivar	Seed characteristics		Reaction in Tshirumbi[b]	
	Size[a]	Color	1991A	1991B
BAT 76	M	black	R	R
Calima	L	red mottled	I	I
Montcalm	L	red	I	I
A 62	M	cream	I	I
BAT 332	S	cream	I	I
G 5686	L	cream	I	R
Caraota 260	S	black	R	R
Seafarer	S	white	I	I
Alabama No.1	M	black	I	I
Jalo EEP 558	L	cream	R	R
BAT 1647	S	black	R	R
A 21	S	red	I	I
Pompadour Checa	M	red mottled	I	I
A 235	S	black	R	R
G 1805	L	cream	I	I
A 212	S	black	R	R
Amendoin	M	pink mottled	I	I
G 2858	M	pinto	S	S
A 301	S	cream	I	I
A 339	M	cream	R	R
Cornell 49242	S	black	I	S
A 285	S	cream	R	R

[a] L = large, M = medium, S = small

[b] Reaction at flowering and pod formation stages. R = resistant, I = intermediate, S = susceptible

In inoculations made on different lines or F2 populations from crosses made by the breeding section, a number of populations and lines expressed susceptible reaction when inoculated with a mixture of isolates. Results of these evaluations are discussed in the presentation on "Breeding for resistance to angular leaf spot" (page 13-17).

In conclusion, this study has shown once again the existence of pathogenic variation among the isolates from GLR. The differences among isolates varied within and between locations. Consequently, breeding for ALS resistance should be based on this variability. Moreover, these results showed that isolates from different locations where beans are grown season after season in the same plot were the most pathogenic. Thus, screening for disease resistance should be conducted in hot spot areas such as Mulungu-Tshirumbi. The choice of isolates for use in a screening program should also be based on their ability to cause adequate disease levels. Finally, some differential cultivars mainly Montcalm, A 285, A 339, Caraota 260, and BAT 1647 should be considered as the best indicators to demonstrate occurrence of new pathotypes in a given area.

Table 2: Pathogenicity groups of *Phaeoisariopsis griseola* isolates based on greenhouse reaction of 11 differential cultivars

Pathogenicity group	Isolate	Country[a]	Disease reaction on cultivars[b]										
			Montcalm	Seafarer	Pompa Checa	Cornell 49242	G 2858	G 5686	Carota 260	BAT 332	BAT 1647	A 339	A 285
1	Moso	BU	S	S	S	S	S	I	I	I	I	I	R
2	Tshirumbi	ZR	I	S	I	I	S	I	I	I	R	R	R
	Kambove	ZR	S	S	S	S	I	S	I	I	R	R	R
3	Kavumu	ZR	S	I	S	S	I	S	I	R	I	R	R
4	Bukavu	ZR	I	S	I	I	S	R	I	S	R	I	R
5	UNR-1	RW	I	S	I	S	S	R	R	I	I	R	R
6	Kashusha 1	ZR	S	I	S	S	I	S	R	I	R	R	R
	Kaziba	ZR	S	I	S	S	I	I	R	I	R	R	R
7	Kashusha 2	ZR	S	I	S	S	R	S	R	R	I	R	R
8	Bishibirhu	ZR	S	S	S	S	I	I	R	R	R	R	R
	Rwerere	RW	S	S	S	S	I	I	R	R	R	R	R
9	Mudusa	ZR	I	I	I	I	I	R	R	I	R	R	R
10	Cyangugu	RW	I	S	I	I	I	R	I	R	R	R	R
11	Molehe	ZR	I	I	I	I	R	I	R	R	R	R	R
12	Kipopo	ZR	S	I	R	R	I	R	I	R	R	I	R
13	Burhale	ZR	I	I	I	I	R	I	R	R	R	R	R
14	Ibanda lu.	ZR	S	I	S	R	R	R	R	S	R	R	R
15	Kutshatsha	ZR	S	R	R	R	R	S	S	R	R	R	R
16	Kibututu	ZR	S	R	R	S	R	R	R	R	R	R	R
17	Bugarama	RW	S	R	R	R	R	R	I	R	R	R	R
18	Kidote	ZR	S	I	R	R	R	R	R	R	R	R	R

[a] Bu = Burundi, RW = Rwanda, ZR = Zaïre
[b] R = resistant, I = intermediate, S = susceptible

Failures

Although our laboratory has mastered isolation techniques, some difficulties that have affected our work may be worth mentioning. These include the inability to culture many isolates at once due to the low capacity of our incubator and the difficulties experienced in preserving isolates for further work. Another technical difficulty is related to getting spore germination on WA or PDA from old isolates. In fact, we have observed that conidia viability decreases with the increase in storage time of infected leaves or pods.

Future Plans and Collaborative Links

After the identification of existing variation, the angular leaf spot sub-project should be able offer service to screen materials from national and regional programs for resistance to representative pathogenic variation characterized. This will enable national programs to identify and develop resistant varieties with broad based resistance.

We also plan to offer a similar screening service of material to eastern and southern African bean regional programs interested in evaluating them (such as Malawi). Thus, this sub-project could serve all regional programs. Collaborative research is needed to determine field reaction of ALS differentials and the distribution of pathotypes in bean growing regions of Africa.

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Breeding for Resistance to Angular Leaf Spot in Beans at Mulungu Station, Zaire

Mbikayi Nkonko and Luis H. Camacho

Introduction

Bean consumption in the Great Lakes Region is the highest in the world but productivity of the crop is low due to many different constraints. One of the most important constraints associated with low yield is disease susceptibility in farmers' cultivars.

Angular leaf spot (ALS) caused by the fungus *Phaeoisariopsis griseola* Sacc. is one of the most prevalent diseases of bean in the region. It can cause considerable yield reduction (Ferraz, 1980; Schwartz *et al.*, 1981; Rava *et al.*, 1985), and affects seed quality.

In the Great Lakes Region, most of the local varieties are very susceptible to angular leaf spot although they are adapted and accepted by farmers. Inheritance studies of the resistance to ALS, conducted elsewhere, have shown that disease expression may be controlled by recessive and dominant genes, depending upon the parental cultivars (Ferraz, 1980). But in the Great Lakes Region, no similar studies have been conducted on the disease.

Our breeding program has two objectives; the first, to select disease resistant lines in segregating populations introduced from CIAT; and the second, to incorporate resistance and study its inheritance in progenies derived from crosses made at Mulungu station between local adapted cultivars and introduced resistant cultivars.

We present in this paper some of the results obtained at Mulungu station on the selection work to identify resistant lines to ALS and the hybridization work to incorporate resistance into locally adapted cultivars.

Materials and Methods

Activities of the first objective started in 1986 with the introduction of F2 populations from CIAT, Cali obtained from crosses between some sources of resistance and local varieties from the region. The selection method used, has been one based on single plant selection in F2 populations followed by progeny rows in the F3. The bulk method has also been used in seasons when the disease pressure has been low. Selection has been done under natural infection and the parameters

used are plant architecture, date of flowering, date of maturity, resistance to diseases, and plant efficiency. Homogenous and stable lines were selected in 1988 and 1989 and given the code "MLB" which means Mulungu Bush lines for preliminary yield trials. In 1991, a group of selected MLB lines were evaluated in PRELAAC-5 in different sites of the Great Lakes Region. Some MLB lines are presently being evaluated in different variety trials in the region and in some cases have entered on-farm trials.

The second objective of the breeding program started with single crosses and backcrosses after the screening of sources of resistance to ALS in our region. Thus varieties A 285, A 140, XAN 68, A 345, A 300, A 384, A 163 and A 387 were used as donor parents, and the local cultivars D6, Rubona 5 and Munyu were the recurrent parents. The backcross method was used to maintain desirable characteristics of the local varieties. Twenty one populations of the first backcross ($F2BC_1$) were divided in two groups to allow space availability in the greenhouse for inoculation. The first group was planted in May 31, 1991 and inoculated three weeks later with a mixture of four isolates of the ALS organism. The second group was planted in February 26, 1992, and inoculated in March 16, 1992 with another mixture of four isolates different from those used in the first group.

The inoculum preparation and inoculation was done by the pathology section of PNL-Mulungu. After incubation and symptom development, disease evaluation was done using a scale of 1 to 9 where 1 = no visible disease symptoms and 9 = 25% or more of the leaf surface covered by large sporulating and often coalescing lesions. The sources of resistance were small-seeded materials and local cultivars were large-seeded ones.

Results and Discussion

From the selection work on ALS conducted at Mulungu on segregating populations introduced from CIAT, a group of 32 advanced lines were tested in the PRELAAC-5 in different research stations of the three national programs in the region. Results on ALS resistance at three stations, and on yield at two stations are shown in Table 1 for the best 10 lines. The selected lines maintained a high level of resistance to ALS at Mulungu and several of them did not show disease infection at Rubona and Rwerere station. Since the three environments are completely different and the disease is always present in them, one can conclude that selection at Mulungu was effective in identifying resistant lines to ALS from segregating populations. The yield levels obtained at two stations also shows that the selected lines combine high disease resistance with high yield potential. One of these lines, MLB-49-89A, consistently yielded over 3000 kg/ha at each station and did not show any disease at Rubona and Rwerere.

The same MLB lines were tested for other constraints in the region (results not shown) and gave satisfactory performance. Worth mentioning also is their resistance to root rots particularly to *Pythium* spp and *Rhizoctonia solani*, during a severe attack of the latter at Rubona station in Rwanda. The MLB lines, thus, appear to combine multiple disease resistance and high yield potential and

constitute new sources of genetic variability for bean breeding programs in the Great Lakes Region. These lines occur in different seed and plant types.

Table 1: Some of the promising lines selected for ALS resistance at Mulungu and tested at other stations in the Great Lakes Region

Identification	Reaction to angular leaf spot[1]						Yield (kg/ha)	
	Mulungu, Zaire		Rubona, Rwanda		Rwerere, Rwanda		Rubona, Rwanda	Gisozi, Burundi
	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2		
MLB-38-89A	3	3	1	1	-	-	2319	2008
MLB-47-89A	2	2	1	-	3	1	1200	1633
MLB-40-89A	3	2	1	2	1	1	2481	2024
MLB-39-89A	3	2	3	1	1	1	2513	3133
MLB-36-89A	2	2	1	2	1	1	2688	1547
MLB-49-89A	3	2	1	1	1	1	3019	3297
MLB-45-89A	2	4	1	1	1	1	1813	1781
MLB-42-89A	3	3	1	1	1	1	1213	2336
MLB-43-89A	2	3	1	1	1	3	2813	2213
MLB-48-89A	2	2	1	1	1	1	3263	2531
Mean	2.5	2.5	1.2	1.2	1.2	1.2	2332	2250

[1] Disease scale 1-9 where high levels of resistance = 1-3, intermediate levels of resistance = 4-6 and susceptible = 7-9

Table 2 shows the average disease severity in 11 backcross populations obtained 20 days after inoculation with a mixture of four isolates of ALS (from Rubona, Mudusa, Kisanga and Kipopo). The table shows the number of plants in each of three disease categories. The average disease reaction was in the susceptible range in all populations indicating a high frequency of susceptible plants. The results of 10 backcross populations inoculated with a different mixture of four isolates (Kidote, Karama, Kayandja and Tchirumbi) are shown in Table 3. Here the results also show high frequencies of susceptible plants.

Although at this preliminary stage, a genetic interpretation of the results is not possible, the tendency of all populations to show a large proportion of susceptible plants may indicate that recessive genes may be controlling the resistance to ALS in the donor parents. The results, as shown, may also be due to sampling errors caused by the relatively few number of plants tested in each population. New crosses are being made to clarify this issue. In the meantime the few resistant plants found in some of the populations will be used in new backcrosses to recurrent parents to develop new segregating backcrossed populations from which resistant lines with local parental features can be recovered.

Table 2: Reaction of F_2BC_1 populations to a mixture of four isolates of ALS (Rubona, Mudusa, Kisanga and Kipopo) 20 days after inoculation in the greenhouse

Identification	Parents	Disease severity[1]	Number of plants in each class			
			Total	Resistant	Interme-diate	Suscep-tible
ALSMUL-1	D6 x A 285 x D6	7.5	42	1	5	36
ALSMUL-3	D6 x A 140 x D6	6.0	46	8	14	24
ALSMUL-4	D6 x XAN 68 x D6	7.4	25	0	0	25
ALSMUL-6	Rubona 5 x A 285 x Rubona 5	8.5	38	0	2	36
ALSMUL-7	Rubona 5 x A 345 x Rubona 5	7.5	56	0	5	51
ALSMUL-10	Rubona 5 x A 300 x Rubona 5	8.5	28	0	28	28
ALSMUL-14	Munyu x XAN 68 x Munyu	6.5	32	5	4	23
ALSMUL-16	D6 x A 384 x D6	8.1	24	0	0	24
ALSMUL-19	Rubona 5 x A 384 x Rubona 5	7.8	26	0	0	26
ALSMUL-20	Rubona 5 x A 163 x Rubona 5	7.5	39	3	7	29
ALSMUL-24	Munyu x A 387 x Munyu	8.4	55	0	2	53

[1] Disease scale 1-9 where high levels of resistance = 1-3, intermediate levels of resistance = 4-6 and susceptible = 7-9

Table 3: Reactions of F_2BC_1 populations to a mixture of four isolates of ALS (Kidote, Karama, Kayandja, Tshirumbi) 19 days after inoculation in the greenhouse

Identification	Parents	Disease severity[1]	Number of plants in each class			
			Total	Resistant	Interme-diate	Suscepti-ble
ALSMUL-2	D6 x A 345 x D6	7.6	15	2	3	10
ALSMUL-8	Rubona 5 x A 140 x Rubona 5	8.5	6	0	1	5
ALSMUL 4	Munyu x A 285 x Munyu	8.5	20	0	1	19
ALSMUL-12	Munyu x A 345 x Munyu	8.5	18	0	1	17
ALSMUL 13	Munyu x A 140 x Munyu	8.9	43	0	3	40
ALSMUL-15	Munyu x A 300 x Munyu	9.0	3	0	0	3
ALSMUL-17	D6 x A 163 x D6	7.7	13	1	2	10
ALSMUL-18	D6 x A 387 x D6	9.0	11	0	0	11
ALSMUL-21	Rubona 5 x A 387 x Rubona 5	9.0	15	0	0	15
ALSMUL-22	Munyu x A 384 x Munyu	9.0	3	0	0	3

[1] Disease scale 1-9 where high levels of resistance = 1-3, intermediate levels of resistance = 4-6 and susceptible = 7-9

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Evaluation of Malawi Bean Germplasm for Resistance to Angular Leaf Spot

Wilson A.B. Msuku

Introduction

The common bean (*Phaseolus vulgaris* L.) is one of the most important food grain legume crop in Malawi; being second only to groundnuts in total production among grain legume crops (Edje *et al.*, 1981).

Bean production constraints in Malawi include lack of suitable varieties, insects, pests and diseases. Diseases are the most important single factor limiting bean production in most bean growing regions of the country. Among the most important diseases are angular leaf spot (*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*), bean rust (*Uromyces appendiculatus*), bacteria blights (*Pseudomonas syringae* pv *phaseolicola* and *Xanthomonas campestris* pv *phaseoli*) and bean common mosaic virus (BCMV).

Great losses due to angular leaf spot are experienced year after year, especially in regions where warm temperatures prevail during the growing season. The disease affects yields largely due to damage caused by leaf necrosis and premature defoliation resulting in loss of photosynthetic area (Inglis and Hagedorn, 1986).

Literature Review

Phaeoisariopsis griseola survives during off season in seed as well as on crop debris, which acts as a source of inocula for the following season. Control of ALS therefore, may be achieved by use of cultural practices such as rotation, burying or burning of crop residues. However, rotation is difficult to practice in smallholdings due to land scarcity (0.8 ha per farmer). Another control measure is the use of chemicals. But in view of the fact that use of chemicals may not easily be within the reach of most smallholders, the most effective control strategy for the disease is the use of resistant cultivars. The latter method is cheaper, easy to apply and the farmer can keep seed (Edje, *et al.*, 1981). The objective of this study was thus to screen both local and introduced germplasm for resistance to angular leaf spot.

Materials and Methods

Up to 1248 of the total 2778 accessions of Malawi local collection and a few introduced germplasm were evaluated for their reaction to angular leaf spot during the seasons 1988/89 and 1989/90 at Bunda College of Agriculture.

(i) As an on-going study with a general objective of screening the local bean germplasm for resistance to some of the most important bean diseases, vis-a-vis angular leaf spot, rust, anthracnose, bacterial blights, floury leaf spot, ascochyta blight, scab and viral diseases, 1032 bean accessions have been evaluated mainly under field conditions. Each accession was planted in a plot of two 4 m rows spaced at 91 cm. Spacing between plants was 15 cm with one seed per hill. Observations on disease incidence and severity were done on foliage, stem and pods during flowering and podding stages. Disease severity was evaluated based on a scale of 1-9 where 1 meant no disease symptoms and 9 meant a susceptible reaction.

(ii) Bean accessions that give a "favourable" reaction (with score grades of 1, 2 and 3) to angular leaf spot are selected for further screening under both field and greenhouse conditions.

Field trials, 1990/91 season

The current study involved 100 bean accessions previously shown to have a "favourable" reaction. Evaluation was done at Bunda College of Agriculture farm in 1990/91 growing season. Each line was sown on two 5 m ridges spaced at 91 cm with intra-row spacing of 15 cm with one plant per hill. Nasaka, a variety susceptible to angular leaf spot, was grown on alternate rows (between test lines) as a spreader.

Inoculum preparation: *Phaeoisariopsis griseola* isolated from infected bean pods at Bunda was maintained on yeast glucose chalk agar (10 g yeast extract; 20 g $CaCO_3$; 10 g agar and 1000 l distilled water) by periodic transfer of spore suspensions to fresh plates. Inoculum for inoculation was multiplied on potato dextrose agar (4 g potato extract; 20 g dextrose; 15 g agar and 1000 l distilled water) plates incubated for 10 days at 24 C.

Field inoculation and disease assessment: Two weeks after emergence (when plants were at 1st trifoliolate stage) plants were artificially inoculated with an isolate of *Phaeoisariopsis griseola*. Inoculum was sprayed as a fine mist using a 7 litre hand spray on to the upper and lower leaf surfaces of all plants. Disease assessment was based on the CIAT scale of 1 to 9. The scale was categorized into three groups: resistant, intermediate and susceptible.

Results and Discussion

Table 1 summarizes results of field evaluation. Bean lines having values from 1 to 3 were considered resistant, 4 to 6 as intermediate and 7 to 9 as susceptible. Some lines had disease score values of 9 suggesting that they were just escapes in the previous field evaluations (where they had been considered resistant).

The results showed that out of the 100 lines screened, 65 were resistant, 15 were susceptible and 20 gave an intermediate reaction. Disease occurrence was observed some 43 - 50 days after sowing and severity increased with time in some of the lines until there was very severe damage towards the end of the growing season. Most climbers gave a resistant reaction, while only a few of the dwarf were resistant (Table 1) which agrees with previous studies (Mbalule, 1986; Msuku and Bokosi, 1989; Zamadenga, 1991). There was no correlation between resistance and time taken to reach physiological maturity. It seemed that there was some relationship between time taken to 50% flowering and reaction to the disease as most of those that flowered late showed some resistance and most of those that matured early tended to be susceptible.

Table 1: Reaction of bean lines to angular leaf spot (*Phaeoisariopsis griseola*) based on growth habit

Growth Habit	Number and % of lines with ALS disease reaction									Total
	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6	Score 7	Score 8	Score 9	
Climbers	47 62%	5 7%	2 3%	2 3%	5 7%	6 8%	3 4%	4 5%	2 3%	76 100%
Dwarfs	8 33%	1 4%	1 4%	1 4%	2 8%	5 21%	1 4%	1 4%	4 17%	24 100%
Total	55	6	3	3	7	11	4	5	6	100

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SESSION II: ANTHRACNOSE

Studies on the Importance, Pathogenic Variation and Management of Anthracnose in the SADCC Region

Coy H. Haciwa and Frederica Mwalyego

Introduction

Bean anthracnose is prevalent in Northern Zambia, the Southern highlands and North Eastern Tanzania, as well as parts of Angola and Malawi. There are reports of high disease severity during most seasons (Kannaiyan *et al.*, 1987; Kannaiyan, 1989). At a Planning Workshop held in Zambia in March 1991, anthracnose was identified amongst the top five constraints to bean production. In fact, it was second only to bean fly as the top biotic constraint. Some work has been carried out on yield loss assessment in the region (Greenberg *et al.*, 1987) but there is still little information on actual yield losses caused by the disease in farmers' fields and the exact boundaries of the disease. Knowledge of races present in the region is necessary for effective screening of bean genotypes for resistance, but researchers in various countries have identified races using different sets of differentials. Knowledge of existing races using uniform sets of differentials would make it easier for the exchange of resistant genotypes between countries since their type of resistance would be known.

The working group on bean anthracnose in Africa which met at Ambo, Ethiopia in February 1991, recognized these limitations and identified research priorities for different regions. Among the recommendations made were the need for studies on yield loss in farmers' fields, pathogenic variation using a uniform set of differentials and for the SADCC region, an evaluation of cultivar mixtures for disease control.

Cultivar mixtures having resistant components have been reported to reduce the spread and severity of some bean diseases, e.g angular leaf spot (Mukishi and Trutmann, 1989). Small scale farmers in Northern Zambia and Southern Tanzania prefer to grow beans in mixtures of landraces. This provides the possibility to control anthracnose using the farmers' established system. Since cultivar mixtures are only effective if they contain resistant components, studies on mixtures would be most effective if combined with screening for disease resistance.

Objectives

The objectives of this study are:

a) to assess the importance of the disease through crop yield loss studies in farmers' fields and surveys throughout the bean growing areas,

b) to identify the prevailing pathogenic races and map out their distribution, and

c) to study disease control measures through cultivar mixtures and plant resistance.

Materials and Methods

Crop loss assessment

a) At the research stations, Uyole and Lucheche. Factorial design with treatment factors being varieties (a local variety, a known susceptible and a known resistant) and various levels (5-6) of disease severity, managed by spraying with conidia and limiting disease development in some treatments by spraying with the fungicides benomyl and dithane M45. Plots will be separated by large paths and a different crop. Trial will be carried out during the first season.

b) At hot spot areas; Kaka, Mwamba and Kapatu in Northern Zambia and Iyula, Itete, Nkundi and Mubugai in Tanzania. A single factor randomized design using only farmers' varieties. The treatments will be various levels (4-6) of disease severity, managed by planting spreaders (or inoculation with local isolates if possible) and use of fungicides. Plots to be separated by large paths and a different crop. Second and third season.

c) In bean growing areas where information is not available, surveys on disease severity shall be made. The distribution and importance of the disease in different areas will be mapped out. Disease severity scores will be correlated with yield loss results. First and second season.

Race studies

During the survey, different isolates of the pathogen shall be collected. These will be isolated, purified and multiplied in the laboratory on artificial media. The different isolates will be used to inoculate the 12 CIAT differential varieties so as to identify the races.

Disease control

a) Together with already existing programmes, local and introduced germplasm will be screened for resistance to anthracnose. This will involve artificial inoculations

with all the races identified in the race studies. These will be carried out during the first two years at Lucheche and Uyole. The promising genotypes will be tested at Kaka, Mwamba and Kapatu in Zambia, at Iyula, Itete, Nkundi and Mubugai in Tanzania and at sites to be selected in Angola and Malawi.

b) Effective levels of resistant components in a mixture: Single factor replicated design with treatments being various combinations of a resistant and a susceptible variety, including pure stands of the components as controls. Large plots of at least 40 m^2. Disease severity and spread will be monitored throughout the season. First season at Lucheche and Uyole, thereafter at 2-3 other sites in each country.

c) Assessment of farmer's mixtures: Single factor replicated experiment. Treatments will be 3-6 mixtures which are currently grown and pure stands of the components. Artificial inoculation of spreaders with a local isolate will be used. Disease progress will be monitored and yield between mixtures and their components compared. First two seasons at Lucheche and Uyole, thereafter at 2-3 sites in each country.

Progress as at May 1992

In Zambia, a survey in four provinces (Central, Eastern, Luapula and Northern) was made during March and April 1991. Only the North Western province remains. A total of 113 fields in 18 bean growing districts were covered. The field size ranged from a few square metres to 2 hectares. The crop was grown on mounds except for the larger fields which had been prepared using oxen and were flat. The beans grown usually consisted of mixtures of predominantly white and yellow coloured grain. Twenty six fields, mainly from Central and Luapula provinces, had no anthracnose whereas 87 fields showed various levels of disease. In 44 fields, the disease level and distribution was low, in 36 fields the disease level was moderate with at least half the plants in the field affected and 7 fields had severe disease with nearly all plants affected. All the seven severely affected fields were in Mbala district of Northern Province.

A total of 155 anthracnose samples were collected from 87 fields. An additional 12 were collected from research trials at Msekera Research Station. Of these, 110 were successfully isolated, cultured and were placed in slants. As seed of the differentials become available, the cultured isolates will be used for inoculations. Twenty-six have so far been used to inoculate the CIAT differentials. However, there were difficulties in multiplying two of the differentials (Kaboon and Widusa) so these have not been inoculated.

The 26 isolates may be grouped into four groups. The first group, consisting of 4 isolates, infects only Michelite and Perry Marrow. The second group (4 isolates) attacks the above and M.D.R.K. The third group (13 isolates) attacks Michelite, M.D.R.K., Perry Marrow and Mexico 222. The fourth group with three isolates is like the third group but attacks TU instead of Mexico 222 (Table 1).

Table 1: Number of isolates from the 26 tested so far which are able to infect the various differentials

Differential variety	Number of infecting isolates
Michelite	26
Michigan D.R.K.	22
Perry Marrow	26
Cornell 49242	0
Widusa	-
Kaboon	-
Mexico 222	15
PI 207262	0
TO	0
TU	3
AB 136	0
G 2333	0

In Tanzania, a total of 182 isolates were collected from various regions. These were: Kagera (6 samples), Kilimanjaro (24), Arusha (20), Morogoro (9), Tanga (54), Kigoma (2) and Mbeya (63). Twenty of the isolates have been inoculated once on the differential varieties.

