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PROJECT IP-2

Meeting Demand for Beans in Sub-Saharan Africa in Sustainable Ways

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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PROJECT: IP-2

Title: Meeting Demand for Beans in Sub-Saharan Africa in Sustainable Ways

Objectives: To improve bean productivity in Sub-Saharan Africa by deploying gene pools that help solve major production constraints and by supporting networks of NARS for applied research.

Outputs: Enhanced productivity of farms on which beans are an important component. Intermediate goods include improved classification of bean environments. Gene pools with multiple stress resistance. Ecologically sound crop, soil and pest management practices. Closer farmer participation. Nonformal methods of seed production and distribution.

Gains: Varieties resistant to multiple stresses will occupy about 200,000 hectares (5% of the bean production area) in network countries. Farmers growing the new varieties will see a 10% increase in their income from marketing of beans. Five percent of farmers in the region will have adopted improved crop management practices. Regional networks will be fully devolved to local management, with CIAT participating as a research partner.

Milestones:

1998 Pan-Africa network integrates bean research of subregional NARS associations. Climbing beans widely adopted in Kenya and at least one other country.

1999 Lines resistant to bean fly available; multiple disease resistance developed.

2000 Farmers starting to adopt new agronomic practices, including erosion control measures and use of green manures.

Users: Small-scale farmers (mainly women) in both marginal and favorable production areas in central, eastern and southern Africa. Small-scale seed producers in countries that lack an effective formal seed sector for beans. Consumers in African urban areas dependent upon beans as an inexpensive source of protein. Multi-institutional national programs in these regions as users of germplasm and improved research methods.

Collaborators: *Reviewing priorities:* Steering committees of regional networks and of the Pan-Africa Bean Research Alliance (PABRA). *Development of improved germplasm:* NARS, and farmers for FPR. *Improvement in soil, pest and disease management:* ICRAF, CIMMYT, IITA, CIP, TSBF and national partners in the African Highlands Initiative (AHI). *Training in breeding and IPM:* Bean/Cowpea CRSP and ICIPE. *Diffusion of new technology:* NGOs, churches, relief and government agencies, entrepreneurs, universities in the Netherlands, Switzerland, UK and USA, and DFID (UK).

CG system linkages: Breeding (50%), Crop Production Systems (20%), Protecting the Environment (10%), Training (10%), Networks (10%). Participates in the African Highlands Initiative.

CIAT Project linkages: Provision of germplasm and training for resistances to multiple constraints (IP-1). Genetic markers and characterization of African germplasm (SB-2) and gene bank materials and databases (SB-1). Collaboration in methods development and case studies (PE-1, PE-5, SN-3, BP-1). Exchange of information on regional networks (SN-2).

Project IP-2:

Title: Meeting Demand for Beans in Sub-Saharan Africa in Sustainable Ways

Project Objective:

To increase the productivity and commercialization of common bean through adoption of sustainable production technologies developed in close collaboration with national research institutions and farmers

1. Stronger networks in Africa linking NARS, IARCs, NGOs and the private sector	2. Germplasm with relevant traits developed and used widely in Africa	3. More sustainable production systems with beans developed with small farmers	4. Higher rates of technology adoption achieved
1.1 Develop new partnerships within regional networks, forging alliances with strong NARS and directly with small-scale and female farmers to address strategic research needs in generating germplasm for Africa	2.1 Use information on bean-growing environments to target more precisely germplasm that would help alleviate poverty, especially among rural women	3.1 In collaboration with NARS, farmers, and other IARCs, develop and test sustainable crop and soil management practices	4.1 Document local technology diffusion systems and develop innovative seed systems to increase adoption of new varieties, especially by women
1.2 PABRA network members coordinate activities across regions and take greater responsibility for managing regional strategies and projects	2.2 Introduce and generate improved germplasm to address principal African production constraints	3.2 Develop IPM components and strategies to reduce crop losses from pests and diseases in major production systems	4.2 Promote crop and pest management options in collaboration with local partners and farmers
1.3 Provide technical support and participate in network training events, information and germplasm exchange, and planning meetings	2.3 Design and evaluate cost-effective innovative methods for variety development, including participatory plant breeding	3.3 Design more efficient methods for systems improvement, including modelling and community-based participation (that involves females)	4.3 Develop improved methods for documenting social and environmental impacts
1.4 Assist NARS and regional associations in designing more efficient modes of managing networks	2.4 Distribute improved germplasm to network participants	3.4 Strengthen inter-center and ecoregional linkages in systems improvements, including AHI	4.4 Measure adoption and social, economic and environmental impact of bean research and technologies
1.5 Refine the characterization of bean growing environments by using biophysical and socio-economic data	2.5 Enhance NARS' capacity to effectively use new sources of germplasm in their variety development programs		4.5 Propose policy reforms that facilitate technology adoption in collaboration with regional and international organizations
			4.6 Investigate and publicize new market opportunities and products

Project Logframe

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Critical Assumptions
Program goal: Enhanced productivity of farms on which beans are an important component, leading to improved livelihoods especially for the poor and for women farmers.	Family production, income distribution and nutrition in important bean growing areas.	National and regional statistics	Peace, stability and a favorable economical environment
Project Purpose: To increase the productivity and commercialization of common bean through adoption of sustainable production technologies developed in close collaboration with national research institutions and farmers	Regional networks fully devolved to local management, with CIAT participating as a research partner. Varieties resistant to multiple stresses occupying about 200,000 hectares (7% area). Farmers growing new varieties see a 10% increase in income from marketing of beans. Farmers in the region starting to adopt ecologically sustainable practices.	End-of-project and Evaluation reports	Regional bodies and national governments continue to give priority to bean.
Outputs: 1. Stronger networks in Africa linking NARS, IARCs, NGOs and the private sector. 2. Germplasm with relevant traits developed and used widely in Africa. 3. Sustainable bean production systems. 4. Technology adopted.	1. Pan-Africa network integrates bean research of subregional NARS associations by 1998. 2. Lines with multiple disease resistance and resistance to stem maggot available by 1999. 3. Participatory research practiced at sites in key countries by 1999, and options for crop/pest/soil management available by 1999. 4. Climbing beans widely adopted in Kenya and at least one other country by 1998. Poor people including women in at least four major bean producing countries accessing new varieties rapidly through sustainable low-cost seed systems, and improved crop management practices adopted by 5% of farmers, by 2001.	Annual reports of PABRA, ECABREN & SABRN. Network and national program reports. Network and national program reports. Adoption survey reports.	Regional bodies and national governments continue to give priority to bean. Networks bring in non-traditional partners. Sources of resistance exist and adequate germplasm support received from Project IP-1. Adequate methods interaction with NRM projects.
Inputs: Personnel. Research and travel funds. Computers and screenhouse.	1. FTE each in Systems Agronomy, Social Science, Pathology, Entomology, Coordination; 2. FTE in Breeding.	Progress reports.	Two regional networks are also fully funded.

Highlights in 1998

OUTPUT 1. Stronger networks in Africa linking NARS, IARCs, NGOs and private sector

The ECABREN network adjusted its strategy from production driven research to market oriented research, while the SABRN network implemented a modest increase in emphasis to crop management and impact assessment that its members agreed last year. Through the PABRA pan-Africa network, we largely achieved the 1998 milestone of integrating bean research of the sub-regional NARS associations -- e.g. shared agreements for research on tolerance to water deficits and to low fertility soils, and for more attention to participatory development of integrated management for soilborne pathogens.

A regional resource person successfully assisted the startup of a ninth participatory research (PR) site in a new country. This strategy aims to sustain support to PR despite a dearth of skills in NARS. With network partners, strategic research by contract within the region was initiated for the development of laboratory techniques and regional bean breeding.

An Atlas for Common Bean Production in Africa is ready for publication to improve access to information on bean in Africa. In other GIS work, agro-ecosystems in Uganda were better defined and bean production areas in Ethiopia better characterized. Household typologies were developed in Uganda for predicting technological impact and adoption behavior and trends.

OUTPUT 2: Germplasm with relevant traits developed and used widely in Africa

New areas in which bean root rot is expected to become a serious problem in the near future were predicted using a recently developed model and the bean database for Africa. NARS were encouraged to evaluate a first regional root rot nursery that was distributed this year, and some encouraging resistance was confirmed. Bean root characteristics were associated with resistance.

Using a mixture of race isolates of *P. griseola*, the causal agent of angular leaf spot (ALS), several lines were identified as resistant, and resistance in Malawi was confirmed in two additional large-seeded Andean genotypes from CIAT.

We are making excellent progress towards the 1999 milestone of developing multiple disease resistance. Several hundred progenies and lines were selected from segregating populations and, in addition to this output for dry beans, five lines of snap bean were identified with superior resistance to rust, ALS and CBB. However, greenhouse studies confirmed that isolates of CBB from Uganda could induce intermediate and susceptible reactions on CIAT's VAX1 and VAX2 lines, which are highly resistant in Latin America.

In further screening for adaptation in low soil fertility conditions, several lines performed better than previously identified tolerant materials, one of which is expected to be released as a Malawi variety. Low P tolerance was most related to efficiency in acquisition; however, some genotypes rely on utilization efficiency which breeders might combine with acquisition efficiency.

The first bred lines for bean stem maggot resistance were distributed to NARS. Breeders in South Africa and Tanzania initiated crosses to transfer resistance to local materials, and Africa's first two releases for stem maggot resistance were made by Ethiopia. Accomplishing the 1999 milestone of making available resistant lines is already largely achieved.