On-farm trials to assess the economic importance of anthracnose in farmers' fields have been laid out at 4 villages in Mbozi district (Lyula, Nkundi, Chapwa and Hahingu).

Fifty-four entries from the germplasm at Uyole and 70 IBAT lines were screened during 1991. Sixty percent of the germplasm scored highly resistant reactions. A further 112 germplasm and 34 IBAT lines are being screened during 1992.

A trial has been planted at Uyole to study the effective levels of resistant components in a mixture. It has a susceptible and resistant cultivar in the proportions 1/4:3/4, 1/2:1/2, 3/4:1/4 and pure stands. Two popular mixtures from Mbozi district have been planted to study the effect of their separate components on anthracnose development.

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Breeding for Resistance to Anthracnose in Rwanda

Gaspard Gasana

Introduction

Bean anthracnose is a disease caused by *Colletotrichum lindemuthianum* which was described for the first time in 1875 in Germany. Today, this disease has become one of the major factors limiting crop yields and one of the major constraints in bean producing regions. The disease is especially severe in hot and humid tropical regions of Africa, Asia, America, and even in the temperate regions of Europe and North America (Pastor-Corrales and Beebe, 1991).

Research activities carried out in Rwanda by ISAR (Institut des Sciences Agricoles au Rwanda) in the highlands (above 1500 m) identified anthracnose of beans as the second important disease after angular leaf spot, causing economical yield losses (ISAR, 1988). In these zones, conditions for disease development are almost optimal. Temperatures between 18 and 24°C, and a relatively high humidity during the rainy season are favorable for the development and spread of the pathogen. Certain farming practices also facilitate infection of plants through infected seed and crop residues left in the fields.

The ultimate goal of research activities on bean anthracnose is to develop resistant varieties to the disease. Those varieties would then be recommended for diffusion within target zones or would be sources of resistance genes to breeders who would use them to improve the resistance of varieties having other characteristics desirable for farmers (high productivity, good taste, short cycle etc.).

Studies on varietal resistance constitute one of the most important components of research on anthracnose in Rwanda. Several thousand entries of germplasm have already been screened through international (IBAT, VEF), regional (PRER, PRELAAC) as well as national (PPP, breeding nursery) nurseries.

In order to develop bean varieties resistant or tolerant to different bean diseases and pests, CIAT, in collaboration with ISAR, developed, as of 1984, some specific nurseries: Phytoprotection Preliminary Nursery (PPP) and a regional nursery consisting of the best sources of resistance in Rwanda, Burundi and Zaire (PRER). As a result of these activities, some varieties resistant to anthracnose have been identified; these include: BAT 76, A 240, A 252, A 336, G 5971, ZAV 83009, ZAV 83059 and V 7920. In 1987, another regional nursery for evaluating the resistance of advanced lines for Central Africa was established.

In 1989, varieties such as G 2333, G 2331, Ikinimba, G 2641, were confirmed to be resistant following evaluation in PRER and PPP nurseries. At the same time, several bush and semi-climbing varieties such as ZAA 76, AND 662, AFR 300, AFR 8, Ntekerabasilimu, and several climbing varieties such as 7/4, AND 419, AND 671, AND 655 etc. proved to be resistant to anthracnose in the PRELAAC-3 nursery (Gasana, 1991).

Several crosses were also made in order to transfer resistance genes from varieties such as G 2333, Ntekerabasilimu, Ikinimba, Kilyumukwe, RWR 45, BAT 76 etc. to susceptible commercial varieties such as Rubona 5, Ikinyange, Gisenyi 2bis etc. The first stable resistant lines obtained from these crosses are now being tested in the first yield trials.

In addition, advanced selection tests include some varieties which proved to be resistant in the PRELAAC-4 such as RWK 3, AND 6, RWR 602 and RWK 5 (ISAR, 1989 and 1990).

Breeding for resistance to anthracnose in 1991 is described below.

Materials and Methods

Field screening: Screening of bean germplasm (PRELAAC, IBAT) for resistance to anthracnose is carried out at Rwerere where natural conditions are favorable for the development of the disease, and in Rubona under artificial inoculation. Multiplication of the inoculum of Rubona isolate is carried out in the laboratory on sterilized green pods contained in erlenmeyer flasks of 250 or 500 ml. Pods are cut in 5 cm long pieces, sterilized and put into the erlenmeyer. Spore suspension is introduced in the flask under sterile conditions and incubated at 19°C for 7 days. The inoculum is then prepared and after adjusting the concentration to 10^6 conidia/ml, field inoculation is done in the evenings (5-6 pm) by spraying of the plants from R5 (pre-flowering) to R7 (pod filling). Disease pressure is also increased by planting a mixture of susceptible varieties after every 4 test rows to act as spreaders.

Crosses and segregating populations: To improve resistance of susceptible commercial varieties, genes from sources of resistance have been used in a series of crosses carried out at Rubona. Segregating populations have also been evaluated under artificial field inoculation.

Results and Discussion

PRELAAC screening

Results show that most of the 36 varieties of climbing beans in PRELAAC-5 were rather resistant to anthracnose. 12 had no symptom of anthracnose under artificial

inoculation at Rubona as well as under high natural disease pressure at Rwerere (Table 1).

Table 1: Performance of 12 climbing varieties (type IV) in PRELAAC-5 resistant to anthracnose in Rubona and Rwerere, 91B

Variety	Rubona					Rwerere			
	Anthrac-nose	Asco-chyta R8	Angular leaf spot R8	BCMV	Yield (g/m^2)	Anthrac-nose	Asco-chyta R8	Angluar leaf spot R8	BCMV
(YG 104)F1 31M	1	5	6	6	46	1	9	1	1
LAS 295	1	5	7	1	113	1	6	5	1
AND 811	1	7	3	4	277	1	4	4	3
LAS 322	1	4	3	2	308	1	6	3	4
AND 428	1	8	5	3	314	1	8	5	4
IZ 261-1	1	7	2	8	318	1	5	5	1
GLB 5	1	5	5	1	346	1	6	1	4
LIB 1	1	3	7	4	384	1	9	1	4
AND 112	1	7	5	6	408	1	6	1	5
RWV 180	1	4	5	5	465	1	7	1	3
GLB 8	1	6	4	4	528	1	6	1	4
RWV 173	1	5	6	6	657	1	7	1	4

The same twelve varieties were, however, susceptible to ascochyta blight at Rwerere, angular leaf spot at Rubona and to virus diseases in both sites. Some of them such as LAS 295, GLB 5, RWV 180 and RWV 173 performed well in terms of yield and have been tested in the multilocational trials.

A hundred bush and semi-climbing varieties were also evaluated in PRELAAC-5. Under artificial inoculation at Rubona, 46 were resistant to anthracnose; 21 out of the 46 did not show any symptoms at all. However, on the basis of yield exceeding 100 g/m^2 (1000 kg/ha by extrapolation) and tolerance to ascochyta blight (score $\leq$ 4) and to angular leaf spot (score $\leq$ 6), only 14 remained (Table 2).

It should be noted, however, that most of these varieties were susceptible to ascochyta and virus diseases at Rwerere. Only SCAM-80-CM/14 and MLB-48-89A seem to be resistant to almost all diseases in both evaluation sites.

IBAT evaluation at Rubona

The screening of germplasm for resistance to anthracnose also included 100 IBAT (International Anthracnose Nursery) entries from CIAT, Colombia. 81 entries out of 100 tested were highly resistant under artificial inoculation with the Rubona isolate. At the same time seed of all varieties has been multiplied for future yield trials in order to identify the most productive varieties among the resistant ones.

Table 2: Best varieties of bush and semi-climbing beans in PRELAAC-5 resistant to anthracnose at Rubona and Rwerere

Variety	Type	Rubona					Rwerere			
		Anthrac-nose	Asco-chyta R8	Angular leaf spot R8	BCMV	Yield g/m²	Anthrac-nose	Asco-chyta R8	Angular leaf spot R8	BCMV
MORE 90026	III	1	4	4	4	117	1	9	5	5
MORE 88002	I	1	5	1	3	125	1	7	6	3
MLB-47-89A	II	1	1	4	1	128	1	9	1	3
SCAM-80-CM/14	I	1	3	1	1	145	1	6	4	1
MLB-45-88B	II	1	1	4	1	193	1	8	3	1
RWR 694	III	1	2	3	1	211	1	8	1	3
MLB-38-89A	I	1	1	3	1	247	1	7	6	3
MLB-41-89A	II	1	1	2	3	255	1	9	1	3
MLB-39-89A	II	1	3	4	1	268	1	9	1	4
MLB-36-89A	II	1	2	3	1	320	1	9	1	4
MLB-49-89B	II	1	1	4	1	322	1	9	4	4
MLB-48-89A	II	1	1	2	1	348	1	8	1	1

Use of sources of resistance in crosses

Crosses were made in 91B between varieties in PRELAAC-4 resistant to anthracnose and popular commercial varieties from ISAR such as Urugezi, RWR 221, Flora, or susceptible to anthracnose such as Rubona 5 and Ikinyange (Table 3). 53 hybrids will be evaluated in F1 to verify if the crosses were successful. At the same time seed will be multiplied for evaluation in F2 in 92B.

Table 3: Crosses made at Rubona for resistance to anthracnose

No.	Parents	No.	Parents
1.	RWK 5 x RWR 603	20.	RWR 314 x Urugezi
2.	MORE 053 x Rubona 5	21.	RWK 3 x PVA 8
3.	RWR 613 x Ikinyange	22.	Urugezi x RWK 3
4.	Urugezi x To-15(2-61/13/9)	23.	RWK 5 x Urugezi
5.	RWR 603 x RWR 221	24.	RWR 221 x Umubano
6.	RWR 359 x RWR 221	25.	Urugezi x RWR 221
7.	RWR 405 x RWR 221	26.	RWR 602 x RWR 221
8.	RWK 1 x Ikinyange	27.	Urugezi x RWR 603
9.	RWK 3 x Rubona 5	28.	HAL 8 x Rubona 5
10.	RWK 5 x Ikinyange	29.	RWR 359 x RWR 221
11.	RWK 5 x RWR 603	30.	RWK 5 x RWR 359
12.	RWK 3 x PVA 8	31.	RWR 314 x RWR 221
13.	RWK 5 x RWR 603	32.	Urugezi x To-15(2-61/13/8)
14.	RWR 613 x RWR 221	33.	Urugezi x RWR 613
15.	Urugezi x Umubano	34.	RWR 612 x Urugezi
16.	RWR 359 x RWR 221	35.	RWK 5 x PVA 8
17.	INC x RWR 612	36.	RWK 5 x Rubona 5
18.	AND 661 x Urugezi	37.	To-15/2-61/13/9 x RWR 221
19.	RWK 3 x RWR 221	38.	Rubona 5 x RWK 3

For bush and semi-climbing types, 68 F3 lines from 25 F2 populations were planted at Rubona in the first season of 1991. Selection was based on plant vigour and architecture, but more so on resistance to anthracnose. Thus, 116 individual plants were selected to be evaluated in F4.

For climbing types, 36 lines were evaluated for their resistance to anthracnose. As with most other climbing beans, several lines were resistant to the disease. However, selection took into account other criteria such as susceptibility to rust and ascochyta, plant vigour and good architecture. 109 individual selections were thus made for testing in F4.

Current and future research

Current breeding activities for resistance to anthracnose at ISAR include three types of trials:

1. Screening segregating populations of bush and semi-climbing beans in F3, F4 and F5 at Rubona.

2. Preliminary yield trials for stable lines obtained from selections made at Rubona, also called "Essai de prétriage" for anthracnose resistance. This trial is being carried out at Rubona and Rwerere.

3. Advanced evaluation trial of materials found resistant to anthracnose in all evaluation sites. This trial is the first step towards the creation of the Regional Anthracnose Nursery.

Constraints

1. Lack of sufficient and stable staff resulting in disruptions of programme implementation (inoculation, follow-up).

2. Lack of specialized training in phytopathology for programme technicians and scientists.

3. Lack of information on on-going research activities on the disease.

4. Lack of data on other aspects of anthracnose research (pathogenic variability, harvest losses etc.)

Conclusions

Bean breeding for resistance to anthracnose in Rwanda has resulted in the identification of several resistant varieties, notably Ikinimba, Ntekerabasilimu, G 2333 and G 2331. However, since the pathogen causing this disease occurs in several races, research on resistant varieties should be a continuous work.

In the process of breeding, PRELAAC provides sources of resistance that may be used in making crosses, but it also allows exchange of materials of interest at the regional level for other national programmes. This has been the case for resistant bush varieties such as MLB-36-89A, MLB-49-89B and MLB-48-89A contributed by PNL Mulungu (Zaire), if their good performance is confirmed in future tests.

Crosses and evaluations of segregating populations aim at exploiting as quickly as possible the resistance genes locally identified, and improving the resistance of commercial varieties.

Artificial inoculations should be used in all screening trials in order to increase breeding efficiency.

Introductions from CIAT of specific nurseries such as IBAT or F2 populations should be continued for some time to come in order to increase variability.

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Research on Anthracnose of Haricot Beans in Ethiopia

Tesfaye Beshir

Introduction

Common bean (*Phaseolus vulgaris* L.) is an important food legume crop and constitutes an essential part of the daily diet of millions of people especially in Latin America, Central and Eastern Africa (Schwartz and Galvez, 1979). Haricot beans play an important role in the cropping system of Ethiopian farmers; beans are grown either as a relay crop or intercropped with cereals, coffee or enset. However, the average yields obtained by farmers are low due to a combination of several yield constraints among which diseases play a major role (Assefa and Gorfu, 1985). Important bean diseases are common bacterial blight, rust, anthracnose, angular leaf spot, floury leaf spot, phoma blight, web blight, halo blight and bean common mosaic virus. Of these, bean anthracnose caused by *Colletotrichum lindemuthianum* Sacc. is widely distributed in the major bean growing districts of Ethiopia. It is particularly important in the lower to middle agroecological zones with mean annual rainfall ranging between 700-2200 mm. It is a common disease in areas such as Awassa, Ambo, Bako, Arsi Negele, Kulumsa, Nazareth and Jima (Allen, 1983; Assefa and Gorfu, 1985).

This paper is intended to briefly review the research work that has been carried out until 1991 on anthracnose of haricot bean in Ethiopia. In addition, on-going research activities of the anthracnose regional sub-project are highlighted.

In 1989, a survey was initiated by the pulse pathology section of the Plant Protection Research Center (PPRC), Ambo, to assess occurrence and severity of anthracnose disease. This involved sampling of measured length of crop rows at randomly selected locations in a field to estimate disease per unit area. Individual plant samples were also collected.

Results of the survey revealed differences in prevalence and severity of bean anthracnose among regions and farming practices. In the hot and dry areas of the Rift Valley, where rainfall is normally erratic and temperatures rather low, the most prevalent diseases were common bacterial blight and bean common mosaic virus (BCMV). In southern Ethiopia where temperatures are moderate and rainfall is high, rust was severe. In the warm and humid regions of the country, anthracnose, angular leaf spot and floury leaf spot were much more prevalent (PPRC, 1990).

During the survey nearly 150 mycological specimens were collected and most of the pathogens associated with the diseases have been identified and documented.

Among them, 41 samples were anthracnose isolates (Table 1). The preliminary survey showed that anthracnose is predominant and severe at Ambo but occurrence at Areka is sporadic.

Table 1: Isolates of *Colletotrichum lindemuthianum* collected during 1990/91 season

Isolate No.	Locality of collection	Diseased cultivars
1	Ambo	Introduced
2	Awassa	Introduced
3	Bako R.C.	Introduced
4	Ziway	Mexican 142
5	Meki	Mexican 142
6	Metu	Mexican 142
7	Melkassa	Introduced
8	Adami-Tulu	Mexican 142
9	Bako Farmers' field	Mexican 142
10	Field No. 6 (farmers' field)	Mexican 142
11	Field No. 23, 27, 21	Mexican 142
12	Field No. 33	Mexican 142
13	Field No. 21, 22, 23	Mexican 142
14	Field No. 14, 15, 16	Mexican 142
15	Alemaya University	Introduced
16	Arsi-Negele	Mexican 142

Race Identification

Samples of bean anthracnose were collected from major bean growing regions with special emphasis to Ambo, Debre Zeit, Bako, Jima, Areka, Pawe and along the rift valley, Awassa, Ziway. The collected disease samples were isolated, purified and multiplied using the following standard methods.

Isolation

Small segments or sections of the infected materials were isolated by surface sterilizing with alcohol. After a thorough washing in distilled water, the ends of the tissue were sliced off with a sterile scalpel and the central part were placed on PDA plates. After 24 hr at 20-25°C mycelium grew from which the pathogen was re-isolated (Schoonhoven and Pastor-Corrales, 1987; Barrus, 1918).

Culture and inoculum production

Conidia of the isolates were transferred to PDA and allowed to germinate. After 24 hr, 5-6 germinated mono-conidia were transferred to several plates of PDA. Then they were incubated at 24°C for 12-13 days. Conidia suspension was then prepared from these 12-13 days old culture for inoculation in the greenhouse

(Schoonhoven and Pastor-Corrales, 1987; Hubbeling, 1977). Bean pod agar medium, sterilized pods and potato dextrose agar most often were used for culture growth (Schwartz and Galvez, 1979).

Use of green bean pods: Green pods were collected from the field, washed and chopped into small pieces. 3/4 of a 250 ml flask was filled with pieces of chopped green pods. Then 15-20 ml of distilled water was poured in each flask and sterilized for 30 min at 121°C, then excess water from the sterilized media was removed. About 1 ml of *C. lindemuthianum* conidial suspension was poured in each of the flasks and mixed gently for uniform distribution of the spores. The flasks were incubated at 24°C for 8 days. The pods were then blended and filtered. The concentration of conidia was determined using a hemacytometer and adjusted to a concentration of 1.2×10^6 conidia/ml using the formula

$$Vo \times Co = Vg \times Cg$$

where:
- Vo- Initial volume
- Co- Initial concentration obtained by counting on hemacytometer
- Vg- Final volume
- Cg- Final concentration

This method of inoculum production was also used for field inoculation (Hubbeling, 1977).

Inoculation and Evaluation

Greenhouse

Three seeds of each differential variety (Table 2) were grown in a sterilized soil of 15 cm diameter pots in the greenhouse at about 21-30°C. Ten days old seedlings (the first trifoliates) were inoculated by spraying the spore suspensions. Inoculated plants were placed in an incubator with nearby saturated atmosphere (85-100% of relative humidity at 18-22°C) for 4-5 days. Seven days after inoculation each inoculated plant was evaluated separately on a 1-9 scale, i.e. 1-3 = resistant and 4-9 = susceptible (Schoonhoven and Pastor-Corrales, 1987). Inoculation of differential varieties was repeated to confirm the observed results, shown in Table 2.

Field

Trifoliate leaves of beans were inoculated with suspension of conidia until completely wet, using Knapsack sprayer. Inoculation was repeated every 10 days when the disease symptom was not observed. The inoculation was done in the evening, when temperature was relatively low. The disease was recorded on a 1-9 scale as in the greenhouse.

Table 2: Response of differential varieties of beans on some isolates of *Colletotrichum lindemuthianum* (Ambo, 1990/91)

Differential variety	Isolates			
	Ambo	Awassa	Bako R.C.	Ziway
Michelite	5[1]	4	3	2
M.D.R.K.	2	3	4	2
Perry Marrow	1	1	2	1
Cornell 49-242	2	3	3	3
Widusa	2	2	1	3
Kaboon	2	2	2	2
Mexico 222	1	4	3	2
Pl. 207262	2	5	4	4
To	2	4	5	3
Tu	2	4	5	2
AB 136	2	3	3	1
G 2333	2	5	1	3

[1] 1 = no visible symptoms, 3 = 2%; 5 = 5%; 7 = 10% and 9 = 25% or more of leaf and pod area covered with lesions

Of the 101 entries tested in 1991, the majority were resistant. However, only three entries (Negro 150, Mexico 235 and Contanex) were highly resistant (Table 3). The local hybrid cultivars also showed resistant reaction (score 2-4).

Table 3: Response of some Haricot bean cultivars to anthracnose disease in 1991 at Ambo

Entry	Disease score (1-3 resistant, 4-9 susceptible)		
	Anthracnose	Rust	CBB
Icalina-3	2	2	3
Epicure	2	2	5
Negro-150	1	1	3
Mexico-235	1	1	5
W-85 (21305-9)	2	1	2
W-95-08	2	2	3
Negro mecentral	2	2	4
Jalesco-33	6	4	4
Brown spekelled	2	2	3
Mexican 142-R	3	2	3
Contanex	1	1	3
Mex-142	5	3	4
Nazareth small-27	2	2	3
EPID sample-26	2	2	4
Eth-10-27	3	3	3
Diago Calima	2	2	4
Black Dessie	4	3	3
Pinto-650	4	3	3
Exrico-23p576-1	2	2	3
Ecuador-299 (p-693)	3	2	4
Eth-10-39	2	2	3
CUVA-168 N	6	4	5

Future Plans

Considering the research work done on anthracnose of haricot bean, the following areas need more attention:

1. Establish importance of anthracnose disease through systematic surveys in the major haricot bean growing areas of Ethiopia.

2. Study yield losses due to anthracnose disease of haricot bean.

3. Systematic evaluation of local and introduced haricot bean materials for their resistance to anthracnose disease.

4. Study the biology of causal fungi and monitor the variability of the pathogen to support the breeding programme.

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SESSION III: RUST

Bean Rust: an Important Component in the Bean Production System in East Africa

Habtu Assefa

Introduction

Among the many bean diseases reported in Africa, bean rust caused by *Uromyces appendiculatus* has a wide geographical distribution (Allen, 1983; Edje *et al.*, 1973; Lowland and Macartrey, 1966; Leakey, 1963; Patel, 1975; Wallace, 1939; Wamoelo, 1973). Research information on the epidemiology of bean rust and understanding of the bean rust status under farmers' circumstances has been badly lacking.

Prior to 1987, research in bean rust in Ethiopia was very much limited in scope and importance. Apart from evaluations of breeder's nurseries as part of the varietal development scheme and chemical control studies done in the western part of the country in the early 1970's, information on geographical distribution, relative importance vis-a-vis other foliar diseases, its economic importance, physiologic races, biological control, epidemic development in varietal mixtures and in intercrops, and development of resistant varieties with wide adaptation potentials was lacking. The situation remains the same for most parts of East Africa.

Because of this, a rust sub-project was proposed in 1987 to study the epidemiology and control of bean rust. The major foci of the research were disease survey, crop loss assessment, pathogenicity analysis, varietal mixtures and varietal resistance. Ethiopia acts as a coordinating country and collaborating countries include Uganda, Rwanda, Kenya, Zambia, Mauritius, Zaire and Madagascar. With most countries, except for Uganda, the main area of collaboration remains testing of bean rust regional nursery. Hence, most of the information obtained in this report come from research conducted in Ethiopia. Research results obtained in experiments conducted in 1988 and 1989 were reported elsewhere (Assefa, 1990) and this report summarizes results obtained in the 1990 and 1991 experiments.

Bean Crop Survey

A survey of beans grown and bean diseases was conducted in 1990 and 1991 in the major bean growing areas of Ethiopia: central Rift Valley, southern, western and eastern regions.

The survey results revealed important differences among regions. The central Rift Valley is characterized by a mono-modal type of rainfall (June to September). Beans are grown as mono-crop once a year mainly as a cash crop. The dominant variety is Mexican 142. Farmers here do not apply fertilizer or weed their bean crop. There is a large variation in sowing dates mainly depending on the arrival of the first shower. Important bean diseases are rust, anthracnose, and common bacterial blight (CBB). Bean rust is widely scattered.

In the relatively wet parts of the region, anthracnose is dominant but in areas where temperatures are high and rainfall limiting CBB is most prevalent. In areas where farmers use good, healthy seed the incidence of anthracnose was greatly reduced.

The southern part of the country has two rain seasons. Hence beans are grown twice a year (July to October and February to May). Beans are either grown pure or in association with enset, maize, sweet or Irish potatoes. Beans are mainly grown for food and the dominant variety is Red Wolaita. Because of good extension programs, farmers in this region practice row planting, weeding and fertilization resulting in higher yields (800-1200 kg/ha). However, plant density is low due to lack of seeds. As in the Rift Valley, sowing dates are extremely variable and dependent on the rains and preceeding crop. Diseases found here include rust, anthracnose, CBB and angular leaf spot. Rust is both dominant and wide spread. The incidence of anthracnose, CBB and angular leaf spot is slight and highly scattered. Red Wolaita is susceptible to all the diseases found in the region but, perhaps due to the use by farmers of healthy, clean seed and weed free fields, incidence of anthracnose and CBB are greatly reduced.

In the Western part of the country both bush and climbing beans are grown. Climbing beans are traditionally grown as garden crops. Bush beans are grown as mono-crops or intercropped with maize or sorghum. Five diseases found to be associated with beans are rust, anthracnose, CBB, angular leaf spot and floury leaf spot. Due to the humid conditions prevailing in the west, angular leaf spot and floury leaf spot are dominant. On climbing beans the major disease is phoma blight (ascochyta blight) which is frequently found in most gardens. Slight and scattered incidence of rust is also found on climbing beans.

In the Eastern highlands of Ethiopia, beans are grown as mono-crops or intercropped with maize, sorghum or chat. Farmers in this region traditionally grow varietal mixtures, differing in color and size. Due to security problems, a limited survey was made in this area which showed that rust and CBB are the two widely distributed diseases.

The large variations in climate affect the level and type of disease occurring in any region. Of the six diseases mentioned in the survey report, rust, anthracnose and

CBB are the most widespread, while angular leaf spot, floury leaf spot and phoma blight have limited distribution and are restricted to the western parts of the country.

There are also wide variations within regions which may be attributed to crop, agronomic and climatic factors. Further analysis of the survey data should indicate relationships between agronomic practices, climatic factors and disease severities.

Assessment of yield losses

Information on the impact of bean rust on yield is very limited in Africa. Preliminary results on the importance of bean rust on beans (based on a single factor and critical stage analysis) in some parts of Ethiopia has been reported (Assefa, 1990). In 1990 and 1991, field experiments were designed to incorporate other crop and disease factors to determine the relative importance of rust in a multiple factor phenomena.

The study was conducted at Ambo in 1990 and Debre Zeit in 1991. Different disease levels were obtained by manipulating fungicide application at varying intervals. Crop and disease assessment were made weekly.

The results obtained from the two field experiments indicate that, of the four yield components assessed, seed yield and seed weight produced high variation due to changes in spray treatments. Changes in spray treatments also resulted in changes in leaf area index, rust intensity, other diseases and dead tissue.

At Ambo, seed yield loss varied between 0-84.8% and 0-29.6% for Mexican 142 and 6R-395, respectively. Loss in seed weight varied between 0-16.9% for Mexican 142 and 0-11.5% for 6R-392. Similarly the range of seed yield loss in the Debre Zeit experiment was 0-42%. Attainable yields were 155.7 g/m^2, 217 g/m^2 and 186 g/m^2 for Mexican 142 and 6R-395 at Ambo and for Mexican 142 at Debre Zeit respectively.

The results also suggest that leaf area index (LAI) and rust severity cause the greater degree of losses in beans in both Ambo and Debre Zeit. Of the four factors (LAI, rust, other diseases, dead tissue) studied, variation between treatments (spray interval) are greater for LAI and rust severity. Differences between treatments were not significant from other diseases and dead tissue. Overall, the results suggest a possible relationship between LAI, rust, severity, other diseases and dead tissue with yield loss under both environments.

Varietal Mixtures

The use of varietal mixtures is a common traditional practice in the African bean production system. Varietal mixtures provide farmers with several unique advantages, including protection against diseases and pests.

Effectiveness of varietal mixtures in the control of fungal diseases is well documented (Johnson and Allen, 1975; Leonard, 1969; Mundt and Leonard, 1986; Shaik, 1985). Effect of bean genotype mixtures on the development of rust was examined under field conditions in Ethiopia (Ambo and Debre Zeit) and Uganda (Kawanda) in 1990 and 1991. Due to high inter-plot interference as a result of poor performance of the soybean guard row, data collected in Kawanda did not reveal significant variation among the treatments. At Ambo and Debre Zeit the background noise was at acceptable level.

The results obtained both at Ambo and Debre Zeit suggest that growing mixtures of resistant (Negro Mecentral) and susceptible (Mexico 142) cultivars resulted in a lower rate of disease expansion and increase than growing a susceptible genotype alone. The effectiveness of varietal mixtures increased with increasing levels of resistant varieties in the mixture. Mixtures with 20% susceptible cultivar were always more effective than mixtures of higher susceptible proportions.

The relative wave velocity and rate of rust increase appears to be proportional to the log of the proportion of susceptible plants (Leonard, 1969). The calculated r-values show variation between treatments ranging between 0.126-0.226 at Ambo and 0.113-0.20 at Debre Zeit. At both locations r-values were reduced by 45% when proportions of susceptible genotypes decreased to 20% in the mixture. The velocity c also shows great variability among treatments. The c-value ranges between 2.145 cm to 9.98 cm per day for Ambo conditions and from 2.759-13.214 cm per day for Debre Zeit conditions. The value c was reduced by about 75-80% when proportions of the susceptible genotype decreased to 20% in the mixture.

Partial Resistance (PR) Studies

Partial resistance (PR) results in reduced epidemic build-up of a pathogen despite a susceptible infection type, and can be expressed at different phases during the life cycle of a pathogen. In determining the rate of epidemic build up, latency period, infection efficiency, sporulation capacity and sporulation period were used as estimates of PR in several pathosystem (Parlevliet, 1981; Zadoks and Schein, 1979).

In the bean-bean rust pathosystem, effects of genotypes, leaf age and spore density on latency period and infection efficiency were studied. Fifteen genotypes, three plant ages and three spore densities were selected and tested in a completely randomized design in a green house study at Melkassa Research Center.

The study revealed a great deal of variation in both latency period (LP) and infection efficiency (IE) due to changes in genotypes, plant age and spore densities.

LP was influenced by genotypes, plant age and to some degree by spore density. Among the 15 genotypes tested, LP varied between 9.5 to 16.5, 11.5 to 17.5 and 11.5 to 15.0 when inoculations were performed 10, 20, 30 days after planting

(DAP) respectively. BAT 338-1C remained resistant (no pustules were observed) under all treatment combinations.

ExRico 23 (Awash-1), a recently released variety, exhibited a high degree of PR by showing a much delayed response in LP. LP was also affected by plant age; as the plant matured, there was a delay in LP. Duration of LP also varied with spore density but the effect was not very great. A slight reduction in LP was observed following an increase in spore density levels.

Similarly, relative infection efficiency (RIE) was affected by genotypes, age of plants and spore density. RIE was highest in genotypes like Kentucky Wonder 765, Jalisco 33, Kentucky Wonder 760 and Brown Speckled, least in Diacol Calima and ICA 15541, and no rust pustule was observed on BAT 338-1C and ExRico 23 when data was collected 15 days after inoculation. RIE was also affected by age of plants and spore density. Inoculation performed 20 DAP indicated a high RIE. Intermediate spore density (20 mg/100 cc) resulted in a higher RIE, but as spore density increased, RIE decreased; being least at the highest spore density.

The results reported above suggest that considerable variations exist in LP and IE. Differences in LP and IE among genotypes, leaf ages and spore density suggest LP and IE to be important components of PR which can be used in future studies when selections are made for race non-specific resistant (PR) genotypes.

Regional Nursery

Improvement and selection for resistant varieties form the basis of any rust control strategy. Since 1989, a set of bean entries were composed and dispatched to several countries in Africa for rust evaluation across different environments. Materials were sent to Uganda, Mauritius, Rwanda, Tanzania and Zambia. To date, results are available only from Uganda and Ethiopia. Hence, information reported hereafter refers to the data collected in these two countries.

The rust regional nursery was composed of 80 entries at Kawanda (Uganda) and 103 entries at Ambo (Ethiopia). In 1990, there was a good disease pressure at Ambo but the rust severity was slight at Kawanda. In 1991, the regional nursery was not planted in Ethiopia but in Kawanda under a high disease pressure. In Kawanda, test entries were evaluated 5 times; at R5, R6, R7, R8 and R9. Of the 80 entries tested, 24 were found resistant, 43 intermediate and 13 were susceptible. In Ambo, of the 103 entries examined, 40 were resistant, 43 intermediate and 22 susceptible. Varieties like PAN 134 and BAT 448 proved resistant in both locations.

Summary and conclusions

Bean rust is wide spread and an economically important disease of beans in Africa. A survey of farmer's fields provided the information on the relative importance of

rust in a multi-pathosystem where other foliar diseases co-exist. Studies on crop-loss show that rust has potential to cause damage on beans particularly in susceptible entries. The effectiveness of varietal mixtures in reducing rust epidemics, and the variation in genotypes for components of partial resistance suggest future possible means in rust control. Future studies still need to address other research areas like effects of intercrops, biological control, physiological races and performance of rust resistant entries across regions. Understanding of rust epidemiology in these and other areas should form the basis for developing an effective integrated rust management strategy.

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Preliminary Results on the Study of Bean Rust in Madagascar

G. Rakotomalala and A. Tabakoarihanta

Introduction

Common bean (*Phaseolus vulgaris* L.) constitute a source of dietary protein and revenue for the Malagasy farmers and the national economy. It is grown annually under three cropping conditions namely: upland (rainfed), lowland and as an off-season crop. In 1989, about 46.000 ha were under beans (Table 1). The main bean growing areas in Madagascar are found in the High Plateau in the regions of Antanarivo and Fianarantsoa which account for 84% of the total national production. The remainder is produced in the east and the southern part of the country.

Table 1: Bean production in Madagascar in 1989

Region	Area (ha)	Production (t)
Tananarive	20,579	17,625
Fianrantsoa	18,180	14,630
Tamatave	2,510	2,305
Majunga	1,255	1,000
Tulear	320	2,950
Diego-Suarez	330	800

The national bean yield average is about 850 kg/ha. The low yields may be attributed to two types of constraints: biotic factors, mainly diseases, and abiotic factors including drought, floods, and low soil fertility.

Substantial losses are caused by two important diseases: rust and anthracnose. Rust constitutes a major constraint to bean production in the main bean growing regions. This has been the basis for developing a sub-project on rust by the Legume Programme in collaboration with CIAT.

Objectives of the sub-project:

- to determine the nature and extent of pathogenic variation in the country
- to develop control measures mainly on the basis of resistant or tolerant varieties for the different cropping systems and environments.

Activities Undertaken

Preliminary studies on bean rust undertaken so far, include evaluation of 25 selected bean varieties for their reaction to rust. The objective of the trial was to identify rust resistant bean varieties, based on incubation period and disease severity.

Methodology

Twenty five bean varieties, eight of which are local, were planted in the field in a 5 x 5 triple lattice design with three replications at two locations; Antanarivo and Antsirabe. Plot size was four rows, 4 m long, 40 cm apart. Evaluation was based on natural infection. Reaction to rust was evaluated on a scale of 1-5.

Results

In Antanarivo, (at the Agricultural Experimental Station of Nanisana) where planting was done in January 1992, rust appeared at pre-flowering stage. Based on their reaction to rust, the varieties could be classified into three categories; resistant, intermediate and susceptible. The following varieties were classified as resistant: Goiano Precoce, Carioca, PH 14-1, Rosinha G2, Bean Redlando, A 410, Black Turtle Soup, Bico de Ouro and Ikinimba.

Goiano Precoce and Carioca were considered as highly resistant as no visible rust pustules were present. Among varieties that showed intermediate resistance are Lingot blanc, Menakely, Blanc de Majunga and Ex-Rico. Varieties that were classified as susceptible are Gallaroy and Gratiot.

In Antsirabe, where sowing was done late, rust was present only on one variety, PH 14-1 which is a local variety. However, infection by other diseases such as angular leaf spot and ascochyta blight was severe.

Workplan for the Future

Future work will be to:

- survey and determine importance of rust in the main bean growing areas
- determine the influence of different ecological bean regions and cropping systems on incidence and severity of rust
- determine pathogenic variation of the rust pathogen on the basis of the standard differential cultivars

- introduce and evaluate, international and regional rust nurseries and other sources of resistance to prevailing pathogenic variation

- develop other control measures

SESSION IV: ROOT ROTS

Root Rots Research in the Great Lakes Region

R. A. Buruchara and G. Rusuku

Introduction

Within the last five years, an increase in incidence and severity of root rots has been reported in the Great Lakes Region (GLR), particularly in Rwanda (CIAT, 1988, 1990, 1991; ISAR, 1991) and has been associated with a decreasing trend in bean yields. It is estimated that over 60% of bean producing areas in Rwanda suffer from root rot problems of varying severity (Rusuku, 1991). The areas most affected included the prefectures (provinces) of Kibuye, Butare, Gikongoro, Gitarama, and Cyangugu. During the 1992A (1991/92) season for example, root rots were severe and a survey conducted by ISAR in collaboration with CIAT, showed that root rots were responsible for about 50% nation-wide yield loss (unpublished data).

Root rot problems are usually associated with certain crop production systems and environmental conditions. In the GLR, bean production is characterized by the following features which may have a bearing in the prevailing root rots problem:

a. Beans are grown during both seasons (twice and sometimes three times) every year with no fallow period.
b. Rotation periods are short and ineffective due to high human population and reduced land sizes.
c. Bush beans predominate and as a practice are grown in mixtures in the lowlands while climbers are grown in the highlands.
d. High plant densities are used.
e. Application of inorganic fertilizers is uncommon although beans may receive farmyard manure if available.
f. Soil fertility is generally low with nitrogen and phosphorus being some of the limiting nutrients.
g. Soils tend to be acidic and in some cases are compact.
h. Root rot pathogens are widely distributed.
i. Varieties grown are susceptible to most root rot pathogens.

Consequences of such a system is a build up of inoculum of soil pathogens, less vigorous plants prone to attack by the latter, and severe disease levels under ideal environmental and plant conditions (Abawi, 1989). This presentation highlights the strategies and technologies being developed in the management of root roots in the GLR. Some of the results obtained are also highlighted.

Strategies

Considering the systems of bean production in the GLR, research conducted to develop root rot management practices, has focussed largely on evaluation of germplasm and potentially useful cultural practices. Use of resistant bean cultivars is not only effective, but also appropriate for resource limited small scale farmers. Certain cultural practices also influence the degree to which bean plants are prone to infection by root rot pathogens and can be manipulated to lessen the severity of root rot diseases. Given that four or five pathogens are responsible for causing root rots in beans in the GLR, either in isolation or in association, there may be limitations in using only genetic or cultural methods. Thus the objective of these studies is to develop acceptable integrated disease management options based on genetic and cultural components. To achieve these goals, two closely related regional subprojects, one considering genetic, and another cultural and integrated approach were initiated in 1990.

Materials and Methods

Of the several possible control options available, some were chosen for evaluation and development. These include 1. germplasm evaluation and 2. cultural methods (planting on raised beds, ridges and use of organic amendments). The choice of a management option for testing was based on:

a. Farmer's opinion on the alternative control methods available.
b. Present practices and circumstance of the farmers in the area.
c. Effectiveness of the methods.
d. Chances of being adopted.
e. Complementarity in effects of the methods tested. eg. complementarity of two cultural methods that may be applied together, or a variety and cultural method(s).

Germplasm Approach

The objective of this approach was to identify varieties resistant to prevalent root rot pathogens, which may be used directly or as sources of resistance in the improvement of local or popular but susceptible cultivars. To achieve this objective the following studies have been conducted:

Identification of soilborne pathogens associated with root rot diseases: The types of soilborne pathogens associated with root rots and their relative prevalence were determined in 15 communes covering six prefectures (provinces) of Rwanda during the 1990A and B growing seasons. Randomly chosen bean samples were obtained from both research and farmer's fields. They were examined for disease symptoms in the field, and the causal agents were isolated on artificial media in the laboratory and subsequently identified.

Identification of sources of resistance: To identify sources of resistance for direct use or as parents in crosses, certain types of germplasm have been evaluated. This includes the International Bean Root Rot Nursery (IBRRN), and selected varieties from introduced or locally developed germplasm. IBRRN was evaluated both in the field and in the screenhouse. In the latter, entries were evaluated in naturally infected soils obtained from 12 communes representing four prefectures; Kigali-Nord, Cyangugu, Gikongoro and Butare. Evaluation of selected varieties was done in on-station and farmers fields. The regional nursery Pépinière Régionale d'Evaluation des Lignées Avancées en Afrique Centrale (PRELAAC) was evaluated under a natural but severe disease pressure during the 1992A season.

Cultural Methods

Manipulation of certain cultural methods have been observed to influence the severity of root rots. In these studies, effectiveness and acceptability of certain cultural practices in the management of root rots were simultaneously evaluated, in on-station and in on-farm trials. The latter allowed us to evaluate constraints associated with a technology at farm level. The practices that have been or are being evaluated are:

1) Planting on raised beds (1 m wide and about 30 cm high) and ridges (50 cm apart). Raised beds is a system commonly used in areas prone to water logging and valley bottoms.

2) Effects of different types of organic amendments mainly green manures of *Leucaena, Sesbania, Calliandra*, wattle bark and grass weeds in the management of root rots. Decomposing coffee pulp is also being evaluated.

Integrated Control Method

Some of the identified components have been evaluated separately and in association to determine if there are any complementary effects. For example, effects of growing a tolerant variety on ridges or with organic amendments have been tested.

Results and Discussion

Identification of the types of pathogens associated with root rot problems

Results of the survey conducted in 1990, showed that about 40% of plants sampled at flowering, had root rot symptoms, 15% were dead, 21% were affected by beanfly, 15% were healthy and 9% were affected by other insects. There were wide inter-field variation. Average root rot incidence in the sampled communes of the prefectures of Gikongoro was 33%; Butare, 40%; Kibungo, 53%; Gisenyi, 60%; Cyangugu, 33%; and Kigali Nord, 19%. These findings show that root rots are widely distributed in Rwanda, but variations exist in relative importance from region to region. Other observations made also show that seasonal variation in importance and severity of root rots does occur.

The fungi associated with root rots were *Fusarium solani, Rhizoctonia solani, Pythium* spp., *Macrophomina phaseolina* and to a lesser extent *Sclerotium rolfsii.* The vascular wilt fungi *Fusarium oxysporum* f.sp. *phaseoli* was also associated with diseased plants. However, the most widely occurring fungi isolated were of the *Pythium* spp and *Fusarium oxysporum* f.sp *phaseoli.* Occurrence and importance of these fungi have been observed to vary from region to region and from season to season depending on environmental conditions and varieties grown. In many cases, two or more fungi were isolated from the same plant specimen suggesting their occurrence in a complex.

Identification of Sources of Resistance

Some entries of the IBRRN, have been shown to be resistant to root rots based on evaluations using naturally infected soils from various parts of Rwanda. These include A 295, BAT 868, A 191, BAT 1400, XAN 112, A 300, BAT 447, ICA PIJAO, A 70, and G 5059. However, some of them were shown to suffer from black root.

In on-farm trials conducted in Runyinya (Prefecture of Butare), some varieties where shown to be resistant to root rots. However, the semi-climbing variety RWR 221 was shown to be both resistant to root rots and tolerant to poor soil conditions. These attributes have made it receive wide acceptance by collaborating and neighbouring farmers. Variety G 2333 was also well rated but its susceptibility to Fusarium wilt, prevalent in the area, was cited as the main disadvantage. XAN 112 and A 300 were resistant to root rots but the former was very susceptible to anthracnose while A 300 did not perform well in poor soil conditions and was susceptible to ascochyta making them less acceptable. Results from on-farm trials suggest that, because of the low fertility conditions prevalent, varieties which are resistant to root rots should also be tolerant to low soil fertility. Varieties resistant to root rots but not tolerant to low soil fertility could benefit from fertility improvement practices where possible. Much of the farmer's local mixture are susceptible to root rots while most climbing varieties appear resistant to damping-off pathogens.

During the 1992A season, heavy rains came when much of the crop was about 2-3 weeks old and resulted in a severe attack of root rots. The principle pathogens were *Pythium* spp and *Rhizoctonia solani*. Evaluation of 100 entries of PRELAAC-5 showed that 22 lines showed very high levels of resistance. PRELAAC is a nursery composed of the best advanced lines contributed by each of the national programme in the Great Lakes region for testing for disease resistance in a number of sites in the region. Most of the resistant entries were contributed by the Zairian national program and were selections made at PNL-Mulungu from progenies of crosses made at CIAT for angular leaf spot resistance. Some of the resistant lines contributed by Zaire were MLB-10-88B, MLB-13-88B, MLB-17-88A, MLB-36-89A, MLB-38-89A, MLB-39-89A, MLB-40-89A, MLB-42-89A, MLB-43-89A, MLB-47-89A, MLB-48-89A, MLB-49-89B. Those contributed by Rwanda were RWR 432 and RWR 719, and those by Burundi were EM 1616, EM 22/20, SCAM-80-CM/15, and MORE 90026. These entries exhibited high levels of resistance to damping-off at seedling stage and differences in their reaction from susceptible ones could be observed as early as V3 stage.

Cultural Methods: Organic amendments and planting on raised beds

On-farm and on-station trials conducted during the 91A and B seasons, showed that Leucaena organic amendment (20 ton/ha) and raised beds had no significant advantage over the control in seedling emergence, and the number of plants harvested. However, organic amendment significantly reduced root rot severity and increased yields in both seasons, while raised beds had no effect in either season. Use of organic amendment resulted in a yield increase of 43% in 1991A season and 60% in 1991B season over the control (Table 1). In 1992A season when root rots were severe, the use of organic amendments and ridges were effective in reducing damping-off of plants due to root rots, reduced disease severity and increased yield. The 1992A season had a severe attack of root rots particularly due to *Pythium* and *R. solani* because of high rains which coincided with a young crop. The yield advantage in on-farm trials of using organic amendment (10 ton/ha) was 128% and that of using ridges was 139% on local varietal mixtures. The relative advantage of using these practices on the variety RWR 221 were less marked which emphasizes its resistant characteristics. However, the response of RWR 221 (in yield) was better at 5 than at 10 ton/ha of organic amendment whereas the contrary was true with the local mixtures.

Organic amendment (both at 20 and 10 t/ha), has been shown in these studies to reduce severity of root rots and increase yields. These effects were most pronounced in 1992A when severe root rots occurred and to a lesser extent in 1991A season (main bean growing season). In 1991B, the yield advantage in using organic amendment was lower than the previous season. The rates of Leucaena used (20 ton/ha) resulted in increased plant foliage, a prolonged growing cycle and infection by foliar disease mid-season.

Growing beans on raised beds or ridges is beneficial during wet conditions as they increase aeration as well as decrease soil moisture around the root zone. They also promote deeper and greater root formation and thus allows more tolerance to root rots. *Pythium* rot severity is especially reduced on raised ridges. This was the case

in 1992A where use of ridges was effective against a severe attack of root rots. In 1991A and B, raised beds had some but not significant effect on disease severity and yield, implying that conditions during the early and critical stages for damping-off pathogens such as *Pythium* spp. and *Rhizoctonia solani* were not ideal for their development. The root rot infection observed then, was the type characterized by slow rotting of roots, reduced vigour and discolouration. This condition is worsened by low soil fertility.

Organic amendments with Leucaena appear to influence disease severity and at the same time improve the nutritional status of the soil thus exerting complementary effects. Well fertilized and vigorous plants are tolerant to damage caused by root rot organisms.

Table 1: Relative advantage of organic amendment[1] (OA), raised beds (RB) and variety on the severity of root rots and yield in on-station trials (1991 A and B seasons)

	Yield (kg/ha)		Yield advantage (%)				Disease severity[2] (%)	
	91A	91B	91A	91B	91A	91B	91A	91B
Local mixture	1187	1443	-	-			31.9	20.8
LM + RB	1183	1981	-0.3	37			28.5	21.9
LM + OA	2161	2068	82	43			24.7	14.7
LM + RB + OA	1873	1978	58	37			19.8	11.1
RWR 221	3051	1549	157	7	-	-	14.2	14.1
RWR 221 + RB	2804	1640	135	13	-8	6	12.4	13.2
RWR 221 + OA	3254	1978	174	37	6	27	9.1	9.7
RWR 221 + RB + OA	3633	2344	206	62	19	51	7.4	8.1

[1] Leucaena applied as green manure 2 weeks before planting (20 t/ha)
[2] Percentage hypocotyl and root tissues covered with lesions

Future Research Areas

1. Further identification of sources of resistance to root rots and fusarium wilt (on-farm and on-station)

2. Evaluation of other sources organic amendments, methods of application to maximize effects of lower levels

3. Integration of cultural methods and resistance sources

4. Determination of relationship between bean stem maggot and root rots and soil fertility

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Screening Dry Bean Genotypes for Resistance to *Macrophomina phaseolina*, the charcoal rot pathogen

W.A. Songa

Introduction

Charcoal rot is an important disease of beans and causes severe damage on susceptible cultivars in areas where drought, stress and high temperatures are common. The disease is prevalent in many parts of the semi-arid Eastern Kenya. In Sudan, the disease has been reported to cause high mortality in certain seasons, particularly if the crop is grown in the first week of October. With the exception of seed treatment with benomyl or carboxin which helps in controlling the disease during early stages of growth, cultural control methods are ineffective in significantly reducing the disease. Use of resistant varieties is the most effective way of controlling the disease in the long run, for the capital weak subsistence farmers in Kenya and Sudan. There is therefore a need to identify cultivars with resistance to charcoal rot in this region from the local and introduced germplasm available.

Objectives

1. To develop a reliable field screening method for resistance to *Macrophomina phaseolina* in semi-arid areas of Eastern Africa.

2. To identify bean germplasm, resistant to *M. phaseolina* in the local and introduced genotypes.

3. To screen the improved breeders lines for verification of resistance to *M. phaseolina*.

4. To develop a regional *M. phaseolina* nursery.

Materials and methods

Preparation of inoculum

Isolates of *Macrophomina phaseolina* were obtained from infected sorghum, maize and beans from the charcoal rot "hot spots" of Kiboko, and Ishiara in Machakos and Embu districts respectively. Bits of fibrovascular bundles were obtained from fields infected with sorghum and maize plants, surface sterilized with 1% sodium hypochlorite, and placed on the surface of potato-dextrose agar at 30°C. Thin slices of infected bean stems with sclerotia and pycnidia were also surface sterilized and placed on potato dextrose (PDA). After 7 days' growth in the laboratory, the fungus was further sub-cultured to remove any possible contamination. The pure culture was then used to inoculate autoclaved whole grain rice (1:1/w:v rice seed to water) in 250 cc beakers which were incubated at 30°C. Within 20 days the rice was colonized by *M. phaseolina* and was subsequently used for the inoculation of beans in screening for resistance.

The isolates from maize and sorghum were also tested for their pathogenicity on dry beans subjected to moisture stress at between 28-30°C. The isolate obtained from infected bean plants was used in the greenhouse evaluation of the genotypes of the CIAT International Drought, and Macrophomina Nurseries and also the local cultivars. Colonized whole rice seeds were prepared as described by Abawi and Pastor-Corrales (1990) and used in the greenhouse evaluations.

Greenhouse tests

Three rates of colonized rice seeds per bean seed were used to evaluate 18 lines of the International Drought Nursery and five local lines. The rates were 5, 3 and 2 colonized rice seeds per bean seed. Seeds of each accession were planted in four 12 cm pots (five seeds per pot). There was a control with autoclaved uncolonized rice seeds.

The second evaluation trial contained 24 accessions from the International Macrophomina nursery and five accessions from the local drought tolerant cultivars. The rate of three colonized rice seeds per bean seed was used in this trial.

Disease severity ratings (DSR) were recorded 14 days after inoculation (V3 growth stage) using the CIAT evaluation scale of 1 (no visible symptoms) to 9 (all stem tissues and growing tip affected; plants dead). Inoculation procedure consisted of placing 3 colonized rice seeds in contact with the bean seed and covering with a layer of 4-5 cm sterilized soil. Each accession was evaluated in 4 replications with a control.

Results

Isolates from maize, sorghum and dry bean diseased crop samples were all found to be pathogenic to the dry bean. The isolate from the dry bean from the charcoal rot hot spot of Kiboko was used in all the evaluations.