OUTPUT 3: Sustainable bean production systems

Two years of practical, community-based participatory research in five countries have greatly improved appreciation for farmers' diagnosis, technology testing and evaluation processes. While testing of crop varieties was most farmers' initial emphasis, their interest in a wider range of interventions (forages, implements) has grown with confidence in their research collaborators. In a case of IPM, better knowledge of pest biology helped farmers to develop simple management strategies, and cost-effective research on soil fertility management was achieved through judicious use of alternative research approaches with varying levels of participation.

Results from component technology development this year included: the improvement of highland fallows in Uganda with *Tephrosia vogellii*, which also controlled root rats; delayed N application that favored bean productivity and N_2 fixation without reducing yield of the maize-bean intercrop; and the beneficial effect of climbing bean upon productivity of the subsequent crop. Farmer experimentation also showed the feasibility of erosion control using Vetiver grass.

OUTPUT 4: Technology adopted

Supporting national research partners and their collaborators to achieve farm- and household-level impact is the basic expectation both of our collaborators in Africa and of the main donors to Project IP2. Climbing beans are now widely adopted in highland areas of Kenya and Uganda, and have continued to grow in popularity in Congo and Rwanda; this milestone for 1998 has been achieved. New high-yielding bush bean varieties also reached wide adoption, including local market penetration, in Tanzania, Uganda and Ethiopia. The adoption of one variety in Tanzania is expected to save farmers there 10 per cent of annual fuelwood consumption, while the new Ugandan varieties were found to have improved food security and lessens women's work.

In developing sustainable low-cost seed systems that enable poor people including women to access new varieties rapidly (achieving this in at least four major bean producing countries is a milestone for 2001), the Malawi Bean Program being seen as something of a model by many countries. Smallholder farmers having valley bottom land for dry season production successfully produced good quality seed, which was sold through grocery stores, extension staff and NGOs following an aggressive advertising campaign. In Uganda, tephrosia seed started to be sold through shops for control of root rats.

An evaluation of a recent dissemination activity showed that drama can be an effective approach for extending messages to large audiences and changing agricultural practices, and complements other approaches.

Progress Report 1998

Output 1. Stronger networks in Africa linking NARS, IARCs, NGOs and the private sector

Activity 1.1 Develop new partnerships within regional networks

Achievements:

- The ECABREN network adjusted its strategy from production driven research to market oriented research, in line with in accordance with strategy adopted by ASARECA.
- The SABRN network started to implement its new strategy agreed last year, with a modest increase in emphasis to crop management and impact assessments.

A new strategy for ECABREN

Rationale: The Eastern and Central Africa Bean Research Network (ECABREN) adjusted its strategy from production driven to market oriented research, in accordance with the strategy adopted last year by ASARECA and with the encouragement of at least one of its main donors.

Methods: Network members met twice to develop a five-year research plan (1998-2003) based on market driven research, with its new objective being *to increase incomes of small farmers and food security for rural and urban populations*. The proposed plan was reviewed by ASARECA.

Results and discussion: The Network identified intervention areas including production, post harvest, processing, and marketing. Other areas included quality control and technology transfer. Increased focus on market types of bean and post-harvest research is expected, but ASARECA agreed that unsatisfied consumer demand for dry beans is such that overcoming production constraints should remain the top priority. The success of this strategy depends on the development of new partnerships at all levels in participating countries. A participatory approach has been adopted and recommended to all ECABREN partners and disciplines to enable ECABREN to contribute to poverty alleviation and economic growth of the region's people.

Seed production and dissemination are important areas where Network partners need to focus and satisfy the continually growing demand in participating countries. The Network budgeted funds for production of breeders' seed of marketable varieties by national breeding programs; individual producers, farmers' associations, NGOs and the private sector will be organized and trained in seed production. ECABREN's vision is to make improved seed available and accessible to all bean growers in the region.

There was effective participation of countries in implementing collaborative research in some research areas, with sharing of results among countries. A good example is the case of the climbing bean system and varieties now being spread in most potential areas in the region. Their impact in the region is creating further demand for adaptation trials in new areas – e.g., Madagascar, Upper Congo (Mahagi) and Katanga provinces in D.R. Congo. Ethiopia's Variety Release Committee approved the release of bean stem maggot tolerant materials (Cross-5 and Cross-14) which will also be made available to farmers similarly affected throughout sub-Saharan Africa via a pan-African nursery.

This year the ECABREN Steering Committee (SC) only approved proposals that were favorably reviewed in advance of the meeting. The number of research subprojects implemented by the range of partners increased in 1998; the great majority (92 %) are still in the area of production, whereas post-harvest, processing and marketing areas are still the least exploited by scientists in the region (Table 1). A widening of partnerships was considered by ECABREN's traditional partners as the way to increase research and development in technology dissemination, processing, post-harvest and commercialization, in which expertise is often limited.

***Contributor*:** M. Pyndji
Collaborators: ASARECA; NARS, Steering Committee members and scientists from Burundi, D. R. Congo, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda.

Innovations within the southern Africa network

The SADC Bean Research Network (SABRN), which currently has 9 active country members within the SADC grouping, is coordinated by Tanzania's national bean coordinator; Malawi's coordinator has network responsibility for germplasm exchange. Mauritius is in the process of moving from ECABREN to SABRN, following the country's accession to SADC. The Bean/Cowpea CRSP project, involving universities in Malawi, Tanzania and USA, has been brought fully into the network, with one place on the SC.

This Network continued to be constrained by lack of a special project donor, but the Southern Africa Centre for the Coordination of Agricultural and Natural Resources Management Research and Training (SACCAR) again funded a small core set of research sub-projects (Table 2). The CRSP took responsibility for funding and implementing one SABRN sub-project from its USAID support. Under donor support to the Pan-Africa Bean Research Alliance (PABRA), CIAT passed on some funds to selected SABRN activities, including participation of scientists from southern Africa in pan-African nurseries and technical working groups.

Despite the low level of funding, regional germplasm exchange has proven very useful. Malawi is now seen as a regional role model for its seed promotion and dissemination strategy, with a radio and poster campaign that created demand for sale of small packets totaling over 30 tons. The greatest impact so far from use of new bean varieties has been documented by Tanzania, where they are being widely consumed even in urban areas. Revised regional priorities, established by the Network and reported last year, were expected to be fully effected during the Steering Committee (SC)'s annual meeting in October (too late for inclusion in this Report).

Contributors: C. Mushi (DRT/SABRN) and R. Kirkby
Collaborators: SACCAR; NARS, SC members and scientists from Angola, Lesotho, Malawi, Mauritius, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

Table 1. Regional research sub-projects implemented by ECABREN countries in 1998

Domain and sub-project title	Country	Institution/Station	Startup
Production Technology			
Selection of climbing and bush beans			
Selection of climbing beans for participatory plant breeding	Rwanda	ISAR Rubona	1998
High yielding climbing snap beans & varieties in northern Tanzania	Tanzania	DRT-SARI	1998
Evaluation and dissemination of climbing bean genotypes among small farmers in SW Uganda	Uganda	NARO-NAARI	1998
Adapting high yielding climbing bean cultivars in Rift Valley Province of Kenya	Kenya	Egerton University	1998
Climbing beans in Southern Ethiopia	Ethiopia	EARO-Awassa	1997
Eliciting food bean preferences of farmers in Areka area of Southern Ethiopia	Ethiopia	EARO-Areka	1998
Breeding activities on French beans	UGA	NARO-KARI	1998
Adaptation of climbing beans: Ecological zones	Rwanda	ISAR Rubona	1997
Promotion of climbing beans: Calliandra stakes and farmers	DR Congo	INERA-Mulungu	1994
Production and use of stakes for climbing beans	Rwanda	ISAR/A. Rumongi	1996
Climbing beans under banana field: pruning frequencies	DR Congo	INERA-Mulungu	1995
Adaptation of climbing beans in the highlands of eastern and central Kenya	Kenya	KARI-Embu	1996
Adaptation of climbing beans in Kagera region	Tanzania	DRT Bukoba	1997
Adaptation of climbing beans in Kilimanjaro region	Tanzania	DRT-SARI	1997
Genetic Improvement	Mad'ascar	FOFIFA Tana	1997
Germplasm conservation	DR Congo	INERA-PNL	1997
Genetic diversity on-farms	DR Congo	INERA Mulungu	1993
Diseases Management			
Development of bean lines with multiple constraint resistance	Kenya	Univ. of Nairobi	1998
Effect of nematodes and BSM on Fusarium wilt	DR Congo	INERA-Mulungu	1998
Anthracnose			
Anthracnose resistance	Mad'ascar	FOFIFA	1996
	Rwanda	ISAR Rubona	1996
Anthracnose Regional Nursery	Ethiopia	EARO Ambo	1997
	Rwanda	ISAR Rubona	
	Kenya	KARI-Thika	
	Uganda	NARO-NAARI	
	Mad'ascar	FOFIFA	
	Burundi	ISABU-FACAGRO	1998
Charcoal rot nursery	Kenya	KARI Katumani	1996
Common bacterial blight: use of resistance sources	DR Congo	INERA-M'vuazi	1995
Multiple disease resistance: low altitude	DR Congo	INERA Gandajika	1993
Integrated Pest Management			
Bean stem maggot: farmer assessment	Tanzania	DRT Selian	1995
BSM: population dynamics and resistance	Kenya	KARI-Katumani	1997
Leaf beetle epidemiology	Uganda	NARO-NAARI	1996
Apoderus effect on seed yield	Mad'ascar	FOFIFA	1997
On-farm evaluation and integration of IPM components for BSM in southwestern Kenya	Kenya	KARI-Kisii	1997
Bean stem maggot management strategies using various IPM components	Tanzania	DRT-SARI	1998

Crop/Soil Productivity and FPR			
Developing integrated crop management packages to alleviate in drought areas	Tanzania	DRT-SARI	1998
Optimizing the efficiency of applied two P sources	Tanzania	DRT-SARI	1998
Development and verification of farmer oriented decision guides to soil fertility	Uganda	NARO-KARI	1998
Biological fixation of nitrogen (BNF)	Burundi	ISABU Bujumbura	1992
FPR on soil productivity	Ethiopia	EARO Nazareth	1994
Soil organic matter	Uganda	NARO Kawanda	1995
Use of waste house for bean fertilization	Burundi	ISABU Moso	1994
Effect of lime and rock phosphate on bean production	Rwanda	ISAR Rubona	1996
Nodulation of climbing bean varieties	Burundi	ISABU Bujumbura	1996
Green manure application in pure and in association with annual crops	DR Congo	INERA Mulungu	1995
Improvement of farmers' techniques of incorporation and use of ash as fertilizer	DR Congo	INERA Mulungu	1995
Development of decision guides to use of organic and inorganic inputs	Kenya	KARI Kakamega	1998
Management of soil fertility in southern Kivu: Use of *Tithonia*, basalt and fertilizer	DR Congo	INERA Mulungu	1998
Bean improvement for low fertility in Africa (BILFA-III)			1995
Evaluation of BILFA II	Ethiopia	EARO-Nazareth	
Evaluation of BILFA II	Mad'ascar	FOFIFA	
Low N preliminary evaluation of BILFA III	Uganda	CIAT	
Low N preliminary evaluation of BILFA III	Tanzania	DRT/SARI	
Low P preliminary evaluation of BILFA III	Kenya	KARI Kakmega	
Low P preliminary evaluation of BILFA III	Rwanda	ISAR Rubona	
Low pH complex	DR Congo	INERA-Mulungu	
Adoption, Dissemination, and Seed Systems			
Production and fast dissemination of bean seeds by women associations	DR Congo	INERA-Gandajika	1998
Participatory selection for seed dissemination	Burundi	ISABU-Moso	1998
Adoption studies of new bean varieties	Mad'ascar	FOFIFA Tana	1998
Seed dissemination of released food bean varieties Gofta (G 2816) and Ayenew (GLPx92) in eastern Ethiopia	Ethiopia	Alemaya Univ	1998
Study of local bean systems in Tanzania: Implications for efficient production	Tanzania	DRT-SARI	1998
Introduction of root rot resistant varieties in southwestern highlands of Uganda	Uganda	NARO-NAARI	1998
Decentralized secondary multiplication of seeds	Ethiopia	EARO Nazareth	1995
Farmers' constraints for seed production	DR Congo	INERA-M'vuazi	1996
Effectiveness of women associations on seed dissemination	DR Congo	INERA-Gandajika	1995
Monitoring the adoption of the technology, staking climbing beans with banana fibers	DR Congo	INERA-Mulungu	1998
B. Post-Harvest			
Improved locally available technologies to control insects	Rwanda	ISAR-Rubona	1998
Back-cross breeding program for bruchid resistance	Kenya	Univ. of Nairobi	1998
Field management of Acanthosceleides	Uganda	NARO-KARI	1997
C. Processing & Marketing			
Development and characterization of a composite flour meal from cassava and bean	Uganda	NARO/FSRI	1998
The commercialization of alternative bean products	Uganda	FDAU/TDC	1998

Table 2. Regional research sub-projects implemented by SABRN countries in 1997/98

Title	Country	Institution	Year approved
Breeding for tolerance to drought	Tanzania	SUA	1995
Breeding for bruchids resistance	Tanzania	SUA	1994
Dissemination of new varieties	Lesotho Malawi Mozambique Tanzania	MoA Maseru DARTS Chitedze INIA DRT Selian	1995
Pathogenic variation of rust	South Africa	ARC/GCRI	1995
Bacterial diseases	South Africa	ARC/GCRI	1995
Physiological races of angular leaf spot	South Africa	ARC/GCRI	1995
Dissemination of new varieties	Zambia	MoA	1997
First and secondary multiplication of two varieties	Angola	MoA	1997
Evaluation of BSM resistant lines in Southern Highlands	Tanzania	DRT Uyole	1997
Ootheca management in Southern Highlands	Tanzania	DRT Uyole	1997
Farmer participation in selection and seed multiplication	Zambia	MoA	1997
Mass rearing for resistance breeding against bean stem maggot	South Africa	ARC/GCRI	1997

Activity 1.2 PABRA members coordinate and take greater responsibility for managing regional networks

Achievements:

- The PABRA pan-Africa network largely achieved the 1998 milestone of integrating bean research of the sub-regional NARS associations.
- With network partners, opportunities for contract research in the region were identified and initiated for the development of laboratory techniques, regional bean breeding and regional resource persons

Rationale: Some priority constraints and opportunities occur across the boundaries of the two regional bean networks in Africa. While efficiencies can be expected from improved coordination, communication between them is not facilitated by political groupings, infrastructure or geography. While coordination has been mediated by CIAT, this is not an optimal arrangement institutionally. Also, stronger NARS may now be in a position to undertake some strategic or tactical research that might otherwise be expected of CIAT, a shift that should reduce costs and increase sustainability particularly in the face of bean breeding reductions within CIAT Project IP-1.

Methods: The ECABREN and SABRN networks are self-governing under the policy direction of their respective regional NARS association, with CIAT remaining an active member of each grouping. The second Annual Meeting of the SC of the Pan-Africa Bean Research Alliance (PABRA), in Arusha in March 1998, again brought together the two networks, CIAT and principal donors to bean research in Africa. Integration of the networks' annual workplans was achieved by coordinators' identifying opportunities for merging activities or by applying for PABRA funds to permit participation in an activity led by the other network. Opportunities for contracting strategic research in the region were examined.

Results and discussion: The following opportunities for contract research in the region were identified and initiated:

Development of laboratory techniques: The Agricultural Research Council (ARC/GCRI) of South Africa was contracted to develop a laboratory method for distinguishing among same-color bean varieties. This work was completed on time, and has been publicized among NARS for impact assessment sampling of farmers' fields or markets. Similarly, ARC's Plant Protection Research Institute has been commissioned by CIAT and SABRN to develop a laboratory method for mass rearing of populations of the bean stem maggot, the principal insect pest of beans in Africa, that would increase efficiency of evaluating bean varieties for resistance.

Regional bean breeding: Following last year's decision to assist at least two NARS to develop capacity for supplying varieties resistant to multiple diseases, the University of Nairobi (Kenya) and Department of Agricultural Research and Technical Services (DARTS Malawi), made commitments to this activity. Training was provided in late 1997 by CIAT's Project IP-1, when senior breeders from each institution made the initial crosses at CIAT that are now being advanced locally.

Regional resource persons: On several occasions ECABREN has used an experienced national scientist, usually a leader of a successful sub-project, to assist another country in the capacity of regional resource person. Examples have included advice to another country in setting up similar research there, acting as professional trainers in a major regional course, and assisting a neighboring country that had no available agricultural economist to carry out adoption and marketing studies. This year, one of the very few national scientists experienced in participatory research was used to good effect in assisting the development of a PRIAM community and team in a new country.

Another type of contribution by ECABREN to broader research and development objectives is recognized by both ASARECA and the Special Program for African Agricultural Research (SPAAR). SPAAR's Plenary Meeting this year asked regional NARS associations to be more active on gender issues. ASARECA reported that it considered ECABREN and its national programs to be at the forefront regionally in carrying out much of their work with and for women farmers: e.g., an Ethiopian sub-project assesses gender issues there, and they are embedded in sub-projects on topics such as seed systems. Although many bean researchers are themselves female in Eastern Africa, they are however notably lacking in the Great Lakes national programs.

Contributor: R. Kirkby
Collaborators: M. Pyndji; C. Mushi (DRT/SABRN)

Activity 1.3 Technical support and participation in network training, information and planning

Achievements:

- The networks identified a critical set of activities focussed on national and regional needs for research support, and CIAT provided specialized technical assistance upon request.

- A cross-commodity working group on social science research for the ASARECA region was established.

- A cross-country monitoring tour enabled network collaborators to identify promising root rot resistant materials and new climbing bean lines soon to be available from Rwanda

- The 3rd Pan-Africa Bean Pathology Working Group meeting recommended updated strategies and priorities for the networks; more attention needs to be given to participatory development and evaluation of cultural and integrated management methods, especially for soilborne pathogens cultural methods.

- Research strategies were redefined, together with NARS partners, for selection for tolerance to water deficits and for adaptive soils research in Africa.

- A regional resource person successfully assisted the startup of a ninth participatory research site in a new country; this strategy to sustain support to PR despite the dearth of skills in NARS appears correct and promising, but the approach is far from being institutionalized.

Workshops, monitoring tours and training by ECABREN and SABRN

Rationale: Each network's portfolio of regional research sub-projects depends upon adequate research capacity within member NARS, effective means for exchange of information that ensures that all countries benefit and coordination skills within and between countries.