The disease severity increased with the number of colonized rice seeds per bean seed. Five colonized rice seeds per bean seed gave very severe disease symptoms whereas two colonized seeds per bean seed gave moderate symptoms with the known susceptible check A 464. The inoculum level of three colonized rice seeds per bean seed gave moderate to severe disease symptoms and was chosen for subsequent evaluations.

The 23 and 28 bean genotypes evaluated in the first and second green house trials consisted mainly of the International Drought and Macrophomina nurseries respectively. Local genotypes were also evaluated and compared. The reactions of the 45 accessions evaluated are listed in Table 1 and 2. A 54, BAT 798, EMP 175, Aguascalientes 13, BAT 477, KAT B1, CG 82-69, CG 82-79, A 247, A 300, BAT 1293, Mwezi moja (GLP 1000), BAT 1400 and CG 82-24 were the most resistant entries to *M. phaseolina.* A 464 was the most susceptible entry to *M. phaseolina.*

Future Plans

1. To test the inoculation method in the field in charcoal rot 'hot spot' areas
2. To evaluate more local and introduced dry bean genotypes for resistance
3. To screen improved breeders' lines for resistance to charcoal rot
4. To develop a regional *M. phaseolina* disease nursery

Table 1: Reaction of Bean International Drought Nursery and local accessions to *Macrophomina phaseolina* under greenhouse conditions at 3 rates of colonized rice seeds per bean seed

Accession or entry	Disease severity rating[1]		
	2 rice seeds/bean seed	3 rice seeds/bean seed	5 rice seeds/bean seed
G 2816	4.3[2]	5.3	7.0
ILA 15506	5.3	6.3	7.3
A 422	5.3	7.0	6.3
M 142	5.3	6.3	6.3
BAT 3381C	5.3	6.6	7.6
G 5201	3.6	5.0	6.3
EMP 175	4.6	4.3	6.6
A 410	5.3	5.6	6.3
BAT 125	5.3	5.3	6.6
G 5059	5.3	6.3	6.0
BAT 477	5.6	6.0	6.3
AND 197	5.0	6.6	7.0
Aguascalientes 13	4.0	4.0	5.6
BAT 798	4.3	3.3	4.0
G 8025	6.3	6.3	7.3
AND 338	5.3	5.3	6.6
Mwezi Moja	4.0	4.6	4.0
KAT B1	4.0	4.6	4.6
KAT B2	5.0	4.6	6.0
KAT mm	4.6	5.6	5.6
Tepary Bean	3.6	4.6	5.6
A 54	3.3	4.3	4.6
A 464	4.5	7.0	8.0

[1] DSR recorded 14 days after inoculation using the CIAT evaluation scale 1 (no visible symptoms) to 9 (all stem tissues and growing tip affected, plants dead)
[2] Each number is an average of four replications with five seeds per replicate (12-cm pot)

Table 2: Reactions of Bean International Macrophomina Nursery and local accessions to *Macrophomina phaseolina* under greenhouse conditions

Bean accession	Disease severity rating[1]	Bean accession	Disease severity rating
V 8010	4.6[2]	A 55	6.7
BAT 1477	6.7	BAT 1581	6.0
EMP 86	6.6	V 8017	6.0
BAT 1297	7.0	BAT 1293	4.0
A 70	6.0	A 300	4.0
A 120	4.6	A 247	4.0
BAT 1651	5.3	A 464	5.3
G 5059	4.6	BAT 1297	6.6
CG/82-24	4.3	CG/82-79	3.3
BAT 1400	3.3	GG/82-69	3.0
BAT 1385	4.7	KAT B2	4.5
Mwezi Moja	3.0	KAT B1	3.5
V 8025	6.0	KAT B9	5.0
BAT 1289	5.7		

[1] DSR recorded 14 days after inoculation using the CIAT evaluation scale 1 (no visible symptoms) to 9 (all stem tissues and growing tip affected, plants dead)
[2] Each number is an average of four replications with five seeds per replicate (12 cm pot)

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Seedling Blight and Root Rot Diseases of Bean (*Phaseolus vulgaris*) in Sudan

Mohamed E.K. Ali

Introduction

Haricot bean (*Phaseolus vulgaris* L.) is the second most important food legume in Sudan, with major production areas in the northern region. Within the latter, 97% of the total bean acreage is in Shendi-Berber area with an average yield of 1.3 t/ha (Mohamed and Salih, 1990). Bean is grown as a winter crop under irrigation on flooded basins after the flood recedes. The area cropped with bean in 1991/92 season was estimated at 6000 ha.

Root rots are widely distributed and economically important diseases of bean in Central and South America, Africa and other areas (Abawi and Pastor-Corrales, 1990). *M. phaseolina* is widely distributed in the warmer parts of the world (Tarr, 1955) and occurs in most Sudan soils.

This paper reports the results of the different studies conducted on seedling blight and root rots of beans at Hudeiba Research Station, Sudan.

Materials and Methods

Isolation and identification of root rot pathogens

During field visits to experimental plots at Hudeiba research farm and farmer's fields in 1991/92 cropping season, bean plants with root rot symptoms were uprooted and brought to the laboratory. The roots were thoroughly washed under running tap water, cut into small pieces and surface disinfected in 2.5% sodium hypochlorite for one minute. They were rinsed in sterile distilled water, blot dried on sterile filter paper and plated on potato dextrose agar (PDA). The plates were incubated at 22-25° C in an alternating light regime of 12 hr light and 12 hr darkness. Pathogenicity tests of fungal isolates were performed on potted plants in the screenhouse.

International bean *Macrophomina phaseolina* nursery

The reactions of 40 bean cultivars to seedling blight (*M. phaseolina*) were assessed in the field during 1990/91 cropping season. The local bean selections P1 and HRS

545 were also included for evaluation. The local bean cultivar Ro/2/1 was planted after every two test entries to serve as a standard check. The experimental design employed was a randomized complete block. Each entry was sown in two rows 3 m long and replicated twice. Planting was done on 10 November 1990. The nursery was irrigated every 10 days. Other standard cultural practices were used.

Incidence of seedling blight (% mortality) was recorded at 4 and 8 weeks after planting. The reactions of bean cultivars to *M. phaseolina* were characterized as resistant, moderately susceptible or susceptible according to the rating system developed by Haware and Nene (1982) for chickpea wilt.

Incidence of seedling blight in relation to sowing date, cultivar and whitefly control in two soil types

This study was conducted in 1987/88 season at Hudeiba research farm. Treatments included:

- Sowing dates: 1 Oct, 20 Oct, 9 Nov and 29 Nov
- Whitefly control: sprayed with Sumicidin and unsprayed
- Cultivars: Ro/2/1 and P1

The experiment was conducted in two soil types (a sandy clay loam and clay soil). Treatments within each soil type were combined in a factorial randomized complete block design with four replications. Standard cultural practices were adopted. Incidence (% mortality) of seedling blight was recorded. Disease counts started two weeks after planting and continued at 14-day intervals.

Effect of seed treatment, pest control and sowing method on incidence of seedling blight and root rots in two soil types

The effects of seed treatment, pest control and sowing method on incidence of seedling blight and root rots of bean in two soil types (sandy clay loam and a clay soil) were studied in a field trial at Hudeiba research farm during 1991/92 season. Treatments included:

- Seed treatment: treated (dressed with Captan at 4 g/kg seed) and untreated.
- Pest control: sprayed and unsprayed
- Sowing method: ridge and flat planting

The treatments were combined in a factorial randomized complete block design with four replications. Variety Ro/2/1 was used and planting was done on 8 November 1991. The experiment was planted with the cultivar Ro/2/1. Other standard cultural practices were adopted. Disease counts started two weeks after planting and continued at 14-day intervals.

Results and Discussion

Identification of root rots pathogens

Isolation from roots and collar region of bean plants with root rot symptoms consistently yielded *Macrophomina phaseolina*, *Rhizoctonia solani* and *Fusarium oxysporum* f. sp. *phaseoli*. *M. phaseolina*, the causal organism of seedling blight, was the most frequently isolated pathogen. Pathogenicity of the three fungi was confirmed. *M. phaseolina* was previously reported on bean in the Sudan (Tarr, 1955; Ibrahim, 1973; Freigoun, 1976) but the present reports of *R. solani*, (Rhizoctonia root rot pathogen), and *F. oxysporum*, (Fusarium yellows pathogen), are probably the first on beans in Sudan.

Reaction of bean cultivars to *M. phaseolina*

Of the 43 bean cultivars evaluated, 4 (CG/82-69, BAT 1289, HRS 545 and Ro/2/1 were resistant, 29 moderately susceptible and 10 susceptible (Table 1). It is necessary to confirm the resistance of the four cultivars in an artificially infested soil.

Seedling blight incidence in relation to sowing date, cultivar and whitefly control in two soil types

The seedling blight occurs early in the season about 2-3 weeks after planting, causing seedling mortality. Its incidence is influenced by sowing dates. Sowing in early October resulted in significantly ($P = 0.01$) higher disease incidence than later sowings (Table 2), probably due to the high temperatures (max. 40°C and min. 25°C) that prevailed during that period. The effects of cultivar and whitefly control on incidence of seedling blight were not significant (Table 2). The seedling blight incidence was relatively higher in the sandy clay loam soil than in the clay soil.

Seedling blight and root rot incidences in relation to seed treatment, pest control and sowing method in two soil types

Dressing the seed with Captan significantly ($P = 0.01$) reduced seedling blight incidence in the sandy clay loam soil (Table 3). The incidence of seedling blight in the clay soil was not affected by the seed treatment. Neither pest control nor sowing method has any significant effect on incidence of seedling blight in both soil types. None of the factors studied had any significant effect on incidence of root rot diseases.

Table 1: Reaction of bean cultivars to seedling blight

Entries	Percent mortality		Reaction[1]
	4 weeks after planting	8 weeks after planting	
BAT 400	4.5	40.2	MS
A 464	2.6	55.5	S
BAT 1355	12.5	25.0	MS
A 300	22.9	36.7	MS
A 347	21.0	25.4	MS
A 294	28.2	29.1	MS
BAT 85	7.1	25.0	MS
BAT 332	0.0	52.1	S
G 5059	11.4	51.8	S
BAT 868	4.5	64.4	S
BAT 1232	5.1	51.0	S
CG/82-121	8.3	45.7	MS
BAT 1581	16.7	28.9	MS
BAT 1375	40.0	43.3	MS
BAT 1651	12.7	36.5	MS
BAT 1669	13.8	44.4	MS
BAT 1293	5.5	70.1	S
BAT 1297	4.5	48.5	MS
BAT 1477	5.0	34.7	MS
BAT 1616	17.4	35.4	MS
A 55	12.5	62.5	S
Ica Pijao	15.5	56.0	S
Rio Tibagi	4.2	44.2	MS
CG/82-24	13.9	41.7	MS
CG/82-69	11.8	18.8	R
CG/82-106	0.0	50.0	MS
A 70	5.6	52.3	S
BAT 477	12.5	55.9	S
IPA 1	15.0	24.6	MS
EMP 86	3.3	45.8	MS
A 120	8.9	36.1	MS
BAT 1289	12.5	19.1	R
Aroana 80	18.2	31.8	MS
San Cristobal 83	37.8	43.7	MS
BAT 1500	16.7	50.0	MS
V-8010	18.7	40.4	MS
V-8025	15.7	32.6	MS
CG/82-79	3.3	21.4	MS
CG/82-115	25.0	25.0	MS
V-8017	33.3	33.3	MS
P1	8.6	21.2	MS
HRS 545	7.1	8.3	R
Ro/2/1	7.8	12.2	R

[1] R = resistant; MS = moderately susceptible; S = susceptible

Table 2: Effect of sowing date, cultivar and whitefly control on incidence (percentages transformed to square root of x + 1) of seedling blight on two soil types

Treatment	Incidence of seedling blight	
	Sandy clay loam	Clay
Sowing date		
1 October	3.09	2.57
20 October	1.13	1.38
9 November	1.10	1.01
29 November	1.00	1.00
S.E. +	0.17	0.10
Cultivar		
P1	1.49	1.47
Ro/2/1	1.67	1.51
S.E. +	0.12	0.07
Whitefly control		
Sprayed	1.53	1.51
Unsprayed	1.64	1.47
S.E. +	0.12	0.07

Table 3: Effect of seed treatment, pest control and sowing method on incidence (percentages transformed to square root of x + 1) of seedling blight and root rots of bean on two soil types

Treatment	Sandy clay loam		Clay	
	Seedling blight	Root rots	Seedling blight	Root rots
Seed treatment				
Untreated	1.32	2.97	1.13	1.43
Treated	1.15	2.57	1.04	1.59
S.E. +	0.045	0.165	0.046	0.093
Pest control				
Unsprayed	1.16	2.73	1.11	1.46
Sprayed	1.31	2.81	1.06	1.57
S.E. +	0.045	0.165	0.046	0.093
Sowing method				
Flat	1.29	2.61	1.14	1.45
Ridge	1.18	2.93	1.03	1.57
S.E. +	0.045	0.165	0.046	0.093

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SESSION V: ASCOCHYTA

Screening for Ascochyta Resistance and Crop Loss Studies

B.S. Male-Kayiwa

Introduction

Ascochyta blight or Phoma blight caused by *Phoma exigua* var *diversispora* is an important seed-borne disease of beans favoured by cool temperatures (20-24°C) and high humidity (Schwartz and Galvez, 1980). It is spread by rain splash, wind and cultural practices such as weeding. Under favourable conditions, the disease can result in plant death or variable degree of destruction of vegetative and reproductive tissues. In Africa, the disease is important in the highland areas of Rwanda, Burundi, Uganda, Zambia, Zaire (Schoonhoven, 1980; CIAT, 1987; Kainnaiyan *et al.*, 1986) and to a lesser extent in Tanzania and Kenya. A regional sub-project (supported by CIAT Eastern Africa Network) on Ascochyta blight was initiated in 1987 and was expected to facilitate access to a wide range of germplasm and environments. The objectives of the sub-project were:

1. To screen a wide range of germplasm so as to identify resistance sources.

2. To study resistance across sites and exploit host-pathogen interactions within the region

3. To develop resistant genotypes through hybridization

4. To study the inheritance of disease resistance so as to identify suitable breeding strategies

5. To study the epidemiology of the disease in pure stand and in association with maize

6. To develop integrated control measures

A number of studies have been conducted to meet the above objectives but this paper reports on (i) germplasm screening for resistance and (ii) crop loss studies

which have been conducted to provide information on the relative importance of the disease.

Screening for Ascochyta Resistance

Screening for resistance done at CIAT in the early 80s (Lewnison, 1983; CIAT, 1987) led to the development of the International Bean Ascochyta Nurseries (bush and climbing types). These nurseries were tested in Rwanda and Colombia (CIAT, 1986) and later in Uganda (Anonymous, 1987). Varieties evaluated under intercropping at Kachwekano were found to have higher ascochyta levels than those in pure stands, though the differences were not statistically significant. Subsequently, screening was done in a pure crop. Over 1000 lines (Table 1), introduced through various nurseries (VEF, PRELAAC and AFBYAN I and II) and local collections from within Uganda have been screened for ascochyta resistance at Kachwekano in southwest Uganda. Recently, crosses made to introduce resistance to certain backgrounds have also been evaluated.

Materials and Methods

Spreader varieties, Carioca and EMP 117 were planted at the perimeters of the trials. Test lines were planted in three meter rows with each entry replicated at least twice. One replication was used for VEF nurseries. Spreader rows after each entry were planted two weeks before planting test lines. Some of the trials were inoculated by spreading diseased leaves on plants at flowering stage (R6) especially in 1987 and 1988. A spore suspension prepared from infected leaves was used to inoculate plants in 1989. Disease was evaluated on a 1-9 scale at flowering (R6), pod filling stage (R7) and pod ripening stage (R8) in inoculated trials and at R7 only for the non-inoculated trials (PRELAAC).

Results and Discussion

Results of the screening trials were reported in a Workshop of Bean Research in Eastern Africa in 1990 and are hereby reproduced in Table 1. A comparison of the reaction of a few entries (bush types) across seasons (1989A and 1989B) was undertaken. Significant differences ($P>0.05$) were obtained for entry scores for ascochyta at R7 and R8 while scores at R6 were not significantly different.

Seasons vary considerably, and varieties that seem to be resistant in one season may be susceptible or intermediate in another. The methodology used may have allowed for disease escapes, since the inoculum concentration was not known. Initial disease development and spread was much dependent on rainfall; spreading faster within foliage in the wetter season possibly through rain splash. Soilborne inoculum may serve as the initial inoculum which may be spread to leaves by water-splash but as the canopy closes spreading occurs from leaf to leaf within the canopy providing a micro-environment suitable for disease development. Thus

some differences among varieties would be attributed to differences in growth habits.

Table 1: Summary of trials and number of entries screened for Phoma blight resistance

Season	Trials	Source of seed	Total entries	% entries scoring 1-2 at R7
1987B	Bush nursery	CIAT	62	32
	Bush nursery	Kawanda		
	Climber nursery	CIAT	13	85
1988A	Climber nursery	Kawanda	14	14
	AFBYAN I	African N.P.	25	0
1988B	IBYAN *P. coccineus* ssp *polyanthus* (climbers)	CIAT	10	70
	VEF 86 and CIAT accessions (bush)	CIAT	648	40
1989A	Great Lakes Regional Trials (climbers)	Rwanda	16	37
	GLR Trials (bush)	Rwanda	108	9
	VEF87 selections from VEF86 + acc.	CIAT		
1989B	AFBYAN II/Regional nurs. and trials	African N.P.	147	1.3
	International Ascochyta Nurseries:			
	Climbers	CIAT	12	25
	Bush	CIAT	12	0
1990B	Climber and bush	Rwanda	55	7

Rainfall distribution was variable in different seasons during experimentation and probably affected the rate of development of ascochyta blight, and other diseases especially halo blight and angular leaf spot and their interactions. This made evaluation for ascochyta resistance in the field rather difficult.

Climbing beans were generally less susceptible but our work concentrated on bush types (Type I and II) since they are the most widely grown. Resistance was found in BAT 1416, BAT 1569, G 17098 and G 4603 (Pintado) among the bush types. In climbing beans, resistance was found in VRA 81051, G 35182, G 12582 and G 10474 but flowering and pod production in the former three were very low, making them of limited value in the a breeding programme. The *P. coccineus* ssp *polyanthus* exhibited good resistance but no further assessment could be made as it became highly contaminated through cross pollination.

Given the resistance expressed (continuous variation), it is unlikely that higher resistance levels would be found among the bush beans. It has been suggested (Lewinson, 1983) that resistance observed in climbing beans may be due to disease escape, as the plant architecture does not allow soilborne inoculum to reach much of the leaf canopy by water splash. Presently, entries that show low susceptibility in breeding trials at Kachwekano are included in the crossing blocks, with the aim of increasing resistance levels through gene pyramiding. In 1991A season, six crosses that were tested at Kachwekano succumbed, but a cross

between K 20 and G 4603 was resistant. The same crosses were tested at Rwerere, in Rwanda.

Crop loss Studies

In Africa, yield losses have been associated with a number of fungal diseases, ascochyta inclusive (Schoonhoven, 1980). However, the magnitude of loss incurred in the case of a disease which is so environmentally dependent is extremely variable, and can range from no effect to 100% loss. Yield loss estimates in Colombia (Schwartz *et al*, 1981) showed that the disease can cause up to 80% yield loss. Yield losses due to the disease in Africa have not been estimated. However, such studies are complicated by the occurrence of many fungal diseases in association with ascochyta, and lack of fungicides which are specific to a particular disease, as well as the influence of the weather.

Materials and Methods

a) A split-plot design was used, with the main plots consisting of three treatments namely: T_1 = natural infection, T_2 = plots protected with a weekly spray of the fungicide Dithane M45 at a dose of 3 kg per hectare and T_3 = inoculated with the pathogen which causes ascochyta at weekly intervals starting at R5 so as to induce higher ascochyta blight levels. Nine varieties known for their different reactions to ascochyta blight were used as sub-plots. A maize crop barrier separated treatments so as to avoid spray drift. The experiment was conducted during three seasons (1990B, 1991A and 1991B). It should be noted, however, that it was not possible to keep the protected plots completely free of disease. The inoculum used was made from crushed leaves suspended in water and sprinkled over the relevant plots using a watering can. Plot yield data and disease records were taken as well as pod infection and pod load (pods /plant).

b) In 1991A season, an experiment aimed at assessing yield loss as related to disease pressure/disease initiation at different growth stages of variety K 20 was set up. Seven treatments were used namely: L1 = natural infection, L2 = protected with fungicide from V_4 to maturity (R8), L3 = protected with fungicide R6 to R8, L4 = protected with fungicide from R7 to R8, L5 = inoculated with the pathogen once at R7 , L6 = inoculated at R6 and R7, L7 = inoculated at R5, R6 and R7. The inoculum and the fungicide dose were as described for the first trial above. There were seven replicates and plot yields were recorded.

c) In 1991B season, the above experiment was expanded to include three varieties namely EMP 117 (susceptible), K 20 (intermediate) and G 4603 (resistant) and the seven disease levels were maintained. The design was a split-plot with disease levels as the main plots and varieties as sub-plots. The trial was replicated three times.

Results and Discussions

Results of experiment (a) are presented in Tables 2a-c and 3. Higher yields were obtained in the wetter seasons 1990B and 1991B, as opposed to season 1991A with less rain. Analysis of results for individual seasons, indicated that, varieties did not show significant differences in their ascochyta disease scores at R6 in the wetter seasons. Probably, ascochyta attack at this growth stage does not affect the final yield. Treatments and varieties showed significant differences for all parameters recorded. The mean yields of treatments where relatively high disease levels were induced, were lower than in naturally infected plots. However, further analysis of the contribution of other diseases and pests need to be determined.

Table 2a: Effect of different levels of ascochyta blight (natural infection, artificially inoculated and protected with fungicides) on yield losses of nine bean varieties at Kachwekano, 1990B season

Variety	Natural infection T_1	Protected by fungicides T_2	% yield loss	Artificially inoculated T_3	% yield loss
Carioca	990	977	1.3	940	5.0
EMP 117	1040	1100	+5.4	893	14.1
BAT 1416	1127	930	17.5	840	25.5
G 2316	1537	1090	29.1	1167	24.1
BAN 6	930	840	9.7	1093	+17.1
G 4603	1480	1260	14.9	900	39.2
G 17098	1327	830	37.5	1060	20.1
BAT 1569	835	333	60.1	343	58.9
K 20	1340	1440	+7.4	740	44.8
Mean	1178	978		864	

+ means yield increase and not loss registered

Table 2b: Effect of different levels of ascochyta blight (natural infection, artificially inoculated and protected with fungicides) on yield losses of nine bean varieties at Kachwekano, 1991A season

Variety	Natural infection T_1	Protected by fungicides T_2	% yield loss	Artificially inoculated T_3	% yield loss
Carioca	767	350	54.4	413	46.2
EMP 117	817	450	44.9	440	46.1
BAT 1416	1123	487	56.6	527	53.1
G 2316	817	293	64.1	520	36.4
BAN 6	923	553	40.1	417	54.8
G 4603	763	283	62.9	163	78.6
G 17098	1123	523	53.4	727	35.3
BAT 1569	927	303	67.3	220	76.3
K 20	813	463	43.1	343	57.8
Mean	897	412		419	

Table 2c: Effect of different levels of ascochyta blight (natural infection, artificially inoculated and protected with fungicides) on yield losses of nine bean varieties at Kachwekano, 1991B season

Variety	Natural infection T_1	Protected by fungicides T_2	% yield loss	Artificially inoculated T_3	% yield loss
Carioca	1857	1507	18.8	1083	41.7
EMP 117	2187	1600	26.8	1193	45.5
BAT 1416	1440	1540	+6.9	1160	19.4
G 2316	2140	1847	13.7	1435	32.9
BAN 6	1267	740	41.6	560	55.8
G 4603	2587	1927	25.5	1817	29.8
G 17098	1857	1613	13.1	1060	42.9
BAT 1569	1707	1220	28.5	877	48.6
K 20	2600	2320	10.8	2057	20.9
Mean	1960	1590		1249	

+ means yield increase and not loss registered

Table 3: Levels of significance in the combined analysis of variance for parameters in the three seasons of the crop loss experiment

Source of variation	df	Asco R6	Asco R7	Asco R8	Pods/plant	% pod infection	Plot yield
Seasons	2	**	**	**	ns	**	**
Treatments	2	**	**	**	**	*	**
Season x treatment	4	**	**	**	ns	*	ns
Varieties	8	**	**	**	**	**	**
Season x variety	16	**	**	**	**	ns	**
Treatment x variety	16	ns	**	**	ns	ns	ns
Season x treatm. x var.	32	*	ns	ns	ns	ns	ns
CV (%)		15.7	13.5	11.7	22.1	32.1	23.0

ns = not significant; * = significant at $p<0.05$, ** = significant at $p<0.01$

b) Analysis of plot yields of variety K 20 showed that, there were no significant differences between the yields obtained for the first six treatments (L1 to L6). However, treatment L7 gave significantly ($P=0.05$) lower yields implying that high ascochyta disease levels during the reproductive phase results in significant yield losses. Plots inoculated with ascochyta at R7 gave higher yields than those protected with fungicide from V4 to maturity.

c) No significant differences were obtained in the scores for ascochyta at R_6 which may imply that plants may have similar reaction to ascochyta at early stages of growth. Disease levels had no significant effect on plot yields but the varieties had significant differences in yield (Table 4). Variety mean yields progressively decreased with changes in the seven disease levels.

Table 4: Levels of significance on ANOVA for plot yield and reaction to various diseases in the crop loss study of three varieties in 1991B

Source of variation	df	Plot yield	Asco R6	Asco R7	Asco R8	Halo	ALS	BCMV	Anthr.
Treatments	6	ns	ns	**	**	ns	ns	ns	**
Varieties	2	**	ns	**	**	ns	**	**	**
Treatment x variety	12	ns	ns	**	ns	ns	ns	ns	*
CV (%)		23.97	19.6	20.78	13.35	36.23	14.56	46.9	34.9
SE treatments		94.0	0.21	0.19	0.14	0.24	0.09	0.27	0.12
SE varieties		39.59	0.11	0.14	0.11	0.19	0.07	0.24	0.11
SE (treatm. x var.)		104.75	0.28	0.36	0.36	0.50	0.19	0.64	0.29

ns = not significant; * = significant at $p<0.05$; ** = significant at $p<0.01$

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Integrated Control of Ascochyta Blight of Beans

P. Nyabyenda

Introduction

Ascochyta (Phoma) blight is considered an economically important disease of beans in the highlands of Rwanda and Burundi. Yield losses due to the disease vary but can reach 90-100% in bush beans. There are no varieties with high levels of resistance making it necessary to complement existing levels of resistance with other control measures in an integrated manner.