Methods: ECABREN's SC approved and funded an annual workplan that included workshops, monitoring tours and training (Table 3). While SABRN had no budget for such activities, some members were enabled by PABRA to join ECABREN participants in a management training course for national coordinators and a pan-Africa working group on bean pathology, and SABRN was able to hold a sensitization session on gender analysis for its SC members.

Results and discussion: To address the acute shortage of economists and social scientists in the region, ECABREN and the CIAT/PABRA socioeconomist initiated the formation of a social science working group across interested ASARECA networks. Participants will include AFRENA (with ICRAF for agroforestry), EARRNET (with IITA for cassava) and PRAPACE (with CIP for potato and sweet potato). For this meeting in October 1998, ECABREN appointed five network members. Some joint approaches and activities are expected as outcomes.

To strengthen research capacity within NARS, ECABREN agreed to support several activities. The one held so far is a traveling workshop on beans for Ethiopia scientists. A strategic planning meeting for the bean program in Kenya is scheduled for November 1998.

Contributor: M. Pyndji

Bean pathology-breeding monitoring tour

Rationale: To enable key network pathologists and bean breeders to visit and evaluate nurseries and collaborative research activities across countries and sites.

Methods: The 6-day tour involved 17 breeders and pathologists from Kenya, Uganda, Tanzania, Rwanda, S. Africa, D. R. Congo, Ethiopia and Madagascar, three CIAT staff and the ECABREN coordinator. Participants traveled by road to sites in Rwanda, Uganda and Kenya.

Results and discussion: Participants visited on-station, on-farm and activities carried out in collaboration with NGO partners in Rwanda (World Vision) and western Kenya (Organic Matter Management Network). Nurseries visited included the Regional Root Rot Nursery, Regional Anthracnose Nursery and the Climbing Bean Nursery; other trials included IPM of root rots, breeding for anthracnose and root rot resistance, multiple constraint resistance and characterization of pathogen diversity of *P. griseola*. Participants agreed to harmonize and improve research methods, and to exchange results. Some root rot resistant materials showed good potential on the basis of their performance in on-station and on-farm trials. Several new and promising climbing bean lines are also being evaluated in Rwanda and will be available to other Network countries. Earlier introductions from Rwanda were visited in Uganda and Kenya.

Contributors: R. Buruchara, H. Gridley, M. Pyndji

Table 3. Principal information exchange and training events of ECABREN in 1998/99

Event	Purpose	Venue	Participants		
			Male	Female	Total
Bean Pathology/ Breeding Monitoring Tour	Evaluate and exchange results, and consider collaborative activities	Rwanda, Uganda, Kenya		4	
BILFA and Soils Research Monitoring Tour	Review BILFA and other agronomy/soil fertility research; develop strategy for soil fertility research and recommendations for ECABREN next phase	DRCongo, Uganda, Kenya	6	1	5
Travelling workshop on beans		Ethiopia	14	2	16
International crop science symposium		South Africa		1	1
Kenya Bean Planning Workshop		Kenya			
ECABREN Strategic planning meeting	Develop and finalize proposal for Network 5 years development plan	Entebbe, Uganda	7	4	11
3rd Pan-African Bean Pathology Working Group meeting	Review and recommend plans for future research activities for the Networks	Thika, Kenya	24	11	35
Social science working group meeting	Identify and prioritize research themes; propose strategies and methods in relevant areas; facilitate information exchange on current research; and develop complementary agendas and methods which encourage collaboration. Organised by CIAT; with ICRAF, CIP, IITA and other networks.	Thika, Kenya	3	2	5
Marketing workshop	Organised by CIP and ICRAF	Nairobi, Kenya			
Management training course for National Coordinators	To promote opportunities for program leaders to improve their capacity and abilities in priority areas of agricultural research management. Organised by ISNAR, CIAT and INTG members	CMRT, Kenya	5	1	6
National training for technicians		Arusha, Tanzania			

The 3rd Pan-Africa Pathology Working Group Meeting (PWGM)

Rationale: The role of the Pathology Working Group, one of PABRA's specialized working groups, is to recommend areas of intervention against bean diseases based on experience and expert information of the members from different countries. This guides steering committees of the bean networks in Africa to arrive at decisions on support to bean pathology research. The meeting is held every three years, and the 3rd PWGM was therefore schedule this year with the objectives:

- to make a self-evaluation of achievements and failures encountered since the last meeting;
- to re-assess research objectives, strategies, and priorities set out in the last meeting;
- to evaluate status of current sub-projects and recommend new areas / theme for consideration;
- to offer a forum for exchange of research results and information;
- to develop recommendations for the 5-year plan of ECABREN.

***Methods*:** There were 35 participants from national bean programs and universities in Burundi, Kenya, Uganda, Malawi, Tanzania, Rwanda, South Africa, D. R. Congo, Ethiopia and Madagascar, two virology participants from USA universities collaborating under the Bean/Cowpea CRSP, and two CIAT staff. The Meeting covered fungal, bacterial and viral diseases and nematodes (previously, viral and bacterial diseases were addressed separately). Following presentation of research results, smaller groups focussed planning on foliar fungal diseases (angular leaf spot, anthracnose, rust, and phoma blight), soilborne fungal diseases (root rots, ashy stem blight, fusarium wilt and nematodes) and viral and bacterial diseases (bean common mosaic virus, common bacterial blight and halo blight).

A self-evaluation, based on a modified strengths/weaknesses/opportunities/constraints method, reviewed accomplishments against activities proposed in the 1995 meeting of the PWGM). The criteria used to determine research priorities and activities were: importance in managing disease constraints, potential for being accomplished and resources needed.

Results & discussions: For each recommended area of intervention, indicators and expected partners were specified. Broad areas of intervention were:

- Development, exchange and use of resistance cultivars:
  - complete/monitor/characterize diversity of specific pathogens;
  - identify new sources and parental lines with single or multiple resistance;
  - distribute and exchange among partners good sources of resistance (as nurseries etc), or segregating populations;
  - develop well adapted multiple disease resistant varieties in preferred backgrounds.
- Development, evaluation of cultural methods, especially for soilborne pathogens:
  - evaluate potentially useful cultural methods;
  - use participatory approaches to develop, evaluate and integrate IPM components.
- Disseminate technologies for all main disease groups:
  - encourage use of on-farm evaluation and involve farmers in technology development;
  - develop materials for training and dissemination of technologies.
- Train farmers, extension staff and scientists through short and long term training, visits and field days.
- Information exchange:
  - establish and distribute newsletters, leaflets of completed technologies and catalogues of resistance sources;
  - facilitate meetings and monitoring tours;
  - publish in journals;
  - facilitate email and internet access.

Contributors: R. Buruchara, H. Gridley and M. Pyndji

BILFA/soils research monitoring tour

Rationale: Given the range of research activities in Africa for improvement of bean for exhausted soils and for improved soil management, a review of on-going activities and development of a strategic framework was considered important.

Methods: Seven agronomists/soil scientists participated in a tour to visit research activities in D.R. Congo, Rwanda, Kenya and Uganda. A workshop followed the tour, to develop strategic frameworks for various research areas.

Results: Suggestions for improved implementation of BILFA (Bean Improvement for Low Fertility in Africa) activities were made. BIWADA (Bean Improvement for Water Deficits in Africa) was initiated and a strategy developed. A strategic framework for adaptive soil fertility research was developed. Coordinators from NARIs were proposed for BILFA and BIWADA and accepted by the networks.

Contributor: C. Wortmann

Participatory research for improvement of agro-ecosystem management (PRIAM)

Rationale: While an increasing proportion of research in the formal sector is moving to farms, very few researchers have the participatory research (PR) skills necessary to work in a collegial manner with farmers, and NARS institutions rarely encourage or assist them to do so.

Methods: Following earlier work focussed on farmer varietal selection and only modest success in raising awareness of PR issues through formal training, for the past three years we have catalyzed and supported interested groups to work directly and intensively with a local community in planning and implementing trials. The Participatory Research for the Improvement of Agro-Ecosystem Management (PRIAM) project, supported by The Rockefeller Foundation (RF) and by an RF Social Science Research Fellow, continued support this year to 8 sub-projects in Ethiopia (3), Kenya (2), Madagascar (1) and Uganda (2). A complementary part of our strategy for addressing the dearth of this expertise among agricultural researchers is to develop a cadre of regional resource persons to support PR.

A regional synthesis workshop was held in August, 1998 in Nazreth, Ethiopia. Additionally, one new PRIAM sub-project was established at INERA's Mulungu research center, South Kivu, D. R. Congo, through an implementation workshop in May, 1998 (see Annual Report 1997 for a description of this workshop series). This workshop was facilitated by Ms. Bodo Rabary, coordinator of the PRIAM sub-project at Antsirabe, Madagascar, who was selected and supported to work as a resource person to facilitate PR training activities on behalf of ECABREN.

Results: Over 100 regional scientists, extensionists and NGO staff have attended implementation workshops and been trained in PR approaches, including researchers of AHI, IITA and PABRA. At least 150 farmers are actively participating in sub-projects, with another 400 farmers being affiliated. PR lectures were provided to over 600 students at Alemaya University, Ethiopia.
Over 30 individuals attended the synthesis workshop, representing both PRIAM and other participatory research (PR) projects in Eastern Africa, NARIs, universities, government extension, NGOs, farmers, RF, ICRAF and CIAT. Researchers from each PR project synthesized their experiences over the last two years, visited PR activities in a local community and analyzed the achievements, limitations and challenges for the PRIAM project in particular and participatory research programs in general. Proceedings are being prepared for publication.

Discussion: The regional resource persons strategy appears correct and promising, but developing more such individuals becomes even more urgent with the departure in December 1998 of Dr Cary Farley, who has been supporting the PRIAM, and the ending of RF's Social Science Research Fellowship Program under which he came to us. Immediate demand for assistance in this area is increasing with growing awareness; for example, he was invited to participate in a review workshop for an NGO Farmers' Research Project in Ethiopia, and AHI is starting community land management research projects at 9 sites across five countries.

Contributors: C. Farley and R. Kirkby

Activity 1.4 Efficient modes of managing networks

Achievements:

- PABRA established principles for closer integration of regional activities across networks.

Rationale: Regional networks need to be cost-effective, achieving good cross-country spillovers at acceptable costs for management and other transactions.

Methods: Network planning by an SC of national coordinators advised by specialized working groups focused on technical issues; research sub-projects awarded on comparative advantage and monitored by a peer group; results shared on the principle of equal access to all; transparent and lean management; mechanisms for collaboration across African regions where problems cut across; IARC support increasingly for solving strategic issues of producers and consumers.

Results and discussion: Climbing bean systems, and rapid impact from new varieties of climbing and bush types of varieties through seed dissemination by informal channels, have produced the largest spillover benefits so far.

This year's meeting of the PABRA SC established principles for integration across networks. Networks already collaborate in evaluating a standard pan-African set of BILFA materials in strategical environments for low fertility tolerance. Coordinators were asked to work together to ensure pan-African harmonization for research on drought tolerance, led by Malawi and Tanzania for SABRN and ECABREN respectively. On the financial side, a country enjoying adequate bilateral donor support is expected to meet at least some of its own expenses in participating in activities of a network; and pan-African collaboration costs should be met, so far as possible, through prior agreement between the individual networks and at their shared expense.

The two network coordinators attended a regional course on "Leading and managing for collaborative advantage" implemented by Training Resource Group Inc. and the Simmons Institute for Leadership and Change.

In response to change in ASARECA strategies, ECABREN's SC brainstormed ideas for the development of its five years research plan for 1998-2003. Research planning was based on product chain analysis, with participants identifying dry seeds for domestic/regional markets, dry seeds for export markets, seed bean, snap beans and alternative bean products as proposed target commodities for achieving further economic impact with local communities.

Contributors: R. Kirkby and M. Pyndji

Activity 1.5 Refine characterization of bean growing environments using biophysical and socio-economic data

Achievements:

- The Atlas for Common Bean Production in Africa is to be published and distributed in 1998, greatly improving access to information on bean in Africa.
- Agro-ecosystems in Uganda are better defined and delineated, and bean production areas in Ethiopia have been better characterized.
- Household typologies developed for predicting technological impact and adoption behavior and trends.

Publication of an atlas on bean in Africa

Rationale: Easy access to information on bean in Africa, which previously existed in disparate forms, was needed to facilitate research and development efforts, as well as policy formulation.

Methods: A bean database for Africa was created drawing information from numerous sources, including expert opinion. The information was compiled to produce an atlas.

Results: The database, which includes agro-ecological and socio-economic dimensions, is available for distribution. The atlas should be published and distributed in 1998.

Discussion: Easy access to information through use of the database and atlas provide opportunity for improving research efficiency, targeting of information and germplasm, policy formulation and seed relief efforts.

Contributors: C. Wortmann and C. Eledu

Definition of agro-ecosystems for Uganda

Rationale: Agro-ecosystems had not previously been well defined or delineated for Uganda. A better basis was needed for selection of research sites, for development of area-specific recommendations, extrapolation of information, targeting of varieties and policy formulation.

Methods: A database for Uganda was compiled consisting of three climate, two population, three land use, 6 soil and 10 crop variables. Much data collection and editing was needed.

Using cluster analysis, coupled with agronomic judgment, agro-ecosystems were identified, delineated and characterized.

Results: Work continues, but eight agro-ecosystems have been broadly defined for southwest Uganda (Table 4).

Table 4. Characteristics of 11 agro-ecosystems in southwestern Uganda

	Area (km^{-2})	Temp °C	Rain mm yr^{-1}	Farm land %	Pop. Km^{-2}	Proportion of soils (%) Sand > %	pH 5.5	OC <	Ca <	K<	P< 5
The high altitude zones											
Cool highlands, acid soils	1200	17	1240	70	290	40	78	22	57	62	28
SW Uganda highlands	3250	18	1140	73	240	34	60	21	15	20	16
The medium high altitude zones											
1. Semi-arid areas	2750	20	830	47	140	44	32	15	20	16	9
2. Sub-humid areas	3575	20	1030	75	210	51	44	21	19	25	13
3. Wet farm/wood lands	2150	20	1310	62	200	36	41	22	15	18	10
The mid-high altitude transition zones											
1. Semi-arid Mbarara grasslands	3850	21	780	7	40	55	36	24	20	29	13
2. Semi-arid farm-grass land transition	3400	21	945	26	70	50	45	19	28	14	12
3. Sub-humid areas	5100	21	1070	58	80	48	57	23	38	20	16

Table 4, cont. Characteristics of 11 agro-ecosystems in southwestern Uganda.

	Proportion of land occupied by, or sown to, a crop (%) Banana	Bean	Cassava	Finger millet	Ground nut	Irish potato	Maize	Sorghum	Sweet potato
The high altitude zones									
1. Cool highlands, acid soils	13	9	<1	8	<1	8	9	6	4
2. SW Uganda highlands	39	8	1	3	<1	2	7	3	5
The medium high altitude zones									
1. Semi-arid areas	47	5	1	<1	1	<1	3	3	3
2. Sub-humid areas	48	5	<1	3	1	<1	4	3	4
3. Wet farm/wood lands	31	5	2	<1	<1	<1	4	<1	2
The mid-high altitude transition zones									
1. Semi-arid grasslands	2	<1	<1	<1	<1	<1	<1	<1	<1
2. Semi-arid farm-grassland transition	9	1	<1	<1	<1	<1	<1	<1	1
1. Sub-humid areas	8	3	2	1	<1	<1	2	<1	2

Contributors: C. Wortmann and C. Eledu

Definition of bean production agro-ecozones in Ethiopia

Justification: Bean is produced under diverse conditions in Ethiopia. Better definition of bean production areas facilitates development of research and extension strategies, and of policies affecting bean production.

Methods: Using data from 18 sites, the agro-ecology of bean production areas of Ethiopia was better defined using cluster analysis and the DSSAT V.3 Drybean model.

Results: Three major and six minor agronomically homogeneous groups were identified (for strategic planning). Rainfall was a major determinant of yield potential which ranged from 1.6 t ha^{-1} ha at Jijiga to 3.3 t ha^{-1} at Bako. Late water deficit stress was important at Nazareth, Mekele and Jijga, especially if planting was delayed until 1 August.

Discussion: Breeding and systems management research can be targeted to the three major groups which differ primarily due to rainfall. For the humid western areas, intercropping of indeterminate bean types and relay, or double, cropping of determinate types should be considered; for sub-humid areas in the east, early maturing beans are needed for the *belg* (short rains) season, and later maturing varieties are needed for inter-sowing with maize or sorghum in the main June rains; and for semi-arid areas of the northern and central Rift Valley and in the East, tolerance to terminal water deficits should be a priority.

Contributors: Simane Belay (AU); C. Wortmann; G. Hoogenboom (Univ. Fl.)

Characterization of household typologies for impact assessment

***Rationale*:** The adoption of new bean varieties is likely to be related to household production and consumption factors such as intensity of production, and proportions sold and consumed. Yet, the relationship between production for home consumption objectives, technology adoption and subsequent adjustments in resource allocations is not well understood. Typologies of farm households on the basis of these factors are likely to be a useful tool for predicting adoption behavior and impact trends.

Methods: Results from a survey of 158 randomly selected bean growing households in Mbale and Mukono Districts of Uganda were used to develop household typologies on the basis of intensity of production, proportion of beans sold and consumed.

Results: The following typologies were developed for market-oriented (as represented by Mbale District) and subsistence-oriented (as represented by Mukono District) environments in Uganda:

<u>Market oriented environments</u>:

Category 1: deficit households (≤10% of population): these include the poorest households (the elderly, female headed households, delinquents, etc.) who lack labor and other resources and do not produce enough beans for consumption or regular sale.

Category 2: self-sufficient households (30-35%): produce enough beans to allow for sale of small amounts (< 60 kg in each of the two seasons per year) on a regular basis. The majority rely on other crops as their principal source of income and some households buy beans to eat during periods of shortage. Beans are a principal source of protein due to limited cash availability, and per capita consumption is high. Most of these households fall in the middle and poor wealth categories and have limited access to land and labor.

Category 3: surplus households (40-45%): these mainly average wealth category households cultivate beans as a cash crop and produce enough to satisfy household needs. Per capita consumption is moderate to high. They sell a high proportion of their harvest (61-200 kg per season) and often experience shortages which forces them to buy beans.

Category 4: commercial households (< 20%): well-off households with sufficient labor, which cultivate a large bean acreage and sell at least 200 kg per season. They consume modest amounts of beans since they can afford to purchase other protein rich foods (meat, fish) regularly.