The objective of this sub-project is to develop components of disease control that can be used in an integrated manner to control the disease in the Great Lakes Region (GLR): These include selection of resistant varieties, chemical control, choice of good planting time etc.

Material and Methods

Breeding for resistance

Segregating populations (F2) introduced from CIAT have been screened at a high altitude and a 'hot spot' (Rwerere) for resistance to ascochyta. Entries in PRELAAC nurseries are also evaluated for resistance to ascochyta at both Rwerere and Rubona. To improve infection chances, plants are dusted with dust of infected bean leaves or debris.

Chemical control

The effects of different fungicides (benlate, dithane M45) have been evaluated using local mixtures at different locations in the highland zone of Rwanda, namely, Byumba, Ruhengeri, and Gisenyi. Determination of the optimum number and frequency of application of dithane M45 has been evaluated in multilocational trials using a mixture of varieties with different levels of susceptibility to ascochyta (Shikashike, PVA 705, Kilyumukwe, and Bataaf).

Results

Breeding for resistance to ascochyta

Only intermediate levels of resistance have been identified in PRELAAC and CIAT introductions (Table 1 and 2). For example in 1992A season, 14 climbing varieties and only 3 bush varieties of PRELAAC-5 were shown to be tolerant to ascochyta at Rwerere.

Table 1: Climbing varieties in PRELAAC-5 identified as tolerant (reaction <6 in the CIAT scale of 1-9) to ascochyta at Rwerere

Variety	Type	Reaction	Variety	Type	Reaction
LAD 17	IV	4.0	RWR 180	IV	5.5
AND 811	IV	4.0	RWV 182	IV	5.5
IZ 306-1	IV	4.5	GLB 4	IV	5.5
IZ 261-1	IV	4.5	LAS 322	IV	5.5
AND 408	IV	4.5	AND 112	IV	5.5
AND 614	IV	5.0	LAS 295	IV	5.5
RWV 157	IV	5.0	IZ 321-1	IV	5.5
IZ 309-1	IV	5.0	AND 401	IV	5.5

Table 2: Bush and semi-climbing varieties in PRELAAC-5 with intermediate disease reaction

Variety	Type	Disease Reaction
MLB-32-88B	IV	5
SCAM-80-CM/14	I	6
EM 25/2	III	6
MLB-38-89A	I	6,5
AND 376	I	7
MORE 88001	III	7
MORE 88002	I	7

Chemical control

Benlate was shown to be effective in the control of ascochyta but it is expensive and uneconomical to use (Table 3). Dithane M45 also gave good control of the disease (Table 4) and is cheaper. One application per week or every two weeks was found to give the best yield.

Table 3: Effect of different fungicides on yield and severity of ascochyta and other fungus diseases

Treatment	Yield		Disease reaction based on the CIAT scale of 1 - 9			
	Kg/ha	% over control	Ascochyta	Anthrac-nose	Angular leaf spot	Rust
Control	965	100	8.0	8.5	7.5	4.5
Dithane M45	2390	248	2.0	2.5	2.0	1.5
Benlate	2670	277	1.0	1.0	1.0	3.5

Table 4: Effect of frequency of application of Dithane M45 on yield, and severity (CIAT scale of 1 - 9) of ascochyta and other fungal diseases on beans

Treatment	Yield		Disease reaction based on the CIAT scale of 1 - 9		
	Kg/ha	% over control	Ascochyta	Anthrac-nose	Angular leaf spot
Control (untreated)	1068	100	7.8	4.2	4.5
Weekly	2468	231	2.1	1.0	1.8
Once/2 weeks	2028	190	3.9	1.9	2.5
Once/3 weeks	1634	153	5.2	2.1	3.0

Conclusions

So far, only germplasm with intermediate levels of resistance to ascochyta have been identified. Some fungicides are relatively effective in controlling ascochyta, but the optimal rates and frequencies of application which are also economical, need to be determined. Based on these components (intermediate resistance, chemical control and cultural methods such as planting date), evaluation of their use in an integrated manner will be considered.

Future Plans

- To continue the screening of germplasm and nurseries such as PRELAAC for resistance to ascochyta.
- To determine the cost effectiveness of using dithane M45.
- To evaluate the identified components in an integrated manner.

SESSION VI: INVITED PAPERS

Functional Diversity of Phaseolus Bean Mixtures in East Africa: Disease Control in Bean Mixtures

Jill Lenné and Dawn Teverson

Introduction

Common bean (*Phaseolus vulgaris*) is the most important food legume in East Africa making an important contribution to protein intake (Allen, 1983). Mixtures of beans are commonly grown by small farmers in East Africa and a great diversity of seed colours, patterns, shapes and sizes exist among beans in these regions (Allen *et al.*, 1989). Farmers handle an array of bean genotypes, mixtures being selected for different seasons, for different cropping systems, and for different soil conditions (Ayeh, 1985; Hardman and Lamb, 1988; Martin and Adams, 1987ab; Trutmann *et al.*, 1992; Van Rheenen, 1979; Voss, 1988).

Diseases and low soil fertility are the major production constraints in East Africa (Allen *et al.*, 1989). Key objectives of both national and international programmes are focused on increasing production through management of major diseases without decreasing varietal diversity.

Common beans in traditional production systems in East Africa are a very appropriate model system for investigation of heterogeneous populations of hosts and pathogens. Results from such studies should make a valuable contribution to the rational management of crop diversity and pathogen variability in traditional agricultural systems in the tropics.

Considerable research has been done on bean mixtures in Malawi and Rwanda over the past ten years, particularly on germplasm variability, agronomy, and anthropological and socioeconomic issues (Ayeh, 1985; Ferguson and Sprecher, 1989; Hardman and Lamb, 1988; Martin and Adams, 1987ab; Trutmann *et al.*, 1992; Voss, 1988). Field studies on diseases in bean mixtures have concentrated on halo blight in Rwanda (Teverson, 1991) and angular leaf spot in Zaire (Pyndji, 1991; Pyndji and Trutmann, 1991; Trutmann, 1991). Some field work has also been done on the pathology of bean mixtures in Tanzania (Mwalyego, unpublished).

Detailed studies of germplasm variability in bean mixtures in East Africa have also been short-term and have produced speculation only about the dynamics and sustainability of the functional diversity in bean germplasm in this region. No work has been done to follow changes in bean varieties or types, their frequencies, and resistance gene frequencies in individual components and mixtures over time. This is particularly important as farmers readjust their mixtures each season. More importantly, the effects that farmers have on the frequency of resistance genes in mixtures have not been studied. Under high disease pressure, seasonal advances towards higher levels of resistance may be lost by seasonal reconstitution of mixtures by farmers for following plantings. A study involving one or several farmers would be a valuable complement to the work on disease control in mixtures and would contribute information for future strategies to improve disease control in bean mixtures with minimal extra input.

Available data suggests that mixtures have potentially provided farmers with more reliable yields under unpredictable pathological and environmental stresses. Diversity *per se* has been assumed to contribute to improved disease control and, by association, increased yield. No reliable estimates of the levels of disease control inherent in traditional bean mixtures, that is functional diversity, have been made.

Studies by Teverson (1991) and Trutmann *et al.* (1992), have clearly demonstrated that both component and within-component variability for reaction to diseases (halo blight and anthracnose, respectively) may contribute to disease control in bean mixtures. Knowledge of the types and range of resistances in traditional mixtures; their contribution to disease control under field conditions; and the effects of supplementing mixtures with additional resistances will facilitate assessment of the contribution of functional diversity to disease control in bean mixtures.

A project was therefore developed between the Natural Resources Institute, National Bean Programmes in Central, Eastern and Southern Africa and the CIAT Regional Bean Programmes to investigate functional diversity in bean mixtures. Laboratory and glasshouse studies will be carried-out at Horticultural Research International, Wellesbourne, which has extensive expertise with bean diseases, while field studies will be made at several locations in Africa. The project will be carried out from April 1992 to March 1995.

Objectives

1. To characterize component and within-component reaction to important bean pathogens of selected bean mixtures in East Africa in collaboration with national and regional programmes,

2. To quantify the inherent contribution of such mixtures to disease control under field conditions,

3. To make a preliminary assessment of the dynamics of one or two selected bean mixtures,

4. To supplement mixtures with resistant varieties and quantify their contribution to disease control and increased yield.

Choice of Diseases to Study

Many diseases affect beans in East Africa. Priorities for selection of diseases to include in the project were based on (a) their widespread and serious nature and (b) the appropriateness of control through the use of mixtures. That is, diseases for which existing levels of resistance are currently inadequate (either due to insufficient levels of resistance or resistances available only in inappropriate backgrounds) and diseases whose pathogens are known to be extremely variable, necessitating supplementary strategies for stabilising good sources of resistance, were given high priority.

The most widespread and serious bean diseases in East Africa are considered to be angular leaf spot (ALS) (*Phaeoisariopsis griseola* (Sacc.) Ferraris); common bacterial blight (CBB) (*Xanthomonas campestris* pv. *phaseoli* (Smith) Dye); halo blight (HB) (*Pseudomonas syringae* pv. *phaseolicola* (Burkholder) Young *et al.*); anthracnose (*Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav.); rust (*Uromyces appendiculatus* (Pers.) Ung); and necrotic strains of bean common mosaic virus (BCMV).

Diseases for which existing levels of resistance are currently inadequate (either due to insufficient levels of resistance or resistances available only in inappropriate backgrounds) include CBB and ALS while diseases whose pathogens are known to be extremely variable, necessitating supplementary strategies for stabilising good sources of resistance, include anthracnose and rust. Based on both considerations above and the time frame of the project, diseases which will be given highest priority are ALS, anthracnose, rust, CBB, HB and BCMV.

Selection of Project Location

An assessment of the importance of bean mixtures, current research interests in mixtures, and the potential collaborative support from national and international programmes was made across countries of East Africa. Tanzania is the country of first choice because of its decentralized bean research with a large range of field sites, the excellent laboratory available at the Selian Research Centre, Arusha; together with the interest shown by national and regional bean scientists which is partly based on their experience from past and on-going research on bean mixtures. It is hoped that trials may be carried-out in Uganda during Years 2 and 3 of the project.

Selection of Bean Mixtures

Three mixtures from the Southern Highlands of Tanzania were selected for detailed study. These include "Mbimba" with seven components, four of which make up more than 85% of the mixture; "Sumbawanga" with eight components, three of which make up about 78% of the mixture; and "Masebe" the most complex mixture with 15 components, six of which make up about 79% of the mixture.

Outline of Project

Pre-project

Representative bean mixtures were collected from traditional bean production zones in Tanzania and Uganda in collaboration with national bean scientists from Uyole Agricultural Centre, Mbeya, Tanzania and Kawanda Research Station, Kampala, Uganda in September to October 1991. Eight mixtures were collected from each country. Full documentation (particularly characteristics of the most important components of each mixture) was made at the time of collection through extensive farmer interviews. Three mixtures have been selected from each country for the project. National programme scientists provided valuable input during the collection of mixtures through their knowledge of local mixture culture. A sample of each mixture was deposited at a national institute in the respective countries.

After collection, the mixtures were separated into components; documentation was completed; and the first multiplication of seed for characterization was completed at HRI, Wellesbourne. Up to 60 seed (20-60) per seed type of the common components (up to three) of each mixture will enter the initial multiplication phase to retain as much of the within-seed type variability as possible in the common components. This seed will be essential for a comparative assessment of between and within seed type variability and their relative contribution to disease control in the mixtures.

At this stage, although Rwanda is not being considered for field work, three Rwandan mixtures have been processed by HRI, Wellesbourne as part of a previous project. Some work has continued and will continue on these mixtures: including an assessment of within seed type variability for reaction to important diseases for the major components.

Project

Year 1:

Arusha, Tanzania: Initiation of the project; field multiplication of seed; establishment of laboratory; development of field methodology. The Tanzanian mixtures will be multiplied for field trials in the following year which will also satisfy the Tanzanian quarantine requirements prior to the initiation of field trials in the second season of 1992. Local isolates of key pathogens will be collected. Preliminary field

trials will develop and refine methodology for mixture trials. Attention will be paid to: a) experimental design (plot size; arrangement of spreaders [complicated by the multi-disease objectives of this project]; and plant spacing; b) establishing the needs for field inoculation of important pathogens and refining field inoculation technique; c) developing and defining methods of identifying individual components in mixtures; and d) finalising evaluation techniques and scales. Field work will be kept as simple as possible under the requirements of the project.

HRI, Wellesbourne: Multiplication and intensive characterization of mixtures for reactions to important pathogens. Multiplication of mixtures (both components and sub-component variability); characterization of both components and sub-components of mixtures for reaction to important diseases (ALS, rust, anthracnose, CBB, HB, and BCMV). Note: Years 2 and 3 will be spent in servicing the project in similar activities.

Year 2:

Arusha, Tanzania: Basic field trials with mixtures to determine the inherent levels of disease control in traditional mixtures. Mixture trials comparing disease development, severity and yield of mixture components in pure stands and in mixtures will be carried-out. Although these trials are not dependent on prior knowledge of characterized components, it would be useful to have as many of the components characterized as possible (to facilitate field evaluations). Although initial field trials will be done in Arusha, field trials will be conducted in other sites in Tanzania in subsequent seasons, especially in the Southern Highlands.

HRI, Wellesbourne: Further characterization of mixture components; analysis of results of first field trials; planning further field trials. Results from first field trials in Tanzania will be analyzed; component and within-component characterization continued; and knowledge of the resistances lacking in the mixtures from characterization studies and field trials will be developed; subsequent field trials will be planned. The contribution of within-seed type variability to disease control in the mixtures will be compared with the contribution of between seed type variability. Characterization of within-component (seed-type) variability for common components of mixtures will form an important part of the work and will be extended to the field trials (possibility of selecting within common farmer-preferred components for superior varieties)

Year 3:

The same timetable of defined periods in East Africa (April to August and October to December) and continued input from HRI, Wellesbourne will continue during Year 3 of the project. Field trials in Tanzania and possibly Uganda and Rwanda will follow the same three basic steps: firstly, mixture components will be characterized for reaction to the most common strains of the most important pathogens; secondly, field trials will assess the inherent levels of disease control in these mixtures; and thirdly, field trials will incorporate resistant varieties into mixtures as determined by those resistances that the characterized mixtures are lacking.

Results from both characterization studies and field trials will build-up detailed knowledge of the resistances lacking in the mixtures for use in field trials in Year 3 which will incorporate "missing" resistances in varying proportions in an informed manner. Close collaboration with national and international bean improvement projects in the region will identify promising lines to incorporate.

A complementary proposal on the dynamics of bean mixtures - following changes in bean varieties or types, their frequencies, and resistance gene frequencies in individual components and mixtures over time will be linked to the project. An attempt will be made to document the effects that farmers have on the frequency of resistance genes in mixtures. Under high disease pressure, seasonal advances towards higher levels of resistance may be lost by seasonal reconstitution of mixtures by farmers for following plantings. A study involving one or several farmers would be a valuable complement to the work on disease control in mixtures and would contribute information for future strategies to improve disease control in bean mixtures with minimal extra input.

Outputs

1. Quantification of the function of genetic diversity for disease resistance at the component and sub-component levels in bean mixtures in controlling major diseases under field conditions in East Africa.

2. Potential strategies to improve the contribution of bean mixtures to the management of diseases while maintaining varietal diversity.

3. A key opportunity will be taken to complement the diversity of national and regional *Phaseolus vulgaris* germplasm collections with mixture components and selections characterized for reaction to local strains of important pathogens.

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Breeding-Pathology Interface in the Improvement of Beans

H.E. Gridley

Introduction

Since its domestication, the common bean (*Phaseolus vulgaris* L.) has become distributed world wide and is now produced primarily in low income countries in Africa and Latin America (around 69% of world production) where it is a major contributor to calories and, in particular, protein in rural sector diets. In Africa it is the most widely produced legume and grown almost exclusively by resource poor farmers, and yet the production of this very important legume is declining whilst the population continues to increase in this part of the world.

In the period 1986-88 annual bean production for the 16 main producing countries in sub-saharan Africa averaged 2,025,200 tons, around quarter of world production. The aggregate growth in production for the period 1970-89 is estimated at 2.1% annually, but all occurred in the first decade, and reflected an expansion in the area cultivated as no increase in productivity was evident. In the second decade, where no increase in productivity was again evident, FAO data for the eight principal producing countries of the sixteen, showed that annual growth in productivity had declined in Burundi, remained unchanged in Ethiopia, Kenya and Uganda and increased by 1.0% in Malawi, 2.8% in Rwanda, 2.3% in Tanzania and 1.4% in Zaire (Grisley, 1991).

With no growth in production in the second decade, combined with productivity increases that were less than the World Bank estimate of 3.1% for population growth in sub-Saharan Africa, the per capita supply of beans is diminishing. For the eastern Africa region projected estimates indicate deficit of 417,000 MT of beans, equal to 18% of expected consumption by the year 2000 and similar deficits seem likely for the other regions. To counteract this trend requires significant increases in productivity which can be attained by alleviating the biological, edaphic and climatic factors that constrain yield.

Marked yield increases are possible by the chemical control of fungal and bacterial diseases and pests, as can fertilizer application improve yield in nutrient deficient soils, but small farmers in Africa, growing beans for subsistence, have few or no resources to purchase such inputs. Genetic improvement of the crop, through the development of cultivars with heavier yield potential, greater resistance to pests and diseases and improved tolerance to infertile soils, therefore, has a key role to play in improving productivity. Such cultivars allow the farmer to attain increased productivity without recourse to inputs and are easily integrated into his production

system. To achieve this objective with scarce resources that exist in many national programmes requires:

- that research priorities are clearly established based on quantitative evaluation of the factors constraining seed yield on the farm;

- a source of genetic resistance for the constraint(s);

- a selection strategy cognizant of farmer and consumer requirements pertaining to cultivar acceptance.

In the longer term the development of yield-increasing technologies of improved crop, soil and water management are vital to fully exploit the greater yield potential derived from genetic improvements and sustain the natural resource base to help reduce the expansion of producers onto less productive and fragile land.

Amongst the CGIAR centres CIAT has responsibility for improvement of the common bean and in collaboration with other institutes has for many years focused on identifying resistant or tolerant sources to diseases and pests in the extensive world germplasm collection held at CIAT. Such sources are available to national programmes for augmenting their genetic resources to assist in generating new cultivars with greater disease resistance to endemic pathogens and thus heavier and more stable yields.

Resistant sources, screening and deployment

Amongst the diseases, anthracnose, angular leaf spot (ALS), rust, common bacterial blight (CBB) and bean common mosaic (BCMV) virus are very widespread, can markedly reduce yield and are associated with beans in most bean-producing regions in Africa. Of the other diseases, ascochyta blight, halo blight, charcoal rot, root rots and fusarium wilt, web blight and white mold can cause severe yield losses but are usually restricted to specific bean-growing regions where environmental conditions favour their development (Beebe and Pastor-Corrales, 1991).

Estimates of yield losses from some of these diseases in Africa (table 1) have chiefly been obtained on research stations, where inoculation can be relied upon, and although they give some indication of the potential loss, they do not necessarily reflect the relative importance, particularly with respect to frequency and distribution, of a disease on the farm. With limited resources available to most National Programmes such base line farm data is essential to define research priorities amongst the biotic constraints. Furthermore, continued on-farm monitoring of the disease spectrum and pathogenic variation provides forewarning to combat the onset of a new disease and/or the potential breakdown in a resistance with the concomitant effect on production.

Table 1: Estimates of crop losses induced by pathogens in beans in Africa

Disease	Cultivar	Crop loss (%)
Anthracnose	-	92
	T 8	86
	Mexico 142	27
	T 3	4
Angluar leaf spot	Selian Wonder	25
	Kabanima	8
Rust	White seeded types	100
	Selian Wonder	11
	Canadian Wonder	14
Scab	-	43-76
Bean common mosaic virus	Kabanima	14-18
Common bacterial blight	-	63[2]

[1] Loss recorded for a susceptible cultivar
Source: Allen *et al.* (1989)

Progress from selection for disease resistance depends on a source of genetic variation and effective screening method. Sources of resistance can and should initially be sought in local landraces/cultivars to provide material of immediate and practical use, being well adapted to the existing production constraints. Material for introduction can be obtained from a number of sources with major collections of bean germplasm preserved in gene banks at CIAT, USDA, the Pullman institute in the USA and at the University of Cambridge in the UK. CIAT has actively used the genetic resources in its collection to select resistant/tolerant sources to many bean diseases, and these have been assembled in international nurseries for distribution to national programmes for screening and selection.

Whilst disease 'hot spots' have proved effective screening tools, often artificial inoculation methods are necessary to reduce 'misses' and clearly demarcate differing disease levels, especially where the variation for resistance is inherited quantitatively. Moreover, the selection of a stable and deployable resistance requires exposing the source material to all the pathogenic variation existing in a production area and testing in an established yield evaluation system that is inherent in any breeding programme. Improved disease resistance, combined with a yield potential of existing commercial cultivars and/or landraces, are essential pre-requisites for a release recommendation; it is all too easy to breed useless resisters.

The wide scale adoption of relatively few released lines, however, can lead to a reduction of genetic variation on the farm, whereas Beebe and Pastor-Corrales (1991) consider that genetic diversity such as exists in landraces is the surest strategy for stable resistance to certain diseases and is a traditional disease control mechanism that should not be abandoned. To mimic this requires the deployment of resistance sources in a range of adapted lines with acceptable consumer characters, which in itself has particular relevance where farmers predominantly

sow mixtures, rather than attempting the pyramiding of different resistances in one line. Whilst it may often be desirable and/or necessary to improve the resistance of a particular cultivar to a number of pathogens, the stabilizing effect of genetic diversity is not only important for diseases but also for edaphic and climatic factors that constrain yield.

Resistance and genetic manipulation

Genetic considerations

Often no resistance can be identified in local germplasm and must be sought in introduced material. However, such sources rarely have the required agronomic and consumer characteristics and yield potential needed for release in a given production zone, and more usually their resistance can only be deployed by incorporating it into an adapted background. Various crossing and selection methods are available for the transfer of resistant traits but in setting priorities in a resistance breeding programme the relative ease in transferring major gene or simply inherited traits, compared to the more complex procedures required for those under polygenic control, has to be balanced by the latter often considered the more stable and enduring form of resistance.

In beans, strains or races have been reported for BCMV, halo blight, rust and anthracnose and genes for resistance to most races of these pathogens are available and have been deployed. No races of CBB were thought to exist until recent work in Uganda (Opio, pers. comm.) indicated evidence of races using differentials of *Phaseolus coccineus*, although prior to this, a number of authors had reported resistance in *P. vulgaris*, *P. coccineus* and *P.acutifolius*. The broad and narrow sense heritability recorded in *P. vulgaris* for resistance to CBB ranged from low to high (Singh, 1991), and where high was considered to reflect the action of a few major genes with modifiers, although other studies have reported quantitative inheritance. On-going work in Zaire have demonstrated the existence of races for angular leaf spot and both a single dominant and recessive gene have been implicated in the resistance.

The transfer of single dominant genes through backcrossing is relatively uncomplicated compared to that for recessive genes or where the transfer of more than one gene is necessary, although success does depend on the intensity of heterozygote expression and the frequency of adverse correlations. Compared to backcrossing the recurrent selection programmes needed to transfer polygenically inherited traits require phases of crossing alternated with generations of selfing, with greater difficulty in identifying resistance determined by genes with a small effect. Further complications can arise in both types of crossing programme from multiple allelism, a not uncommon phenomenon.

Inter-disciplinary interaction is vital to the practical deployment of resistant sources; screening methods must be developed and sources identified for breeding to manipulate and incorporate into heavy yielding, farmer/consumer acceptable cultivars.

Uganda with the aim of soon extending this service to other national programmes in the region.

Breeding for improved seed yield per se

Objectives and source

The objective of a disease improvement programme is to improve the disease resistance of commercial cultivars and/or advance breeding lines being considered for release with no penalty on yield potential (any increase being an unsolicited benefit). In a yield breeding programme the principle objective is to achieve significant increases in productivity, without any increase necessarily sought in resistance to biotic and abiotic constraints, although this may arise out of the selection practised and such characters are routinely monitored in the yield trials.

Active breeding research on beans as a subsistence crop in Africa dates back to the last 25 years and during this period national programmes have released a number of cultivars, utilizing genetic variation in landraces and local germplasm collections. Germplasm exchange between programmes has assisted to augment available variation, but historically the potential for improvement is to a degree limited by the considered common origin of much of the African bean germplasm from the Andean region (Gepts and Debouck, 1991). Although crossing can generate additional variation, increasing the genetic base through the introduction and evaluation of new genetic material from other gene pools is perceived as necessary to attain and sustain the productivity increases needed to meet projected demand.

In this area, breeding and other disciplines at CIAT, aside from developing disease resistant lines, have utilized its genetic resources and interacted in developing a wide range of breeding lines. These are available for distribution in breeding nurseries and trials, ranging from a non-replicated 'VEF' screening nursery with up to 1500 diverse lines to international trials comprised of relatively few lines of a particular class. All the entries have acceptable agronomic and consumer characteristics and undergone testing that qualifies for further evaluation under a wide range of environmental conditions and are thus ideal for introduction, screening and yield evaluation in national breeding programmes in Africa.

Yield/disease relations

The National Programme in Uganda has annually introduced up to 1000 lines in the 'VEF' screening nursery from CIAT for evaluation. Prior to 1989 initial selection emphasised improved disease resistance prior to yield testing, whereas after 1989 multisite seed yield evaluation, combined with monitoring of reaction to the principal diseases, was imposed early in the selection scheme.

To examine the effect of the latter strategy on yield/disease relations for lines differing in yield potential, the mean yield and disease scores of the five heaviest

(HYL) and the five lightest (LYL) yielding lines in three trials conducted at Kawanda (the principal research station) in 1990a are presented in table 3; the mean yield of the these two groups over all four sites at which they were tested is also included.