Subsistence-based environments

Category 1: chronically deficit households (80%): households across all wealth categories who do not grow beans every season. Most purchase beans for home consumption and may sell negligible amounts occasionally to earn money for purchasing household necessities. In some areas, high market dependence and the availability of other protein rich foods (fish) account for moderate per capita bean consumption among these generally large households.

Category 2: subsistence households (10-15%): due to low production (10-40 kg per season), these relatively large, mainly rich and middle wealth category households, regularly sell small quantities of beans (< 20 kg). They may purchase beans throughout the year, with modest to high mean per capita consumption.

Category 3: surplus households (< 5%): sufficient resources (labor and land), as well as cultural factors (e.g. a strong preference by certain ethnic groups for beans), account for modest to high levels of production (40-200 kg per season) by a few households which cut across all wealth groups. The greater part of the harvest is kept for home consumption and per capita consumption is high. Sales from the first season's harvest range from 60 to 200 kg.

Discussion: The hypothesis concerning the usefulness of these typologies for predicting adoption behavior will be tested using data from a forthcoming impact study.

Contributor: S. David

Output 2. Germplasm with relevant traits developed and used widely in Africa

Activity 2.1 Targeting of bean germplasm

Achievement:

- Areas in which bean root rot will be recognized as a serious problem in the near future were predicted using a recently developed model and the bean database.

Prediction of bean root rot problems in Africa

Rationale: The root rot complex has been estimated to cause 221,000 t yr^{-1} loss in production in sub-Saharan Africa. Detection of the problem is often delayed, with a significant decline in production before solutions are applied. A predictive model can advise researchers to be alert for the problem and to seek solutions early.

Methods: Data from Rwanda, Burundi, Uganda (excluding the North), northern Tanzania and Kenya were used to determine the relationship of root rot incidence and severity with other variables. The resulting model was applied to sub-Saharan Africa.

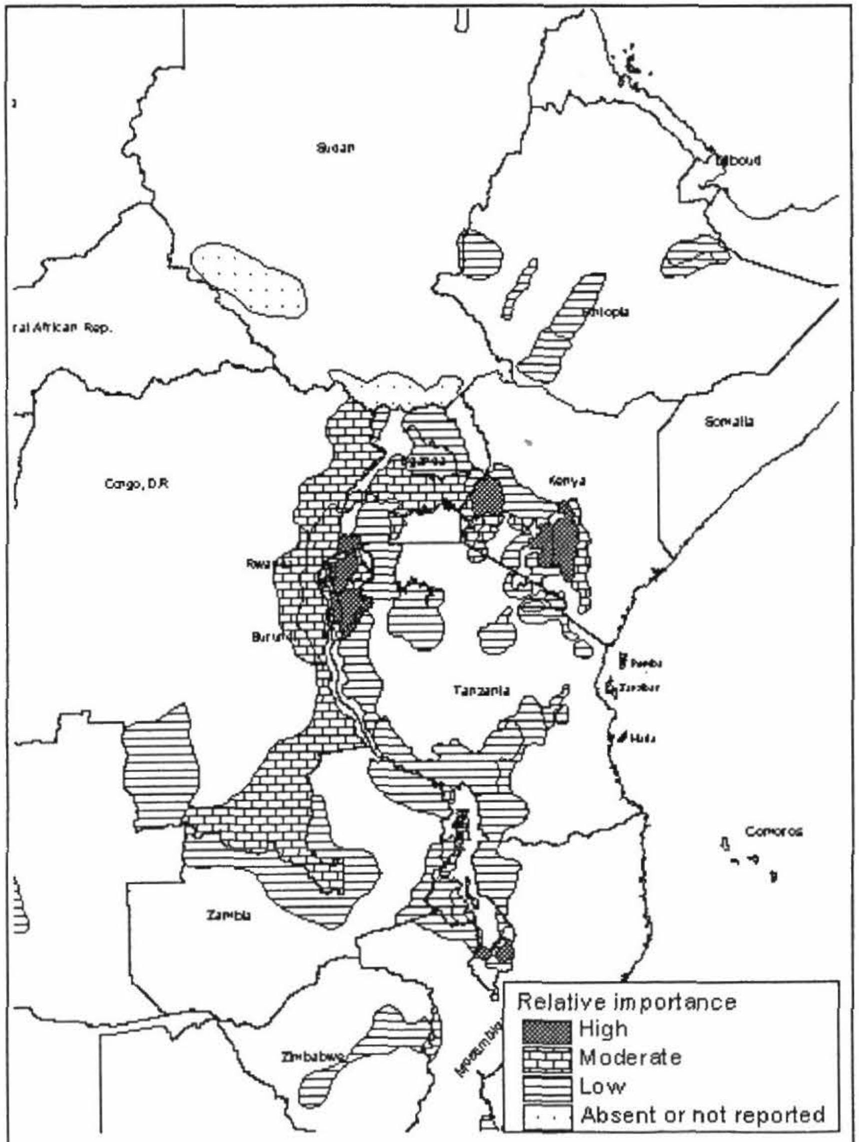
Results: Incidence and severity of root rots are associated with high intensity of bean production and with less productive soils. The following model is an improvement over one reported earlier and explains 58% of the variation in root rot severity (RR) when severity is rated low (3), moderate (4) and high (5).

$$RR = 3.382 + 0.000654 * PD + 0.0605 * INT + 0.191\ PCSOIL$$

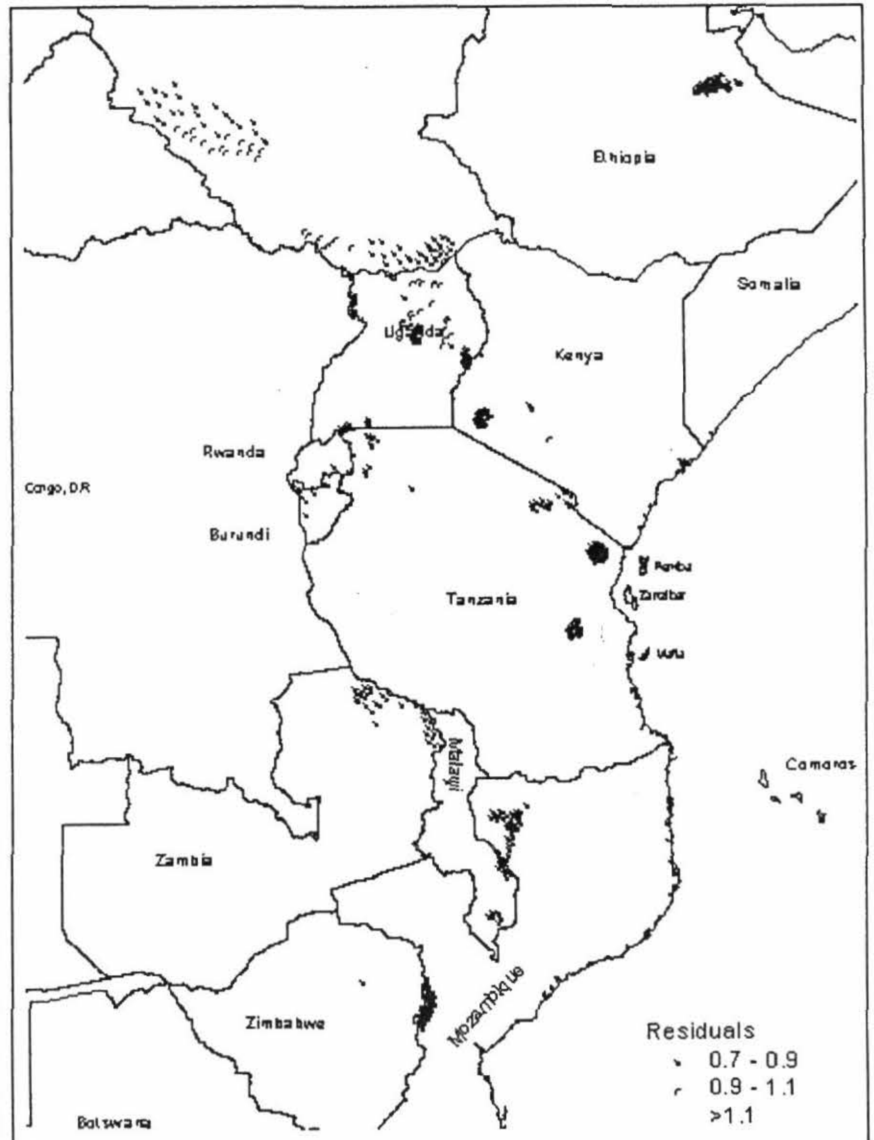
where: PD = human population density (km^{-2}); INT = percent of area sown to beans in a year; and PCSOIL is a principle component which explained 31% of the variation in seven soil properties, including (with vector values) CEC (0.15), exchangeable bases (0.51), organic carbon (0.43), pH (-0.42), and available N (0.22), P (0.48) and K (0.27). When the model was applied to bean production areas of sub-Saharan Africa, the results indicated that root rots are likely to become more serious, or have been underestimated, in areas in the vicinities of: Kisii and Nyahururu in Kenya; Morogoro, the Usambara Mountains, and parts of Kilimanjaro, Arusha and Kagera in Tanzania; Nebbi, Apac and parts of Ntungamo in Uganda; the Lake Kivu Basin in Rwanda; parts of the Imbo Plain of Burundi; parts of Mbala in Zambia; the Chitipa Highlands and Shire Highlands in Malawi; Manica and Lichinga in Mozambique; and in the northwestern part of the Hararghe Highlands in Ethiopia (Map 1).

Discussion: Researchers need to be alert in monitoring incidence and severity of root rots in the identified areas, and should begin developing or verificating root rot management technology.

Contributors: C. Wortmann and C. Eledu



Map 1. Relative importance of root rots in bean production areas



Map 2. Areas where root rot severity may be underestimated or worsen in the future

Activity 2.2 Germplasm to address African production constraints

Achievements:

- In germplasm development at the Uganda regional base, 123 large/ medium or small seeded lines combined resistance to both important viruses with a yield equivalent to released cultivars, and 15 lines showing significant ($P \leq 0.05$) yield increases.

- Twenty-three F_4 and 16 F_5 or F_6 large seeded segregating populations had yields equivalent to the large seeded cultivar, CAL 96, with eight F_4 exhibiting a significant increase.

- Southern African isolates of *P. griseola* , the causal agent of angular leaf spot (ALS), include Andean and Mesoamerican races, with the former group being more prevalent. In Malawi, resistance to ALS was confirmed in two additional Andean genotypes from CIAT.

- The importance of using a mixture of Andean and Mesoamerican races in screening for ALS resistance was confirmed. Using this method, several lines were identified as resistant to mixed isolates of *P. griseola* from nine localities in southern Africa.

- In screening selected for multiple disease resistance, 574 progenies and 161 lines were selected from segregating populations. Five lines of snap bean were identified with resistance superior to the commercial cultivar Paulista for rust, ALS and CBB with further lines exhibiting good tolerance. .

- Out of 292 entries of the Lamb collection of Rwandan germplasm conserved at CIAT, none was resistant against Pythium root rot but 14 gave intermediate reactions.

- Several lines in the first regional root rot nursery were shown not only to be resistant but also adapted to soil and environmental conditions in the three test countries. Plant characteristics associated with root rot resistant entries were identified.

- Greenhouse studies confirmed that some isolates of common bacterial blight (CBB) from Uganda could induce intermediate and susceptible reactions on CIAT's VAX1 and VAX2 lines, which are highly resistant in Latin America. In Malawi VAX lines held up better. Resistance was confirmed in another line in Uganda, and a further 17 with good tolerance to CBB were identified, with 8 being of Andean origin.

- Additional germplasm accessions resistant to aphid were identified for use in breeding programs to develop lines with improved tolerance.

- In further screening for adaptation in low soil fertility conditions (BILFA III), the line DOR 764 performed even better than previous tolerant lines under low soil fertility conditions in Malawi; another tolerant CIAT line RAO 55 is expected to be released.

In Uganda, three large seeded tolerant lines outyielded the released variety CAL 96 across sites with low soil nitrogen and phosphorous.

- Two samples of the majority of the 1336 seed samples collected during Seeds of Hope in Rwanda are now under low moisture storage; one seed sample will be sent to Rwanda and the other at another site for safe keeping.

- The Malawi national program identified Mesoamerican lines that outyielded recently released comparable varieties by an average margin of 40%. Extensive on-farm trials showed the CIAT line RAO 55 to be a potential new variety that is broadly adapted and liked by farmers (although of course not for all characteristics).

General Rationale: Over the past two decades NARS have made intensive use of introduced lines in breeding and constraint nurseries from CIAT, Colombia (Project IP-1), which has provided 95 (59%) of 162 cultivars released by NARS since the 1950s. The rate of cultivar release has accelerated in the last two decades, reaching 49 in the 1980s and 98 in the 1990s. The decision of CIAT, faced by core budget cuts, to terminate this supply of finished lines risks reversing the rate of new cultivar releases in Africa, as few NARS have felt it necessary or feasible to develop crossing programs that could now compensate for this loss. While encouraging stronger NARS to expand their crossing activities, we are selecting and distributing well adapted lines and lines and segregating populations with resistance to single and multiple combinations of important biotic and abiotic constraints.

Development of bush lines with resistance to principal viruses of bean in Africa

***Rationale*:** Bean common mosaic virus (BCMV) is the most important virus disease in Africa. Many CIAT lines carry the dominant 'I' gene that confers resistance all known strains but produces a hypersensitive reaction leading to systemic necrosis with the 'necrotic' strains NL3, NL5 and NL8 (now termed a new virus 'bean common mosaic necrosis virus' or MCMNV), and are common in countries in eastern and central Africa.

Methods: We have bred adapted resistant bush lines with a range of seed types, carrying one or more of the recessive 'bc' genes that confer resistance to all strains of BCMV and BCMNV. To date 134 lines have been distributed to NARS in two pan-African BCMV nurseries. In seasons 97b and 98a we yield tested 139 resistant bush lines (Table 5), selected from segregating populations.

Results: Although 123 (71%) lines had yields equivalent (not differing significantly at $P \leq 0.05$) to the released large and small seeded cultivars controls, significant ($P \leq 0.05$) increases were limited to 15 lines (Table 5). NARS have been informed of the availability of these new lines for distribution.

Table 5. Mean yield over one or more environments of bush lines with resistance to BCMV and BCMNV viruses from 1996b to 1997a in Uganda.

Trial code[1] / season	Seed Size[2]	Number of test lines	No. Environ-Ments	Yield performance[3]			
				Yield (kg/ha)		Number of lines	
				Range lines	Control	=	
				>s			
							control
				controls			
PBR 97B	L/M	46	2	1310 - 1066	1128	38	4
	S	13		911 - 1722	1077	6	7
				LSD_{05} 274.5			
IBR 97b	L/M	22	3	655 - 1766	1038	21	1
	S	12		888 - 1433	1044	12	0
				LSD_{05} 433.6			
IBR 98a	L/M	31	2	800 - 1440	988	31	3
	S	15		1022 - 1703	1309	15	0
				LSD_{05} 344.8			
Total		139				123	15

1. Test lines selected for named constraint or for yield. PBR/IBR: preliminary and intermediate, respectively, evaluating BCMNV resistant lines.
2. Seed size: small ≤29g/100 seeds, medium/large ≥30g/100 seeds.
3. Controls: released cultivars - CAL 96 for medium/large seeded, MCM 5001 for small seeded lines. '=', '>s': respectively, number of lines with yields not differing significantly ($P \leq 0.05$) from the control and with significant ($P \leq 0.05$) yield increase over the control.
LSD: least significance difference at $P \leq 0.05$ to compare test line with control.

Contributor: H. Gridley
Collaborator: T. Sengooba (NARO, Uganda)

Yield evaluation of introduced segregating bush populations and lines from CIAT

Rational: Finished lines can directly enter NARS yield testing programs -- while they select in well adapted populations to generate lines for testing and thereby gain experience in handling populations.

Methods: The populations and lines in the International Bean Yield and Adaptation Nursery (IBYAN) from CIAT were yield tested over two or more environments, and lines for low fertility at one low P site and one low N site.

Results and Discussion: Of 32 F_4 and 41 F_5 or F_6 introduced (from CIAT Project IP-1) populations 23 and 16 had yields equivalent to the large seeded released cultivar, CAL 96, with eight F_4 showing a significant increase (Table 6). All populations are large seeded containing a range of seed types, and selection in the best adapted should identify transgressive progenies with larger yield increases over the parent population and CAL 96. Populations with heaviest yield will be distributed in a regional nursery to NARS on request (with instructions for testing and selection).

The IBYANs were introduced to identify well adapted lines with export market potential. Although none of the lines significantly outyielded the large seeded cultivar, CAL 96, but 32 exhibited equivalent yields. All lines will be offered to NARS.

Table 6. Mean yield over one or more environments of F_4 and F_5 or F_6 bush segregating populations, bush lines selected for tolerance to low fertility and bush lines in the red and white seeded lines in the International Bean Yield and Adaptation Nursery in 1998a in Uganda.

Trial type	Trial code[1] / season	Seed size[2]	Number of test lines	No. Environ - ments	Yield performance[3]			
					Yield kg/ha		Number of lines	
					Range lines	Control	= control	>s control
Yield	F_4 IYT 98a	L/M	32	4	747 - 1516	976	23	8
					LSD_{05} 229.4			
Yield/ Disease	$F_{5/6}$ IYT 98a	L/M	41	2	633 - 1022	872	16	0
					LSD_{05} 219.3			
Low fertility	LF 98a	L/M	17	2	199 - 639	233	17	3
		S	7		449 - 783	733	7	0
					LSD_{05} 316.6			
Yield	IBYAN-Red 98a	L/M	18	2	622 - 1000	759	18	0
					LSD_{05} 240.1			
Yield	IBYAN-White 98a	L/M	31	2	355 - 900	917	14	0
					LSD_{05} 235.6			

1. IYT: intermediate yield trial.
2. Seed size: small ≤29g/100 seeds, medium/large ≥30g/100 seeds.
3. Controls: released cultivars - CAL 96 for medium/large seeded, MCM 5001 for small seeded lines.

Contributor: H. Gridley

Identification of bush lines with resistance and tolerance to common bacterial blight

Rational: The identification of good sources of resistance to common bacterial blight (CBB, caused by *Xanthomonas campestris pv. Phaseoli*), has proved elusive. Screening continued of the lines reported last year continued to confirm resistant sources to use in crosses for multiple constraint resistance.

Methods: Five seeds of 39 lines were sown in pots in two replicates in the screenhouse and inoculated three times at weekly intervals three weeks after sowing. CBB ratings were taken at five-day intervals three times commencing two weeks after inoculation.