Table 3: Seed yield (kg/ha) and disease scores for the five heaviest (HYL) and five lightest (LYL) lines in three trials in Uganda in 1991A

Item	Yield and disease scores at the Kawanda site						Mean yield over 4 sites
	Seed yield	ALS	CBB	Rust	BCMV	Mean disease score	
Trial 1							
HYL	1731	3.4	3.9	3.0	1.3	2.9	1059
LYL	798	4.0	4.4	3.3	1.3	3.2	656
Difference[1]	+933	-0.6	-0.5	-0.3	0.0	-0.3	+403
Correlations with seed yield (df = 47)[2]		-0.16 ns	-0.20 ns	-0.03 ns	-0.17 ns		
Trial 2							
HYL	1329	2.6	2.0	4.0	2.8	2.8	1192
LYL	625	2.2	2.0	3.9	2.5	2.6	794
Difference	+639	+0.4	0.0	+0.1	-0.3	-0.2	+398
Correlations with seed yield (df = 47)		-0.12 ns	-0.11 ns	-0.23 ns	-0.20 ns		
Trial 3							
HYL	1162	3.0	2.0	4.1	2.2	2.8	1310
LYL	464	3.9	2.1	5.5	2.4	3.6	968
Difference	+698	-0.9	-0.1	-1.4	-0.2	-0.8	+342
Correlations with seed yield (df = 47)		-0.39 **	-0.42 **	-0.21 ns	-0.05 ns		

[1] Yield and disease scores for HYL lines minus those for LYL lines
[2] ns: non-significant; **: significant at $p < 0.001$

In all three trials the mean yield at Kawanda of the HYL lines was over double that of the LYL lines, whereas differences for the disease scores were small, and only in two instances was there a significant correlation (derived from all the test lines in a trial) between seed yield and disease score. Although this is only a small sample of trial data available, and the disease scores reflected reaction to natural infection, the results indicate that large differences in yield potential can exist amongst material with similar levels of disease resistance; the corollary being that over emphasis for selection for disease reaction could hinder yield improvement.

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Part 2: Planning of future research activities on fungal bean diseases in Africa

Reports from the Working Group Sessions

U.C. Scheidegger and R.A. Buruchara

Introduction

The primary objective of the Working Group meeting on fungal diseases was to come up with a coherent framework for future activities in this field, based on evaluation of past work. Such a framework will serve as a guide for the Steering Committees of the three bean research networks for orienting, approving or rejecting proposals for sub-projects in the area of bean diseases. Two and a half days of the meeting were therefore dedicated to planning of future activities.

The methodology: PPO

A methodology similar to 'Project Planning by Objectives (PPO)' was followed. This method has been used successfully to plan interdisciplinary interventions which are to be carried out by several actors or teams. PPO has been widely used by the German Technical Cooperation (where extensive literature is available) and other agencies involved in international development.

The PPO principles for working are:

- Democracy: Each idea is considered important
- Consensus: Ideas are discussed and reformulated until all participants can agree on them
- Continuous visualization: Ideas are visualized by means of cards posted on a board; discussion concentrates on these cards and participants may chose to discuss with (reformulated or new) cards rather than verbally.

With PPO the group goes through the following steps:

1. Listing and checking all problems related to the subject
2. Organizing problems in cause-effect chains ---> problem tree
3. Converting the problem tree into a tree of objectives
4. Constructing the planning matrix
5. Quantifying resources needed for planned activities and attributing responsibilities

1. A first list of problems is obtained by having each participant write (e.g. three) cards, each expressing an important problem related to the subject. Problems are always formulated as negative situations. These cards are posted and if not understood by all participants they are clarified. Afterwards, the list is screened; is this a real problem? does it apply to all the countries? (if not, it has to be qualified). New problems or more precise formulations may come up during this screening. Discussions at this stage ensure that all participants (and later actors in the project) understand any one problem in the same way.

2. A problem may be caused by one or several other problems. All cards on the board are therefore organized in a logic of cause-effect, causes being placed below their effect on the board. This yields a kind of tree, with problems being at the base of most others as the finest roots, the central problem being the stem and cards representing negative effects of this central problem being the branches.

3. The logic of the method is based on the fact that the opposite of the central problem (the positive formulation) will make a reasonable overall objective of the project. The opposite of direct causes of the central problem constitute the intermediary results. Thus, by converting the whole problem tree into a tree of objectives, a framework giving clues as to all possible interventions is obtained. The participants then have to decide, along which axes in this framework they want to plan their actions (considering the mandates, expertise and facilities of the institutions which they represent).

4. The framework is then used to construct the planning matrix indicating the concrete activities necessary to reach the expected intermediary results and the objective of the project. For each result, objectively verifiable (quantitative and qualitative) indicators are formulated, and the sources for their verification are determined. Factors putting at risk the success of the project are analyzed; it is determined if the risks can be eliminated by incorporating additional activities, if they are to be considered as 'rather unlikely' (and mentioned in the form of 'conditions' in the matrix), or if they are likely and consequently lead to drop a specific axe of intervention or the whole project.

5. For each activity, the necessary resources are estimated and, especially if several institutions are involved, the responsibilities are attributed. The logical sequence of the activities in time is also established.

If appropriate, going through the above steps is done in groups, who then report to the plenary to ensure that all participants agree on the outcome of each step before starting the next.

Rules for working in groups include the following:
- Chose a moderator
- Brainstorming: Agree on the 'question', silence while thinking/writing cards
- Read all cards and post them
- Explain and reformulate unclear cards
- Organize the cards

The application of PPO in the pan-African meeting on fungal bean diseases

PPO has been successfully used in elaborating mid-term workplans in research networks. Bringing all future actors in a network together for planning ensures a considerable degree of commitment to and identification with the outcome. The effort to clearly understand together the problems one wants to solve creates a common basis for collaboration. Yet, the outcome, the planning matrix, has to be considered as a framework of guidelines only, which should allow for some flexibility along the road, according to the 'bottom up' nature of successful networks.

Some of the participants had already been involved in planning activities of their national bean program or their regional bean network using the PPO method.

The organizing committee set the time horizon for this planning to five years. The institutional context was given by the three interdependent regional bean networks with participating national institutions and CIAT. The area of intervention was limited to fungal diseases on beans in Africa.

The organizing committee proposed to treat bean diseases in five groups, each concentrating on one of the following diseases:
- Angular leaf spot
- Anthracnose
- Ascochyta blight
- Root rots, Macrophomina and Fusarium wilts
- Rust

Problems common to all the diseases and their solutions were discussed in the plenary. Thus the results were six individual problem trees and planning matrices.

The two and a half days did not allow for a full PPO procedure and therefore the following shortcuts were taken: Problems identified during the presentations and discussions in part 1 of the meeting were recorded (step 1). Step 3 was not carried out systematically, except for the top part of each problem tree. Given the fact that participants represented a wide range of institutions, and that the planning matrix could not constitute a 'project' but rather guidelines for three steering committees and other bodies for consolidating coordinated workplans financed in many different ways, all roots of the problem trees were carried forward into

planning of activities (step 3). Objectively verifiable indicators were not discussed and no risk analysis was conducted (step 4), since this will have to be done at the level of individual sub-projects. Finally, in step 5, necessary resources per activity were only determined in terms of researcher-months.

In addition to the standard PPO, all activities were prioritized to allow for some flexibility in responding to availability of resources with individual actors; each participant was supplied with a number of votes and was asked to attribute them to activities of highest priority according to him. Participants agreed to take the following criteria into consideration for attributing their priorities: Efficiency (benefit/cost), importance and integration in the overall plan, present state of the art on the topic, chances of success.

The results: Problem analysis

On the following ten pages the six problem trees are presented (some trees go over two pages).

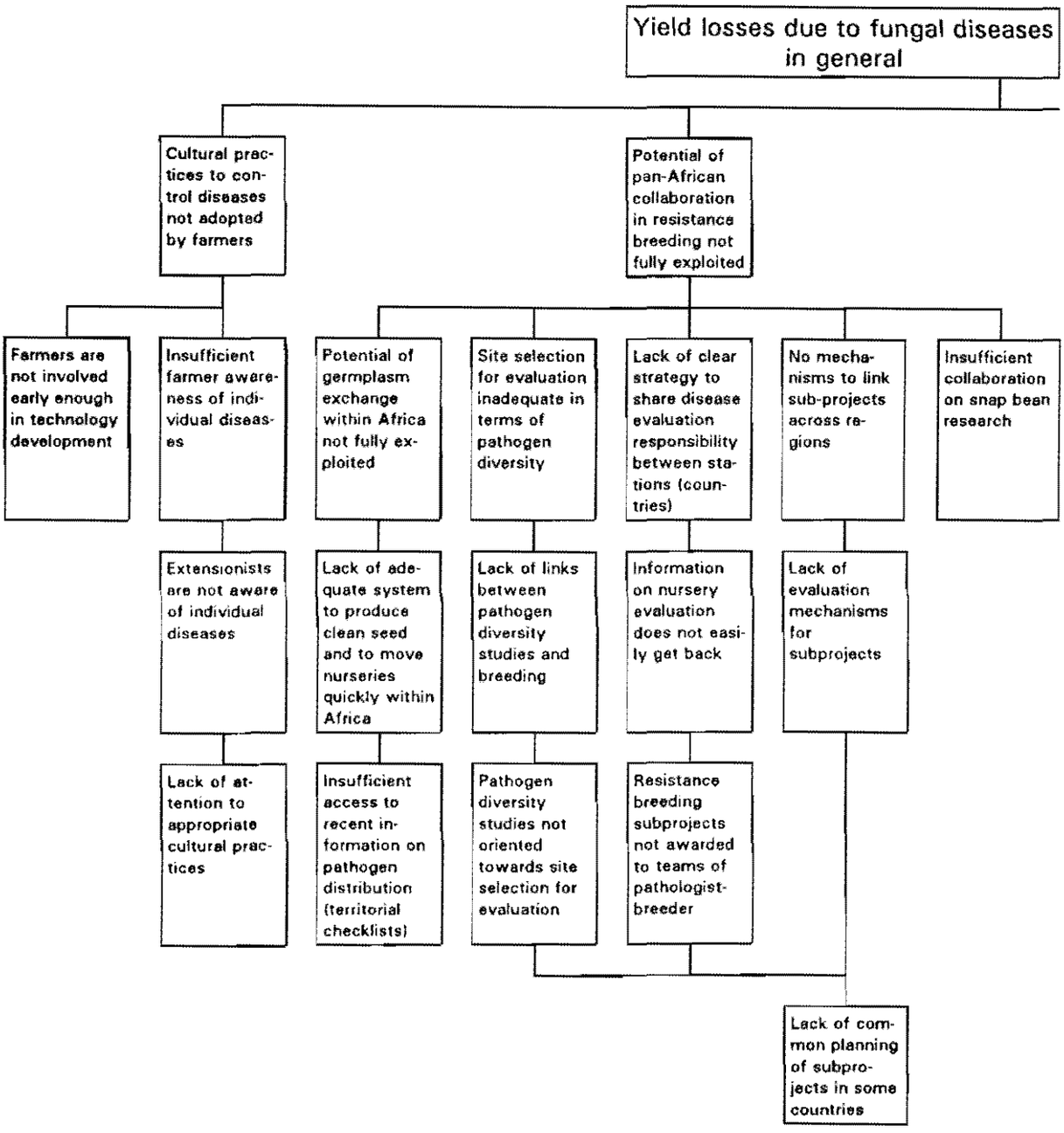
As an example of the logic of the problem analysis, the tree of general problems related to fungal diseases on beans in Africa is discussed here:

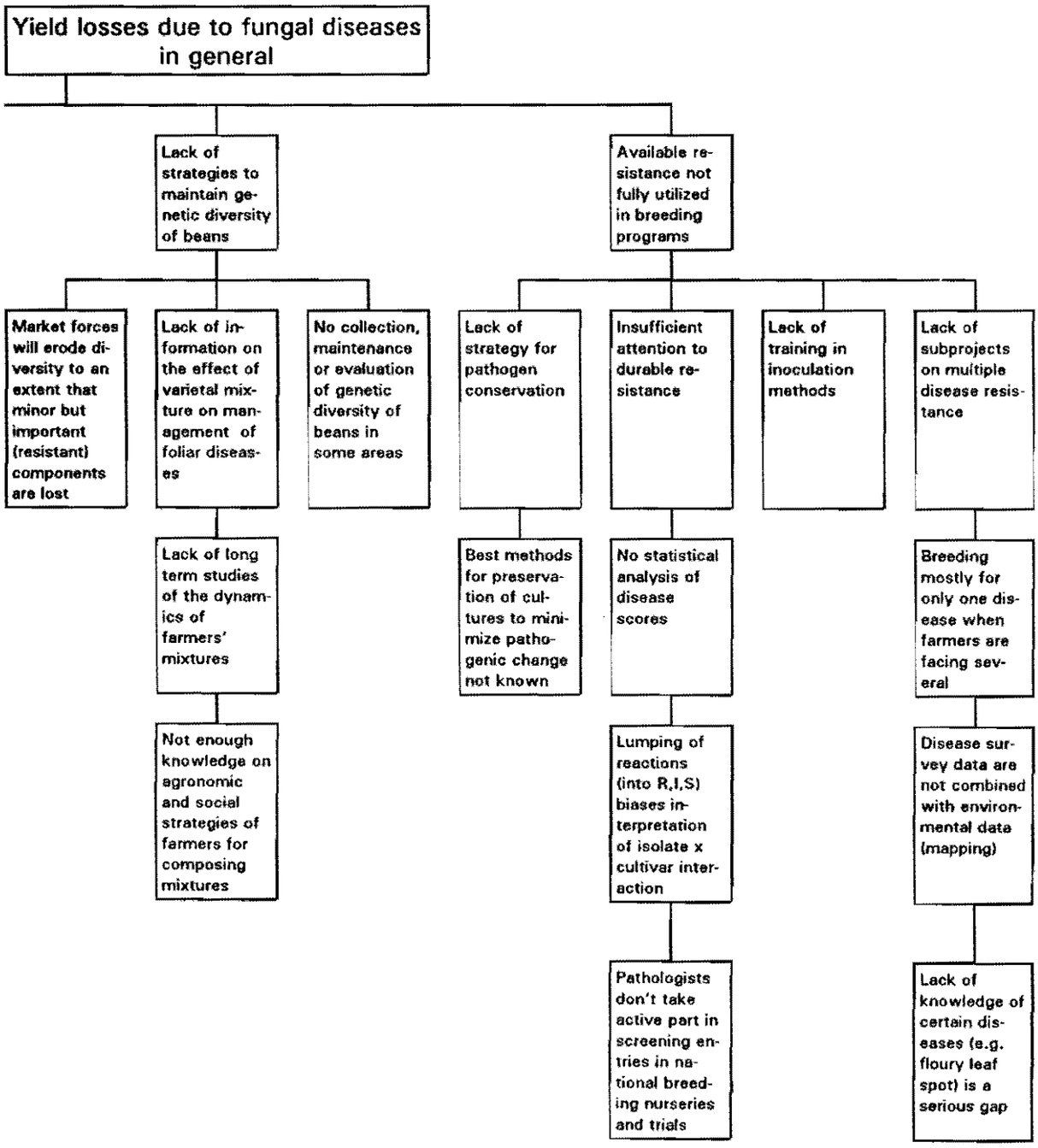
> The central problem was characterized as *Yield losses due to fungal diseases in general*. This was attributed to be due to four immediate causes:
>
> **Cultural practices:** Participants argued that *cultural practices to control diseases* are often *not adopted by farmers*. One reason is that *farmers are not involved early enough in technology development*, and therefore the technologies, although they may be effective, are not in accordance with the means and constraints that farmers face. Another reason is *insufficient farmer awareness of individual diseases* which goes together with *extensionists not being aware of individual diseases*, caused (at least partly) by a *lack of attention to appropriate cultural practices* by research. Since few cultural practices targeting specific diseases are developed, there is little benefit for both extensionists and farmers to distinguish between different diseases and also little opportunity to learn about them informally e.g. during on-farm trials.
>
> **Pan-Africa collaboration:** Presently, the *potential of pan-Africa collaboration in resistance breeding* is *not fully exploited*. First, *germplasm exchange within Africa* could be more active, if there was in place an *adequate system to produce clean seed and to move nurseries quickly within Africa*. The present system is partly hampered by *insufficient access to recent information on pathogen distribution (territorial checklists)*. Secondly, *sites for germplasm evaluation* are often *inadequate in terms of pathogen diversity*, because, even if information on pathogen diversity exists, it is not used efficiently by breeders, often because the underlying studies were *not oriented towards site selection for* disease *evaluation*. Thirdly, breeding for resistance could be more efficient, if there existed a *clear strategy to share disease evaluation responsibilities between* different *stations* ('hot spots'),

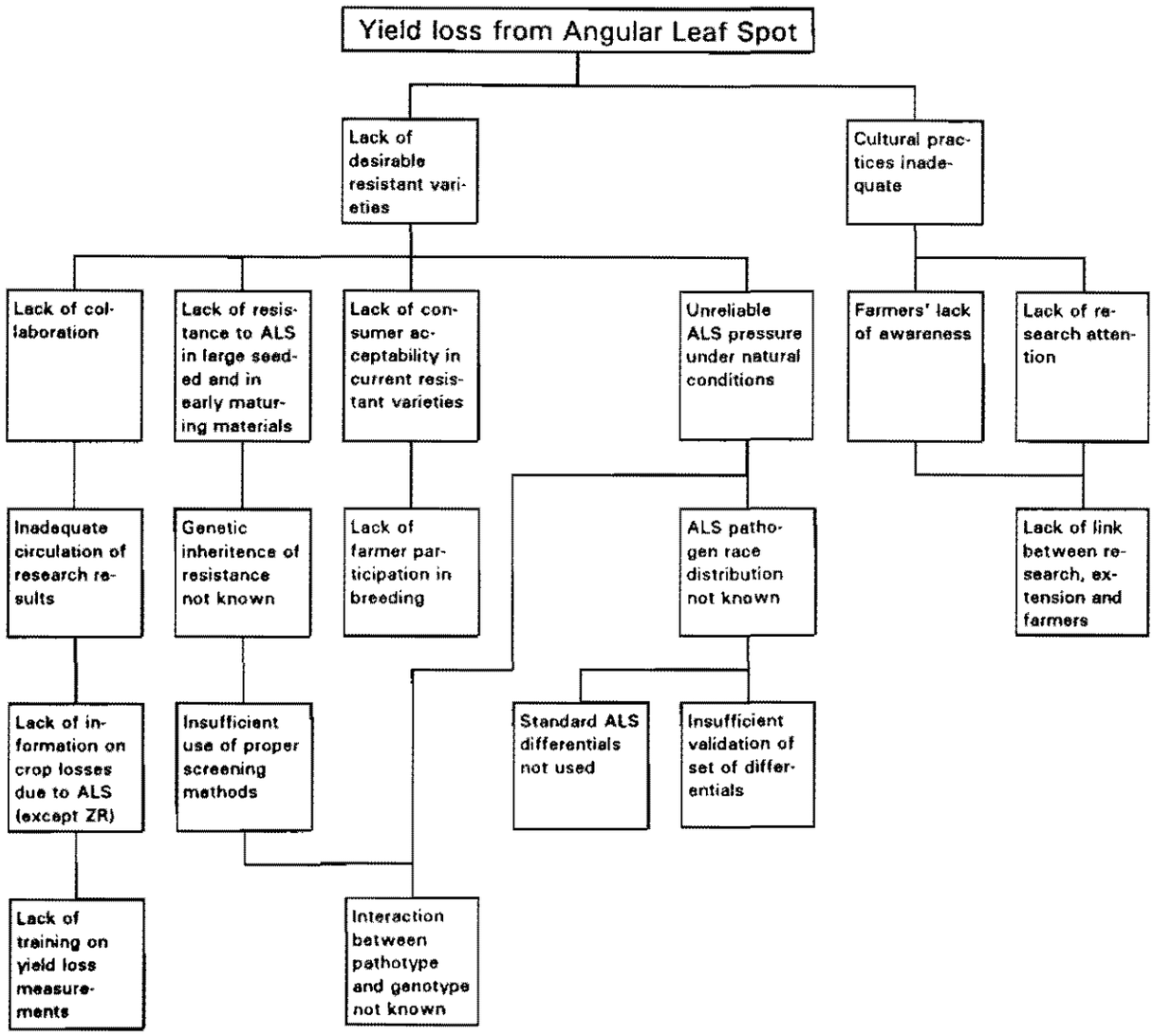
possibly in different countries; such sharing of responsibility is often discouraged, because *information on nursery evaluation does not easily get back* to the nursery coordinator, which may have to do with *resistance breeding sub-projects not* being *awarded to teams of pathologists-breeders.* Fourthly, there exist presently no formal *mechanisms to link sub-projects across regions* and they are not evaluated jointly, for which *common planning* would be a prerequisite (*lack of common planning in some countries* is also at the root of other problems). Finally, there is untapped opportunity for more *collaboration on snap bean research.*

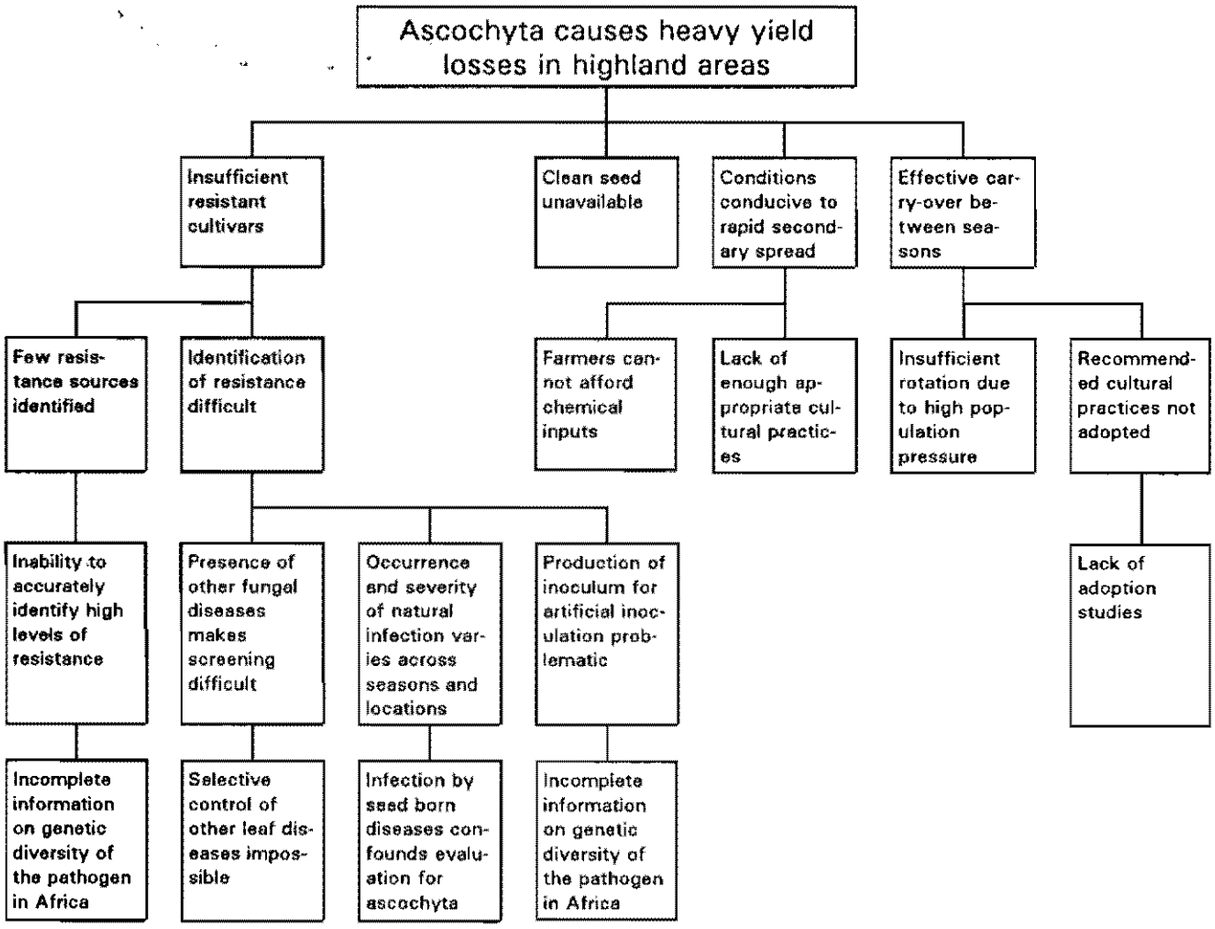
Genetic diversity: There is *lack of strategies to maintain genetic diversity of beans*, and genetic diversity is one of the main ways to reduce yield losses due to diseases. This is all the more preoccupying, considering that *market forces may erode diversity to an extent that minor but important (resistant) components* in varietal mixtures or on bean farms *are lost.* The lack of strategies for maintaining diversity is due to scarce *information on the effect of varietal mixtures on the management of foliar diseases*, no *long term studies of the dynamics of farmers' mixtures* exist and the *agronomic and social strategies of farmers for composing mixtures* are known only for some areas. Finally, *in some areas,* there exists *no collection, maintenance or evaluation of genetic diversity of beans.*

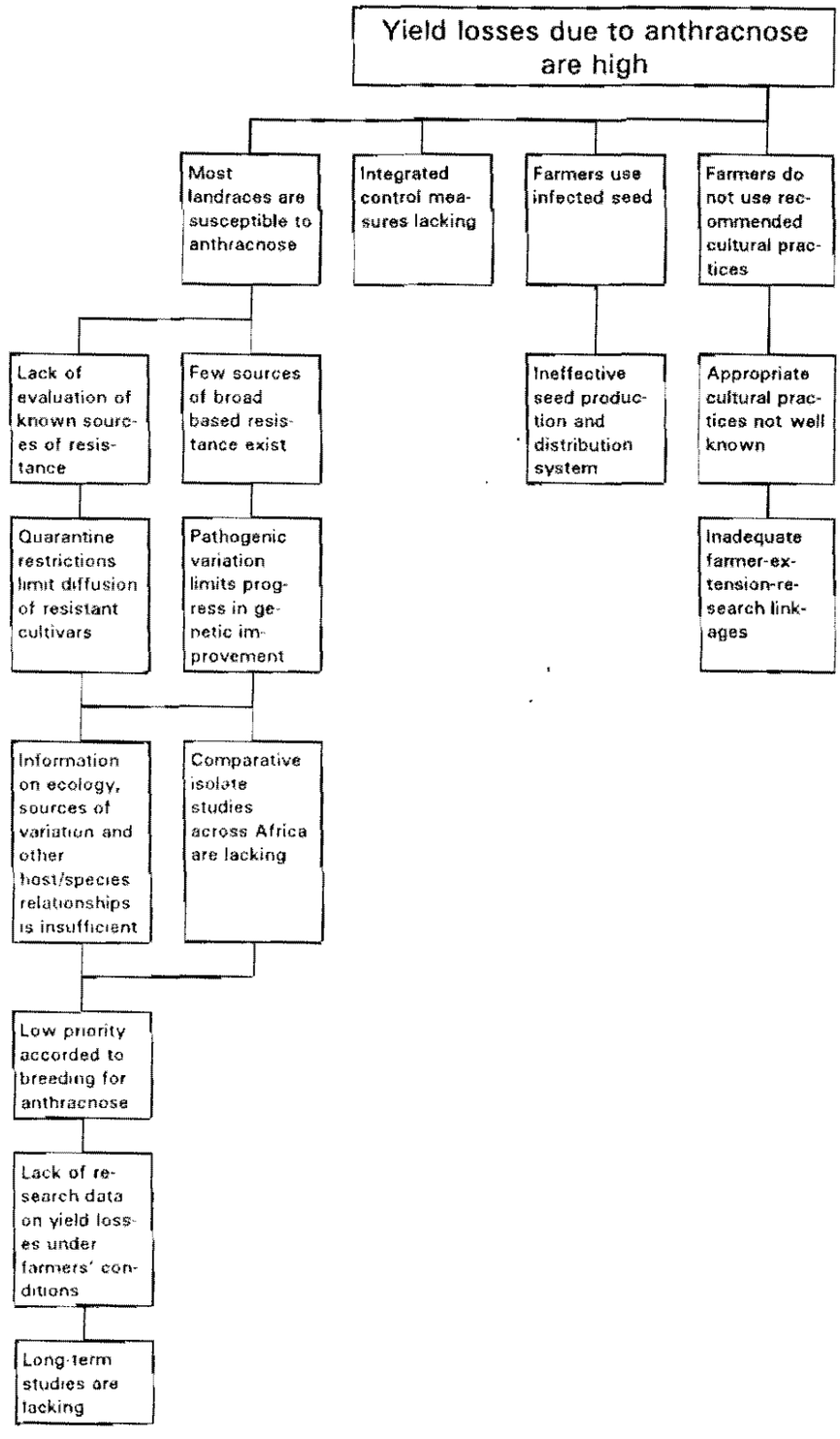
Utilization of available resistance: The *available resistance is not fully utilized in breeding programs.* First, breeding programs have difficulties to identify and verify resistance for lack of standard pathogen spectra because there exists no *strategy for pathogen conservation* as the *best methods for preservation of cultures to minimize pathogenic change are not known.* Secondly, *insufficient attention to durable resistance* is paid, as disease scores are not analyzed statistically but rather lumped together (into R,I,S) which *biases interpretation of isolate x cultivar interaction*; this is partly because *pathologists don't* always *take active part in screening entries in national breeding nurseries and trials.* Thirdly, the efficiency of breeding for resistance is limited by a *lack of training in inoculation methods.* Finally, only few *sub-projects on multiple disease resistance* have been developed, while *farmers are* often *facing several* diseases together; breeding for multiple disease resistance is often not possible because *disease survey data are not combined with environmental data* which would allow for *mapping* of important disease combinations (and the *lack of knowledge of certain diseases, e.g. floury leaf spot,* constitute *a serious gap* in research).

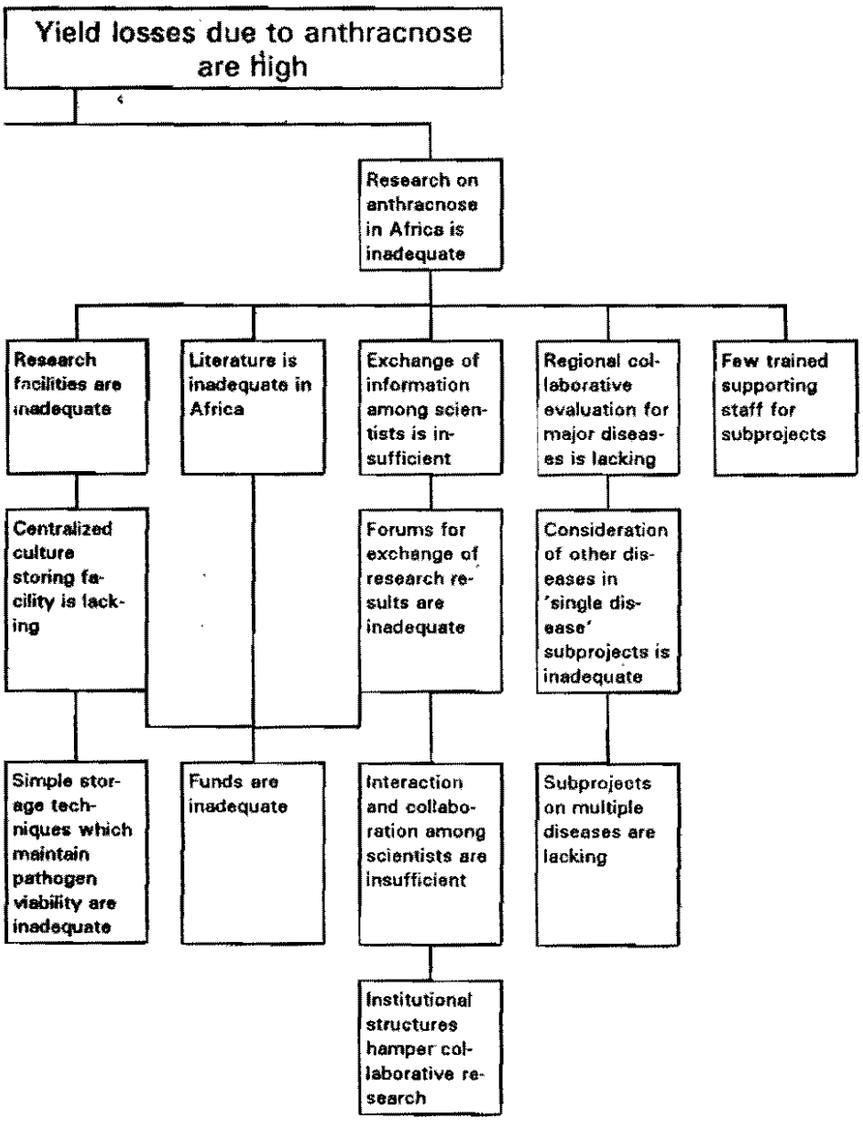

Yield losses due to fungal diseases in general
Cultural practices to control diseases not adopted by farmers
Potential of pan-African collaboration in resistance breeding not fully exploited
Farmers are not involved early enough in technology development
Insufficient farmer awareness of individual diseases
Potential of germplasm exchange within Africa not fully exploited
Site selection for evaluation inadequate in terms of pathogen diversity
Lack of clear strategy to share disease evaluation responsibility between stations (countries)
No mechanisms to link sub-projects across regions
Insufficient collaboration on snap bean research
Extensionists are not aware of individual diseases
Lack of adequate system to produce clean seed and to move nurseries quickly within Africa
Lack of links between pathogen diversity studies and breeding
Information on nursery evaluation does not easily get back
Lack of evaluation mechanisms for subprojects
Lack of attention to appropriate cultural practices
Insufficient access to recent information on pathogen distribution (territorial checklists)
Pathogen diversity studies not oriented towards site selection for evaluation
Resistance breeding subprojects not awarded to teams of pathologist-breeder
Lack of common planning of subprojects in some countries

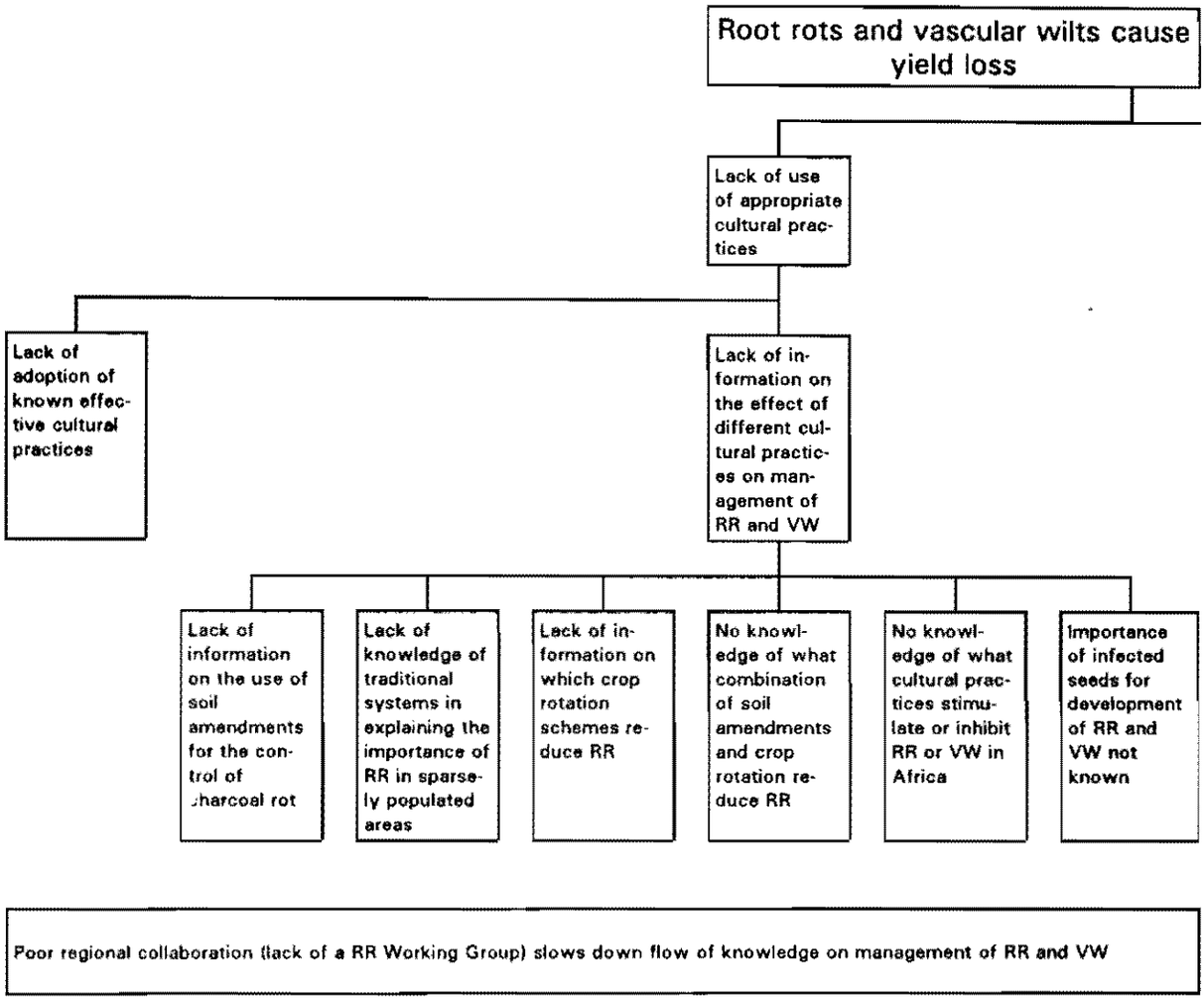

Yield losses due to fungal diseases in general
Lack of strategies to maintain genetic diversity of beans
Available resistance not fully utilized in breeding programs
Market forces will erode diversity to an extent that minor but important (resistant) components are lost
Lack of information on the effect of varietal mixture on management of foliar diseases
No collection, maintenance or evaluation of genetic diversity of beans in some areas
Lack of strategy for pathogen conservation
Insufficient attention to durable resistance
Lack of training in inoculation methods
Lack of subprojects on multiple disease resistance
Lack of long term studies of the dynamics of farmers' mixtures
Best methods for preservation of cultures to minimize pathogenic change not known
No statistical analysis of disease scores
Breeding mostly for only one disease when farmers are facing several
Not enough knowledge on agronomic and social strategies of farmers for composing mixtures
Lumping of reactions (into R,I,S) biases interpretation of isolate x cultivar interaction
Disease survey data are not combined with environmental data (mapping)
Pathologists don't take active part in screening entries in national breeding nurseries and trials
Lack of knowledge of certain diseases (e.g. floury leaf spot) is a serious gap

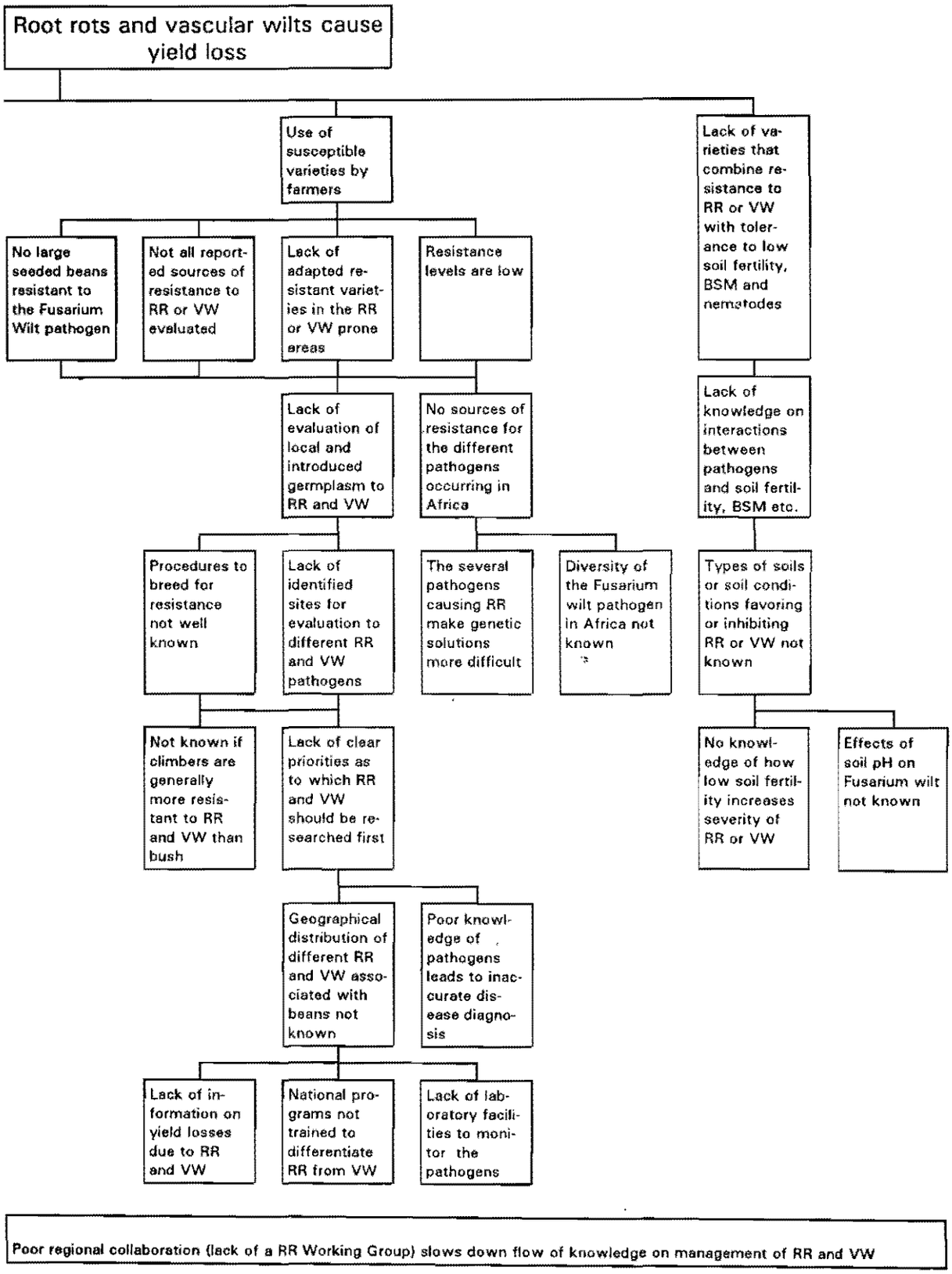

Yield loss from Angular Leaf Spot
Lack of desirable resistant varieties
Cultural practices inadequate
Lack of collaboration
Lack of resistance to ALS in large seeded and in early maturing materials
Lack of consumer acceptability in current resistant varieties
Unreliable ALS pressure under natural conditions
Farmers' lack of awareness
Lack of research attention
Inadequate circulation of research results
Genetic inheritence of resistance not known
Lack of farmer participation in breeding
ALS pathogen race distribution not known
Lack of link between research, extension and farmers
Lack of information on crop losses due to ALS (except ZR)
Insufficient use of proper screening methods
Standard ALS differentials not used
Insufficient validation of set of differentials
Lack of training on yield loss measurements
Interaction between pathotype and genotype not known

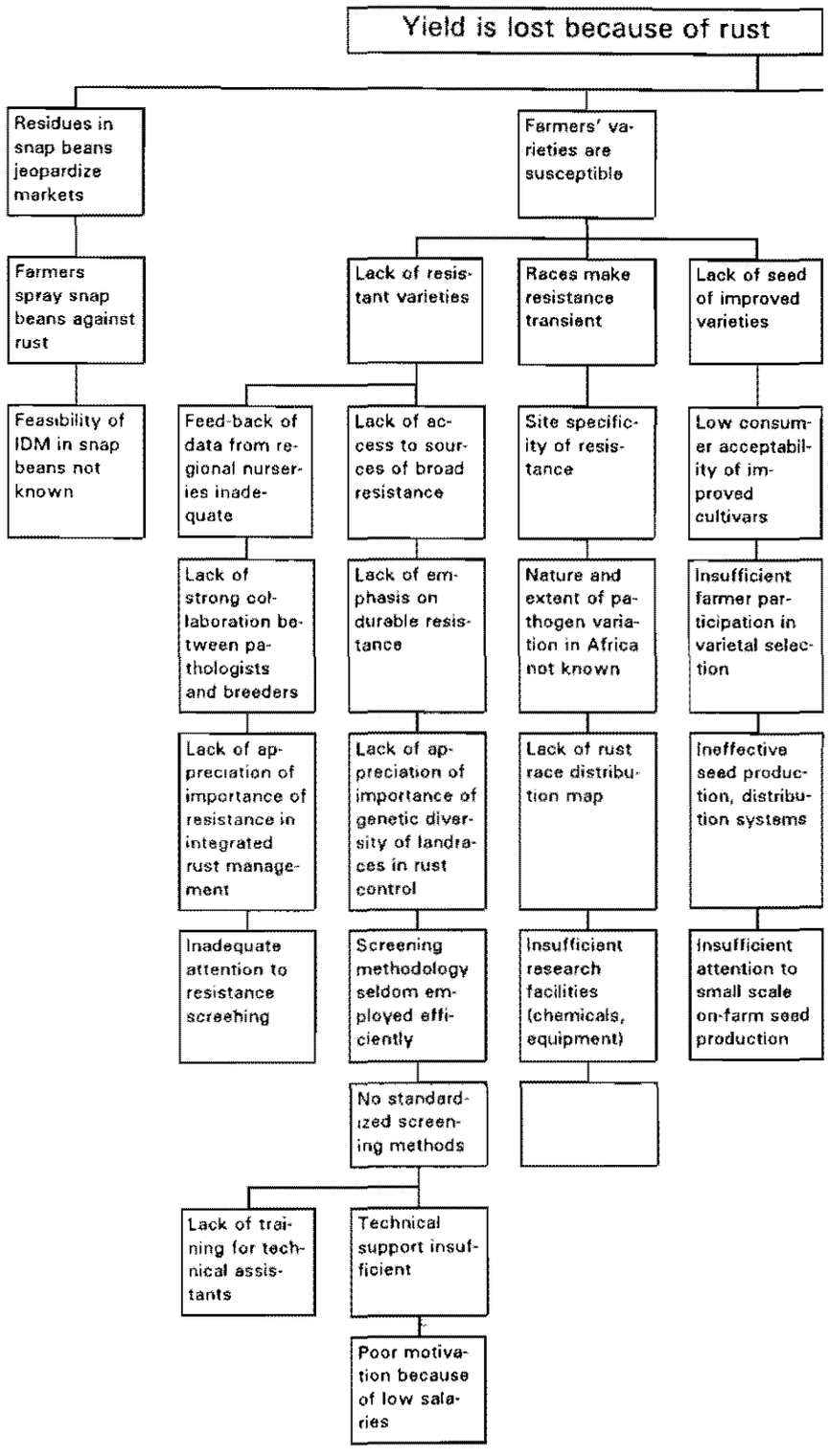

Ascochyta causes heavy yield losses in highland areas
Insufficient resistant cultivars
Clean seed unavailable
Conditions conducive to rapid secondary spread
Effective carry-over between seasons
Few resistance sources identified
Identification of resistance difficult
Farmers cannot afford chemical inputs
Lack of enough appropriate cultural practices
Insufficient rotation due to high population pressure
Recommended cultural practices not adopted
Inability to accurately identify high levels of resistance
Presence of other fungal diseases makes screening difficult
Occurrence and severity of natural infection varies across seasons and locations
Production of inoculum for artificial inoculation problematic
Lack of adoption studies
Incomplete information on genetic diversity of the pathogen in Africa
Selective control of other leaf diseases impossible
Infection by seed born diseases confounds evaluation for ascochyta
Incomplete information on genetic diversity of the pathogen in Africa

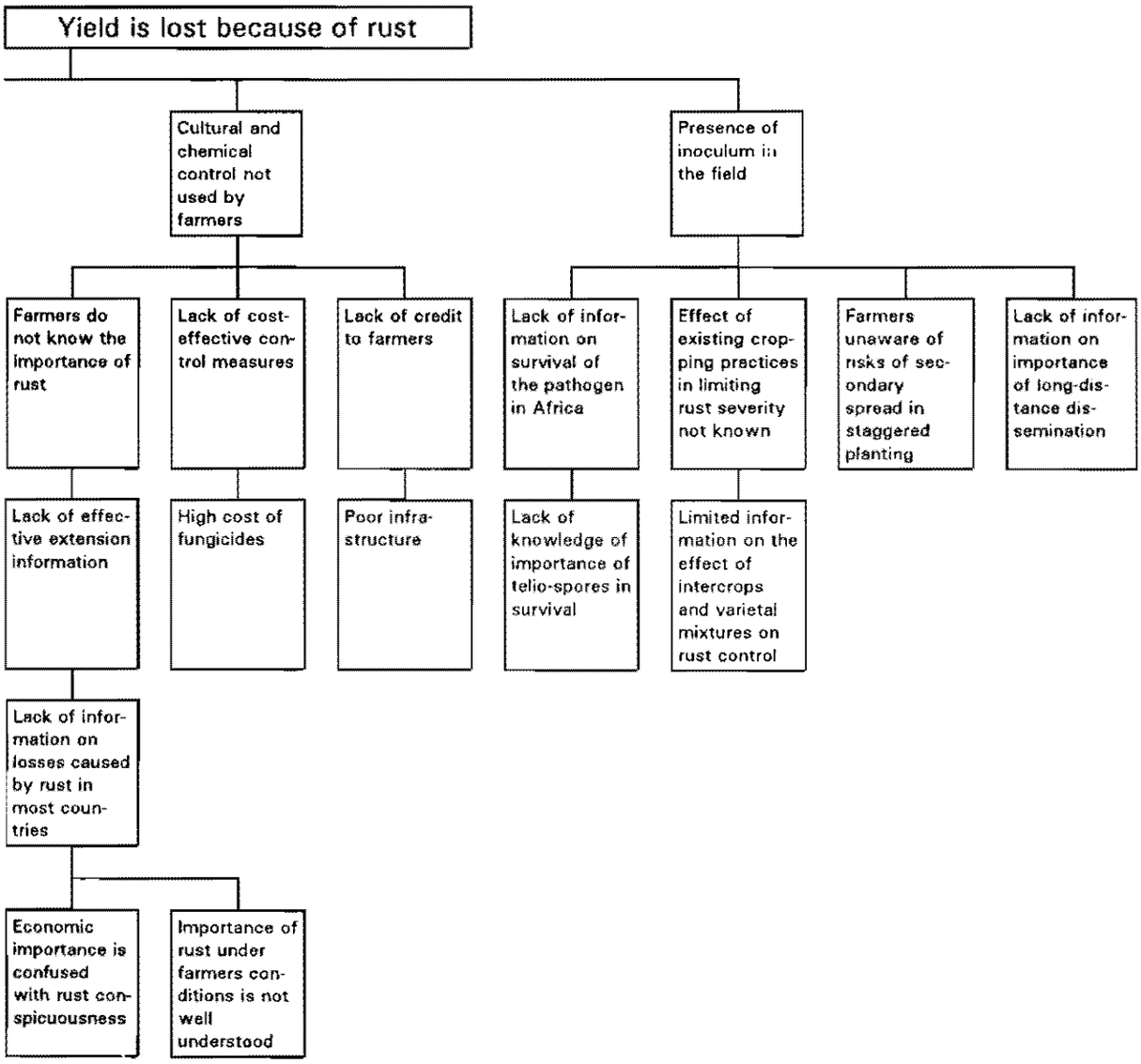

Yield losses due to anthracnose are high
Most landraces are susceptible to anthracnose
Integrated control measures lacking
Farmers use infected seed
Farmers do not use recommended cultural practices
Lack of evaluation of known sources of resistance
Few sources of broad based resistance exist
Ineffective seed production and distribution system
Appropriate cultural practices not well known
Quarantine restrictions limit diffusion of resistant cultivars
Pathogenic variation limits progress in genetic improvement
Inadequate farmer-extension-research linkages
Information on ecology, sources of variation and other host/species relationships is insufficient
Comparative isolate studies across Africa are lacking
Low priority accorded to breeding for anthracnose
Lack of research data on yield losses under farmers' conditions
Long-term studies are lacking


Yield losses due to anthracnose are high
Research on anthracnose in Africa is inadequate
Research facilities are inadequate
Literature is inadequate in Africa
Exchange of information among scientists is insufficient
Regional collaborative evaluation for major diseases is lacking
Few trained supporting staff for subprojects
Centralized culture storing facility is lacking
Forums for exchange of research results are inadequate
Consideration of other diseases in 'single disease' subprojects is inadequate
Simple storage techniques which maintain pathogen viability are inadequate
Funds are inadequate
Interaction and collaboration among scientists are insufficient
Subprojects on multiple diseases are lacking
Institutional structures hamper collaborative research


Root rots and vascular wilts cause yield loss
Lack of use of appropriate cultural practices
Lack of adoption of known effective cultural practices
Lack of information on the effect of different cultural practices on management of RR and VW
Lack of information on the use of soil amendments for the control of charcoal rot
Lack of knowledge of traditional systems in explaining the importance of RR in sparsely populated areas
Lack of information on which crop rotation schemes reduce RR
No knowledge of what combination of soil amendments and crop rotation reduce RR
No knowledge of what cultural practices stimulate or inhibit RR or VW in Africa
Importance of infected seeds for development of RR and VW not known
Poor regional collaboration (lack of a RR Working Group) slows down flow of knowledge on management of RR and VW


Root rots and vascular wilts cause yield loss
Use of susceptible varieties by farmers
Lack of varieties that combine resistance to RR or VW with tolerance to low soil fertility, BSM and nematodes
No large seeded beans resistant to the Fusarium Wilt pathogen
Not all reported sources of resistance to RR or VW evaluated
Lack of adapted resistant varieties in the RR or VW prone areas
Resistance levels are low
Lack of knowledge on interactions between pathogens and soil fertility, BSM etc.
Lack of evaluation of local and introduced germplasm to RR and VW
No sources of resistance for the different pathogens occurring in Africa
Procedures to breed for resistance not well known
Lack of identified sites for evaluation to different RR and VW pathogens
The several pathogens causing RR make genetic solutions more difficult
Diversity of the Fusarium wilt pathogen in Africa not known
Types of soils or soil conditions favoring or inhibiting RR or VW not known
Not known if climbers are generally more resistant to RR and VW than bush
Lack of clear priorities as to which RR and VW should be researched first
No knowledge of how low soil fertility increases severity of RR or VW
Effects of soil pH on Fusarium wilt not known
Geographical distribution of different RR and VW associated with beans not known
Poor knowledge of pathogens leads to inaccurate disease diagnosis
Lack of information on yield losses due to RR and VW
National programs not trained to differentiate RR from VW
Lack of laboratory facilities to monitor the pathogens
Poor regional collaboration (lack of a RR Working Group) slows down flow of knowledge on management of RR and VW


Yield is lost because of rust
Residues in snap beans jeopardize markets
Farmers spray snap beans against rust
Feasibility of IDM in snap beans not known
Farmers' varieties are susceptible
Lack of resistant varieties
Races make resistance transient
Lack of seed of improved varieties
Feed-back of data from regional nurseries inadequate
Lack of access to sources of broad resistance
Site specificity of resistance
Low consumer acceptability of improved cultivars
Lack of strong collaboration between pathologists and breeders
Lack of emphasis on durable resistance
Nature and extent of pathogen variation in Africa not known
Insufficient farmer participation in varietal selection
Lack of appreciation of importance of resistance in integrated rust management
Lack of appreciation of importance of genetic diversity of landraces in rust control
Lack of rust race distribution map
Ineffective seed production, distribution systems
Inadequate attention to resistance screening
Screening methodology seldom employed efficiently
Insufficient research facilities (chemicals, equipment)
Insufficient attention to small scale on-farm seed production
No standardized screening methods
Lack of training for technical assistants
Technical support insufficient
Poor motivation because of low salaries


Yield is lost because of rust
Cultural and chemical control not used by farmers
Presence of inoculum in the field
Farmers do not know the importance of rust
Lack of cost-effective control measures
Lack of credit to farmers
Lack of information on survival of the pathogen in Africa
Effect of existing cropping practices in limiting rust severity not known
Farmers unaware of risks of secondary spread in staggered planting
Lack of information on importance of long-distance dissemination
Lack of effective extension information
High cost of fungicides
Poor infrastructure
Lack of knowledge of importance of telio-spores in survival
Limited information on the effect of intercrops and varietal mixtures on rust control
Lack of information on losses caused by rust in most countries
Economic importance is confused with rust conspicuousness
Importance of rust under farmers conditions is not well understood

The results: Planning Matrices

On the following ten pages the planning matrices are presented. The heading of each table indicates the overall objective for the next five years. Activities are grouped under the intermediary result they are helping to achieve. For ease of later reference, results and activities are numbered.

Different groups assigned responsibilities for activities in slightly different ways: Some indicated just the country or institution which would take the lead, others listed all collaborators, with the leading country or institution underlined. Countries in parenthesis are those not represented at the workshop, from which no firm commitment could be obtained. "P" indicates the priority of the activity (1 = high, 3 = low). "T" indicates the time to be allocated to this activity by all researchers involved (in researcher-months).

To guide readers through the tables, we discuss here the first matrix as an example:

The overall objective is *to reduce yield losses due to fungal diseases in general.* As in the problem analysis, we can distinguish between four main axes of intervention, each leading to an intermediary result:

Cultural practices: *Appropriate cultural practices to control diseases*, meaning cultural technologies which will be adopted by farmers, may be *developed* through emphasis on several activities. Through *increasing* the *contacts of extension and research with farmers*, our understanding of what is acceptable to farmers will improve: Rwanda will take the lead in documenting how this may be done. CIAT will *distribute disease booklets to all extensionists*, which should lead to more accurate recommendations concerning disease control. *Sub-projects on cultural practices with farmers' involvement from the beginning* should lead researchers to work only on technologies which may be acceptable to farmers: extensionists are to be included in this research on which Zaire will take the lead. CIAT will *collect innovative research ideas on cultural control* of diseases and make them available to all National Programs (e.g. treatments with plant extracts). Such *known or potential cultural practices* are to be tested directly *in farmer's conditions* to ensure realistic scenarios.

Genetic diversity: A *Strategy to maintain or increase genetic diversity in beans* will be *elaborated*. One form of genetic diversity occurs in varietal mixtures, widely grown especially in the Great Lakes. Farmers are actively managing these mixtures and Rwanda will *initiate a 10-year study to assess changes in mixture components under farmer's management*. CIAT will conduct *studies on social and agronomic concepts for composing mixtures* (that is, *studies to determine farmers' criteria for composing their mixtures*) and verify these by means of *trials*. To understand both the biological principles for changes in proportions and the occurrence of new genotypes, Rwanda will *assess component change in mixtures with no human intervention, over 10 years*. Tanzania will take the lead in *assessing if mixtures reduce disease levels as compared to their components* grown in pure and will thus broaden on-going research in Zaire. To counteract market forces discouraging farmers from growing mixtures, Zaire will test *an advertising campaign in cities on*

the advantages of eating mixtures. CIAT will *stimulate further germplasm collection where national diversity is poorly represented in* existing *collections*. To give a better understanding and a baseline for all the activities tied to this result, CIAT should *assess* the *genetic diversity in Africa* in *qualitative* terms. Malawi will review efforts to *maintain* a *large number of breeding lines to maintain genetic diversity*, an activity already going on in several countries (Rwanda, Uganda and Zaire). Tanzania will concentrate on *breeding methods to maintain genetic diversity within seed classes*, i.e. within phenotypically similar grain classes.

Utilization of resistance: *Available resistance* can be *fully utilized* by undertaking a number of activities. The *application of available methods and*, where necessary, *development of best methods for short-term preservation of fungal cultures* will be stressed in Tanzania (coordinator), Zambia and Malawi; this should facilitate identification of resistance by proper artificial inoculation. For characterized race collections, NRI in England and INRA in France will help to identify a *third country for pathogen conservation in the long term*, thus minimizing the risk of loss of these valuable collections. CIAT will develop procedures likely to *encourage statistical analysis for advanced lines screening data (disease scores)*, which will allow for finer interpretation of these data. A similar effect is expected from efforts to *use disease reaction score (1-9) for isolate-cultivar studies. Development of varieties with durable resistance* will be specifically stressed by Malawi (leader), Zaire and Tanzania, who will monitor the efficiency of methods to reach this priority goal. Specific initiatives by Uganda (leader), Ethiopia, Kenya and Madagascar to *develop varieties with multiple resistance*, as well as the setting up by Ethiopia of a model to *encourage pathologist to take more active part in screening of national nurseries and trials* should lead to the development of varieties which combine resistance to all major diseases in a given zone. Zaire will provide (upon request) *training in inoculation methods and in the utilization of existing and new screening techniques*. Three countries, under the leadership of Uganda, will initiate *studies on floury leaf spot*, to start filling the knowledge gap on this disease.

***Pan-African collaboration** in resistance breeding* will be *fully exploited*. Thus, Kenya will *establish a network on snap beans* to allow other interested countries to benefit from its considerable expertise in this industry. CIAT will suggest to steering committees ways to streamline collaboration: *Pan-African fora for reporting on, and appraising progress of regional sub-projects*; procedures likely to *increase accountability of sub-project leadership, with research progress subject to regular peer review*; meetings to *improve sub-project planning through in-country and regional working groups*; a strategy to *strengthen inter-disciplinary links in conducting regional sub-projects*; and the organization of *national planning workshops to delineate responsibilities for screening against individual diseases at specified 'hot spots'*. Tanzania will work out a schedule to *improve National Program breeders' access to resistance sources* as well as a strategy to *encourage simultaneous evaluation of diseases*. It is proposed that Burundi *puts into practice the use of specified 'hot spots' for screening of regional or zonal nurseries on a Pan-African basis*, and that it *employs knowledge of race distribution (e.g. halo blight, BCMV) in selecting screening sites on a Pan-African basis*. Taking the example of some nurseries for which it was responsible, Ethiopia will document the value of *feed-back data in the development of improved resistant sources or varieties*; this should encourage researchers to report back their evaluations. To

make germplasm exchange within Africa both easier and safer: Tanzania will *develop an adequate system to produce clean seed and to move nurseries from one region to another*; Uganda will *document and publicize successes of germplasm exchange between countries in Africa*; and CIAT will *compile and update yearly a document on sources of resistance, compile a pan-Africa checklist on bean pathogens*, and (together with NRI) *establish disease distribution maps*.

Objective F: To reduce yield losses due to fungal diseases in general

Activity		Country/ institution	P
			P = Priority (1 = high, 3 = low)
Result F1: Appropriate cultural practices to control diseases developed			
F1.1	Increase extension/research contacts with farmers	RW	2
F1.2	Distribute disease booklets to all extensionists	CIAT	3
F1.3	SPs on cultural practices to have farmers' involvement from the beginning (including extension)	ZR	2
F1.4	Collect innovative research ideas for cultural control	CIAT	2
F1.5	Test known or potential cultural practices in farmer's conditions	ZR	1
Result F2: Strategy to maintain/increase genetic diversity in beans elaborated			
F2.1	Initiate a 10 year study to assess changes in mixture components under farmer's management	RW	1
F2.2	Studies on social and agronomic concepts for composing mixtures - verification by trials	CIAT	2
F2.3	Assess component change in mixture(s) with no human intervention, over 10 years	RW	2
F2.4	Assess if mixtures reduce disease levels as compared to their components	TZ,ZR	1
F2.5	Start an advertising campaign on the advantages of eating mixtures in cities	ZR	3
F2.6	Stimulate germplasm collection where national diversity is poorly represented in collections	CIAT	2
F2.7	Studies to determine farmers' criteria for composing their mixtures	CIAT	3
F2.8	Assess genetic diversity in Africa (qualitative)	CIAT	1
F2.9	Maintain large number of breeding lines to maintain genetic diversity	MW,RW,UG, ZR	2
F2.10	Develop breeding methods to maintain genetic diversity within seed class	TZ	3
Result F3: Available resistance fully utilized in breeding programs			
F3.1	Apply available methods and develop best methods for short-term preservation of fungal cultures	TZ,ZA,MW	3

Activity		Country/ institution	P
			P = Priority (1 = high, 3 = low)
F3.2	Choose a third country for pathogen conservation in the long term	NRI,FRANCE	2
F3.3	Encourage statistical analysis for advanced lines screening data (disease scores)	CIAT	2
F3.4	Develop varieties with durable resistance	MW,ZR,TZ	1
F3.5	Training in inoculation methods and in the utilization of existing and new screening techniques	ZR	3
F3.6	Develop varieties with multiple resistance	UG,ET,KE, MD	1
F3.7	Use disease reaction scores (1-9) and not only R,I,S for isolate-cultivar studies	CIAT	3
F3.8	Encourage pathologists to take more active part in screening national nurseries/trials	ET	1
F3.9	Initiate studies on FLS (floury leaf spot)	UG,MW,TZ	1
	Result F4: Pan-African collaboration in resistance breeding fully exploited		
F4.1	Establish a network on research in snap beans	KE	3
F4.2	Encourage Pan-African fora for reporting on, and appraising progress of regional sub-projects	CIAT	3
F4.3	Improve NP breeders' access to resistance sources	TZ	2
F4.4	Encourage simultaneous evaluation of diseases, additional to target pathogen in early generations	TZ	2
F4.5	Increase accountability of sub-project leadership with research progress, subject to regular peer review	CIAT	3
F4.6	Put into practice the use of specified 'hot spots' for screening of regional/zonal nurseries on Pan-African basis	(BU),KE	3
F4.7	Improve sub-project planning, in in-country workshops and regional working groups	CIAT	1
F4.8	Employ knowledge of race distribution (eg. HB, BCMV) in selecting screening sites on Pan-African basis	(BU)	2
F4.9	Enlighten scientists on the use of 'feed-back' data in development of improved resistant sources/varieties	ET	3
F4.10	Strengthen inter-disciplinary links in conducting regional sub-projects	CIAT	3
F4.11	Encourage national planning workshops to delineate responsibilities for screening against individual diseases at specified 'hot spots'	CIAT	3
F4.12	Development of adequate system to produce clean seed and to move nurseries from region to another	TZ	3

Activity		Country/ institution	P
P = Priority (1 = high, 3 = low)			
F4.13	Document and publicize successes of germplasm exchange between countries in Africa in development of new cultivars	UG	2
F4.14	Compile document "sources of resistances" updated each year	CIAT	1
F4.15	Compile a Pan-Africa checklist on bean pathogens	CIAT	2
F4.16	Establish disease distribution maps	CIAT/NRI	1

Objective I: To reduce yield losses from Angular Leaf Spot

Activity		Country/ institution	P	T
P = Priority (1 = high, 3 = low); T = Time of all researchers to allocate to activity (months)				
Result I1: Sufficient resistant varieties				
I1.1	Prompt exchange of research results among collaborators and colleagues	ALL	2	1
I1.2	Researchers/technicians be exposed to yield loss assessment techniques	CIAT	3	1
I1.3	Course on rustic and lab inoculation screening techniques	CIAT	3	1
I1.4	Conduct inheritance studies on ALS inheritance	ZR,MW,TZ	1	18
I1.5	Develop acceptable, large seeded, (early maturing) ALS resistant varieties	ZR,MW,UG, TZ,KE	1	100
I1.6	Farmer participation be encouraged	TZ	3	1
I1.7	Encourage breeding for specific ecological niche	MW	2	
I1.8	Use standard CIAT differentials for race determination	ALL	2	
I1.9	Collect and identify pathogenic variation	NRI,ZR,UG, KE,MW,TZ	1	36
I1.10	Produce a race distribution map	CIAT,NRI, ZR,MW,TZ	2	6
I1.11	Preserve representative isolates	NRI,ZR,MW	2	10
I1.12	Practice artificial inoculation in the fields	TZ	2	
I1.13	Identification and maintenance of host resistance genes	TZ	2	36
Result I2: Appropriate cultural practices developed				
I2.1	Identify appropriate cultural practices to reduce disease severity	ZR	2	30
I2.2	Strengthen research and extension linkage to educate farmers	TZ	2	5
I2.3	Intensify studies on mixtures to reduce ALS	ZR,TZ,MW, NRI	2	50

Objective C: To reduce yield losses due to anthracnose

Activity		Country/ institution	P	T
P = Priority (1 =high, 3 =low); T = Time of all researchers to allocate to activity (months)				
Result C1: Farmers grow anthracnose resistant varieties				
C1.1	Evaluate more germplasm and nurseries for resistance to anthracnose	TN,ZA,RW, ET,(BU,Z)	1	40
C1.2	Search for broad-based sources of resistance	TN,ZA,RW, ET,(BU,Z)	2	10
C1.3	Continue in-country studies of pathogenic variation	ZA,RW,ET, TN,(BU)	1	24
C1.4	Basic studies on pathogen ecology (monitor variation, study host/species relationship, thesis studies)	TN,(K)	3	40
C1.5	Initiate across-Africa study on pathogenic variation (identify third country eg. UK)	HRI/NRI	3	8
C1.6	National bean programs give higher priority to breeding for anthracnose resistance	TN,ZA	2	
C1.7	Continue yield loss studies under farmers' conditions for several seasons	ZA,RW,ET, TN	1	24
C1.8	Continue surveys for several seasons (or more)	ET	1	6
Result C2: Integrated control measures are available				
C2.1	Conduct studies on integrated control (cultural practices, resistance)	RW	1	10
Result C3: Farmers use clean seed				
C3.1	Encourage farmers to select clean plants for clean seed	ZA	1	12
C3.2	Develop and promote on-farm selection of clean seed	TZ	1	12
C3.3	Develop local, effective clean seed production and distribution systems		3	6
Result C4: Farmers use recommended cultural practices				
C4.1	Document and study appropriate cultural practices: Varietal mixtures, inter-cropping, mixed cropping, agronomic practices	RW	2	40
Result C5: Research on anthracnose in Africa is adequate				
C5.1	Study and apply available simple storage techniques to maintain pathogen viability (short-term)	TZ	2	4
C5.2	Select third-country long-term storage facilities for cultures (long-term)	NRI/HRI	3	2
C5.2	Create an African bean researchers newsletter for exchange of information	CIAT	3	5
C5.3	Improve inter-regional exchange of literature: Scientific literature, annual reports	CIAT	3	

Activity		Country/ institution	P	T
P = Priority (1 = high, 3 = low); T = Time of all researchers to allocate to activity (months)				
R4.6	Establish sites for evaluating germplasm to different RR and VW pathogens	KE,RW,BU, ZR,SD	2	1
R4.7	Evaluate on-farm, selected resistant sources for direct use by farmers	RW,ZR,BU, KE	3	5
Result R5: Varieties combining resistance to RR or VW with tolerance to poor soil fertility and bean stem maggot available				
R5.1	Conduct multi-factor experiments to determine interactions between soil fertility, BSM, VW, RR and MACRO	RW,BU,TZ	2	9
Result R6: For all above				
R6.1	Training in diagnosis and research methodologies in RR and VW research	RW,KE,SD, ZR,MD,ZA,	3	5
R6.2	Development of a regional collaborative system at Pan-African level	SD	3	

Objective U: To reduce losses due to rust below the level of economic importance

Activity		Country/ institution	P	T
P = Priority (1 = high, 3 = low); T = Time of all researchers to allocate to activity (months)				
Result U1: Decreased reliance on pesticides in snap bean production				
U1.1	Obtain and appraise information on IPM on snap beans in Latin America	KE	3	2
U1.2	Screen tropically adapted snap bean cultivars for rust resistance	KE,MW	2	3
U1.3	Develop minimum spray schedule	KE,MW	3	4
U1.4	Study rust epidemiology in snap beans as an aid to developing minimum spray schedule	KE,MW	2	10
Result U2: Use of cost effective control measures (food beans)				
U2.1	Determine yield losses on farmers' fields to establish economic threshold	ET,UG,MD, KE,M	1	25
U2.2	Assemble existing information on crop loss to develop models for prediction	ET	2	6
U2.3	Produce extension leaflets	ET,MD,TZ, UG,KE (MR)	3	5
Result U3: Farmers use resistant varieties				
U3.1	Develop rust resistant cultivars following evaluation of known sources of broad resistance, as are available through the EARRN/IBRN	ET,UG,MD, (MR),(KE), TZ,ZR,MW	1	3

Activity		Country/ institution	P	T
P = Priority (1 = high, 3 = low); T = Time of all researchers to allocate to activity (months)				
U3.2	Determine rust race structure as a base to monitor population shifts with time	NRI,ET,UG, MD,KE	1	20
U3.3	Devise means of improving the durability of rust resistance through adding components to farmers' mixtures/landraces	NRI,ET,ZR	2	24
U3.4	Strengthen EA sub-project to improve data exchange, and to expand network of test sites on a more Pan-African basis	ET,UG,KE, TZ,MD,MR, CIAT	2	5
U3.5	Run training courses for technicians on screening methodology	CIAT,ET,KE MD,UG,ZR	2	5
U3.6	Improve the durability of resistance by gene deployment based on a knowledge of race distribution	KE,ET,UG, MD,TZ,MR	3	12
U3.7	Assemble other sources of proven rust resistance and evaluate them as entries in EARRN/PADN	ET	3	6
Result U4: Decrease field inoculum				
U4.1	Quantify the productive effects of varietal mixtures and cereal intercrops	NRI,ET,TZ, MD,UG	1	50
U4.2	Determine the source of initial inoculum: carry-over and off-season spread	KE,ET,UG, MD	2	20
U4.3	Develop effective IDM for rust management (compile components and analyze)	ET,UG,KE, TZ,MD,MR	2	2
Result U5: For all above				
U5.1	Encourage farmer participation in varietal selection (not rust alone)			
U5.2	Encourage the development of small scale on-farm seed production (not confined to rust)			

Summary of Working Group Sessions

Robin A. Buruchara

Relative Importance of Bean Diseases in Africa

Given the limited available resources, it is regarded essential to prioritize both diseases and aspects that are considered themes for research. This was the basis of an exercise by participants during the working group sessions to obtain a picture of the relative importance of bean diseases both at national, regional and pan-Africa levels (Table 1).

Table 1: Importance of diseases in terms of total yield loss they cause per country (ranking, 1 = cause highest yield loss)

Country	Bean Disease														
	Angular leaf spot	Anthracnose	Ascochyta	Bean Common Mosaic Virus	Common Bacterial Blight	Cowpea Mild Mottle Virus	Floury leaf spot	Halo blight	Root rots	Fusarium wilt	Macrophomina	Rust	Scab	Web blight	White mold
Kenya	3	5	11	1	4	15	13	2	9	7	6	8	12	14	10
Uganda	3	6	8	2	1		5	6	9	9	9	4		12	
Ethiopia	4	1	6	7	3	13	5	9	10	10	10	2	12	8	11
Sudan				5		1			3	4	2				
Madagascar	4	2	5	8	9	7	6	8	3	3	3	1	9	9	9
Mean SA	4	1	11	2	5	12	10	9	8	7	6	2	15	13	14
Tanzania	1	2	4	9	7		6	5	10	10	10	3	11	12	8
Malawi	1	7	11	8	2	8	6	5	12	12	12	3	10	4	
Zambia	2	1	8	4	7	-	10		5		9	3	6	11	
Mean EA	1	3	7	5	4	14	6	9	10	15	7	2	10	10	13
Rwanda	3	2	4	5	6	-	7	9	1	1	-	8	-	-	-
Zaire	1	2	5	9	3		8	10	4	11		6		7	
Mean GL	1	1	4	7	4	12	9	10	3	6	12	7	12	11	12
Overall mean	1	2	7	5	4	13	8	9	6	11	10	3	14	12	15

Participants from the 10 countries represented ranked bean diseases occurring in their countries in order of their importance. This was based on frequency of occurrence and estimated effects of the diseases on yield. Data on yield loss due to bean diseases in most of the countries is scanty and need to be generated to confirm the picture obtained and maintain current research priorities or re-prioritize them in the future. Table 1 shows the ranking of bean diseases (fungal, bacterial and viral) for each country represented. Rank 1 means disease most important, highest value signifies least important. Means were calculated for each disease on a network and pan-African basis (after correction of shared ranks). It is evident that certain diseases are important nationally while others have regional and pan-African importance.

Below is a summary of some of the salient issues brought out in the working group sessions. The reader is however referred to the preceding text (page 95 to 119) reporting on deliberations of the working group sessions for details.

Problem Analysis

Some of the problems associated with bean diseases and research on the latter identified during the meeting are:

1) Despite some efforts that have been made to develop bean disease management technologies, certain diseases continue to be a problem to the farmer. This is thought to be due to the fact that:

   - Farmers continue to use local landraces (in pure or mixtures) which are susceptible.
   - Some of the technologies tested and found (or known) to be effective against certain diseases have not been widely adopted by farmers.

2) There are not sufficient disease management technologies (resistant varieties, cultural methods etc.) which are also acceptable to the farmer.

3) There is a lack of information in certain areas or aspects (e.g. pathogenic variation, effects of certain control measures etc.) essential in developing effective disease control technologies.

4) Links between research, extension and the farmer to facilitate diffusion and adoption of disease management technologies are inadequate; farmers are not involved early enough in development of disease control technologies.

5) National, regional and interdisciplinary collaboration among researchers on research on bean diseases is inadequate.

6) Research funds and facilities in national research programmes are inadequate.

7) There is a lack of adequate training for various players involved in the development and transfer of disease management technologies.

Planning of Activities

To address the above problems, several specific activities were proposed which may be grouped in the following broad areas:

1) Emphasis in developing genetic solutions in disease management should be continued and where effective, other control methods such as cultural methods should be integrated.

2) Gaps in knowledge which limit effectiveness, deployment and full exploitation of genetic, cultural or integrated solutions (e.g. pathogenic variation, appropriate testing methodologies and sites, seed, genetic diversity, mixtures etc.) should be addressed.

3) Factors which limit farmer-adoption of technologies developed to control bean diseases should be identified.

4) Farmer participation in development and early testing of disease management technologies should be encouraged.

5) A collaboration framework in research (including exchange of information, training, division of research responsibilities at regional and pan-African level etc.) was proposed.