Results and Discussion: Eighteen lines were identified with ratings of five or less but only one line, DOR 848, was resistant, rating 3 (as in previous screenings) (Table 7). Three lines identified as resistant last year rated susceptible in this screening and have been dropped. Previously, resistance or good tolerance was only found in the small seeded Mesoamercican type but amongst the 18, eight lines with the prefix 'AND', CAL or SUG are medium or large seeded, Andean types which will be of particular use in improving the CBB resistance of the many CBB-susceptible Andean cultivars released, thus saving the problems encountered in inter-gene pool crosses.

Table 7. CBB ratings[1] for most resistant lines (mean of two replicates)

CBB rating for lines				
3	3.5	4.0	4.5	5.0
DOR 848	AND 1062	AND 1063	AFR 717	AND 1069
	CAL 169	FEB 180	AND 1070	DOR 633
	FEB 190	FEB 191	DFA 55	FEB 195
	FEB 197	FEB 196	SUG 135	
	SUG 131	SEA 9		
Control			8.7	
SE ±			1.32	

1. Ratings on a scale of 1 to 9 (1-3=resistant, 4-7=tolerant, 7-9= susceptible

Contributor: H. Gridley
Collaborator: R. Buruchara

Studies to investigate failure in Africa of CBB resistance in VAX lines

Rationale: CBB is an important bacterial disease in warm and wet bean growing areas. Only moderate levels of resistance are found in *P. vulgaris,* but success has been achieved by Project IP-1 in transferring good levels of resistance from tepary bean, *P. acutifolius,* to *P. vulgaris.* The resulting VAX lines have shown consistently high levels of resistance in Latin America, but field evaluation in Malawi and Uganda last year gave intermediate to susceptible reactions. We initiated studies this year to further characterize and understand reactions of VAX lines to isolates of CBB pathogen from Africa.

Methods: Six bean lines were inoculated in the greenhouse with five isolates of *Xanthomonas campestris* pv *phaseoli* obtained from Kawanda and Bukalasa research stations in Uganda. Among the lines were VAX 1 and VAX 2. Isolates XCP-3 and XCP-4 were obtained from VAX 1 and 2 respectively in the field at Kawanda. Inoculation on 3-week old seedlings using the razor blade cut method was repeated three times at weekly interval on younger trifoliate leaves. Disease scoring started two weeks later at weekly intervals, with final scoring 7 weeks after inoculation. The trial was repeated once.

Results and discussion: Reaction to inoculation 7 weeks after inoculation is shown in Table 8. Disease severity was lower in the second than in the first trial. Four out of five isolates induced intermediate to susceptible reactions on the VAX lines during the first trial, while reactions during the second trial were largely intermediate. Temperatures in the screenhouse were cooler during the second trial. There was more disease on VAX 2 than VAX 1. Isolates XCP-1, XCP-2, XCP-4 and CXP-5 induced susceptible reaction particularly on VAX2 during the first season. The same isolates induced intermediate reaction on the same line. In field evaluation, the two lines at Kawanda also gave a susceptible reaction (rating of 7). These results confirm our earlier field observations regarding reactions of the two VAX lines to CBB in Uganda, and agree with observations made in S. Africa (D. Fourie, personal communication). However, the VAX lines had low susceptibility in related work in Malawi this year, with infection restricted to lower leaves. It is probable that reactions observed in parts of Africa are due to differences in pathogenicity of isolates in the two continents manifested by interactions with resistance genes in VAX lines. The studies are continuing.

Table 8. Reaction[1] of 6 bean lines inoculated with 5 isolates of the causal agent of common bacterial blight in the screenhouse, Kawanda, Uganda. April-June (1st trial), June-August (2nd trial), 1998.

	Xanthomonas. campestris pv *phaseoli* isolates									
	XCP-1		XCP-2		XCP-3		XCP-4		XCP-5	
Entry	1st Trial	2nd Trial	1st Trial	2nd Trial	1st Trial	2nd Trial	1st Trial	2nd Trial	1st Trail	2nd Trial
SEA13	9	7	5	7	5	7	5	6	9	9
DOR 671	8	5	8	4	4	6	8	3	5	5
VAX 1	8	4	6	3	4	4	6	3	5	5
VAX 2	8	5	8	4	4	6	8	3	7	6
A 321	5	5	6	4	4	4	3	3	5	9
Kanyebwa	9	4	5	3	5	6	6	5	9	7

[1] Reaction of bean genotypes based on a severity scale of 1 to 9 where 1, 2, and 3 are resistant, 4, 5, and 6 intermediate and 7, 8, and 9 susceptible 35 days after inoculation .

Contributors: R. Buruchara and B. Bosco
Collaborators: V. Aggarwal; R. Chirwa (DARTS)

Characterization of pathogen diversity of *Phaeoisariopsis griseola* in Africa

Rationale: ALS, caused by *Phaeoisariopsis griseola,* is the second most important biotic constraint in Africa causing an estimated yield loss estimated of 374,800 tonnes annually. Characterization of African isolates of *P. griseola* have shown occurrence of Mesoamerican and Andean pathogen groups associated with small and large seeded cultivars, respectively. Last year we reported occurrence of an Andean sub-group in Africa, designated as Afro-Andean. The objective of these studies is, by extending characterization of the diversity to areas and countries not yet covered, to develop race maps and strategies to manage the disease through host resistance.

Methods: These studies are conducted in collaboration with partners in S. Africa, Kenya, Tanzania and Uganda. S. Africa shares the responsibility to cover southern Africa. Characterization in Kenya and Tanzania was initiated with isolate collection from bean growing regions, isolation and conservation. A total of 79 isolates were characterized from S. Africa Malawi, Zambia, Tanzania, Mozambique and Swaziland, Uganda and D. R. Congo. Virulence phenotypes of isolates were characterized on the basis of the set of 12 bean differential cultivars of Andean and Mesoamerican origins.

Results and discussion: The 59 isolates from southern Africa could be grouped into 18 races, 12 Andean while the rest were Mesoamerican. As reported in eastern Africa, both Andean and Mesoamerican isolates occur together, but the former was the more prevalent group. A third type, which according to isozyme tests appears to be Andean but attacks both small and large seeded cultivars, was also observed; its occurrence is relatively infrequent. Twelve isolates from Uganda could be grouped into 6 races, and all except one were Mesoamerican (Table 9).

The picture emerging from characterization so far in southern Africa is that there are more Andean than Mesoamerican isolates, but the number of isolates characterized and sites from where the isolates have been obtained are still limited. Isolate collection from either a Mesoamerican or Andean bean host may also influence the results because of host-pathogen relationships, and results may reflect the cultivars grown.

Table 9. Virulence diversity of *P. griseola* isolates from Africa

	No. of isolates corresponding to each pathogen	
Country	Andean	Mesoamerican
Uganda	1	11
Tanzania	4	1
Mozambique	3	0
Swaziland	1	0
Zambia	3	0
Malawi	12	4
S. Africa	26	5
D. R. Congo	4	4
Total	54	25

Contributors: R. Buruchara; M. Liebenberg (ARC); F. Ngulu (DRT); F. Opio (NARO); A. Mwang'ombe (UoN); B. Bosco; C. Jara (Project IP-1).

Screening methods for resistance against pathogen groups of *P. griseola*

Rationale: *P. griseola* exhibits wide pathogen diversity between and within the Mesoamerican and Andean pathogen groups. To develop durable resistance, germplasm screening has to be based on prevailing and representative pathogen diversity. This study was designed to determine the effect of using individual components and mixtures of pathogen groups of *P. griseola* in screening for ALS resistance.

Methods: Seven isolates representing Andean (5C, KAK 3, KAK-Fl) and Mesoamerican (13A, 2A, RU-7, KIS4) pathogen groups were used to inoculate 5 and 8 resistant and susceptible lines in the greenhouse, during the first and the second trials respectively. A split plot design was used with bean lines constituting the main-plot and the isolates as the sub-plots. Inoculum for each isolate was prepared separately, and calibrated to form a concentration of 2 x 4^{10} conidia /ml. Three-week old plants were inoculated with each of the 7 isolates individually. They were also inoculated with separate mixtures of Andean isolates, Mesoamerican isolates and a mixture of all 7 isolates.

In a follow-up evaluation, 33 resistant lines from IBN were inoculated with separate mixtures of the Andean and Mesoamerican isolates. Scoring for disease severity on individual plants started 10 days after inoculation, and was done at 3-day interval for three weeks. Average disease severity scores per plant were used to compute area under disease progress curves (AUDPC).

Results and discussion: The overall pattern of response as measured by the area under disease progress curve (AUDPC) for the 5 first cultivars was similar in both trials. MCM 5001 gave the highest while Exrico gave the lowest AUDPC values. In the first trial there was no significant difference between MCM 5001, CAL 96 and Kanyebwa. There were significant differences ($P<0.05$) within cultivars and isolates in both trials. Host-pathogen interactions were significant, indicating host-pathogen specificity. Variation in disease caused by different isolates on susceptible cultivars (MCM 5001 and CAL 96) was significantly more than that on less susceptible and much less in resistant cultivars (Exrico). This means that use of single isolates in screening germplasm can result in variable and possibly unreliable reactions on susceptible hosts.

No significant difference in AUDPC was found between a mixture of Andean isolates and that of Mesoamerican and Andean isolates, but the AUDPC for the mixture of Mesoamerican isolates was higher than that of the other two. In the second trial there was no significant difference between the two, a reflection of individual isolates.

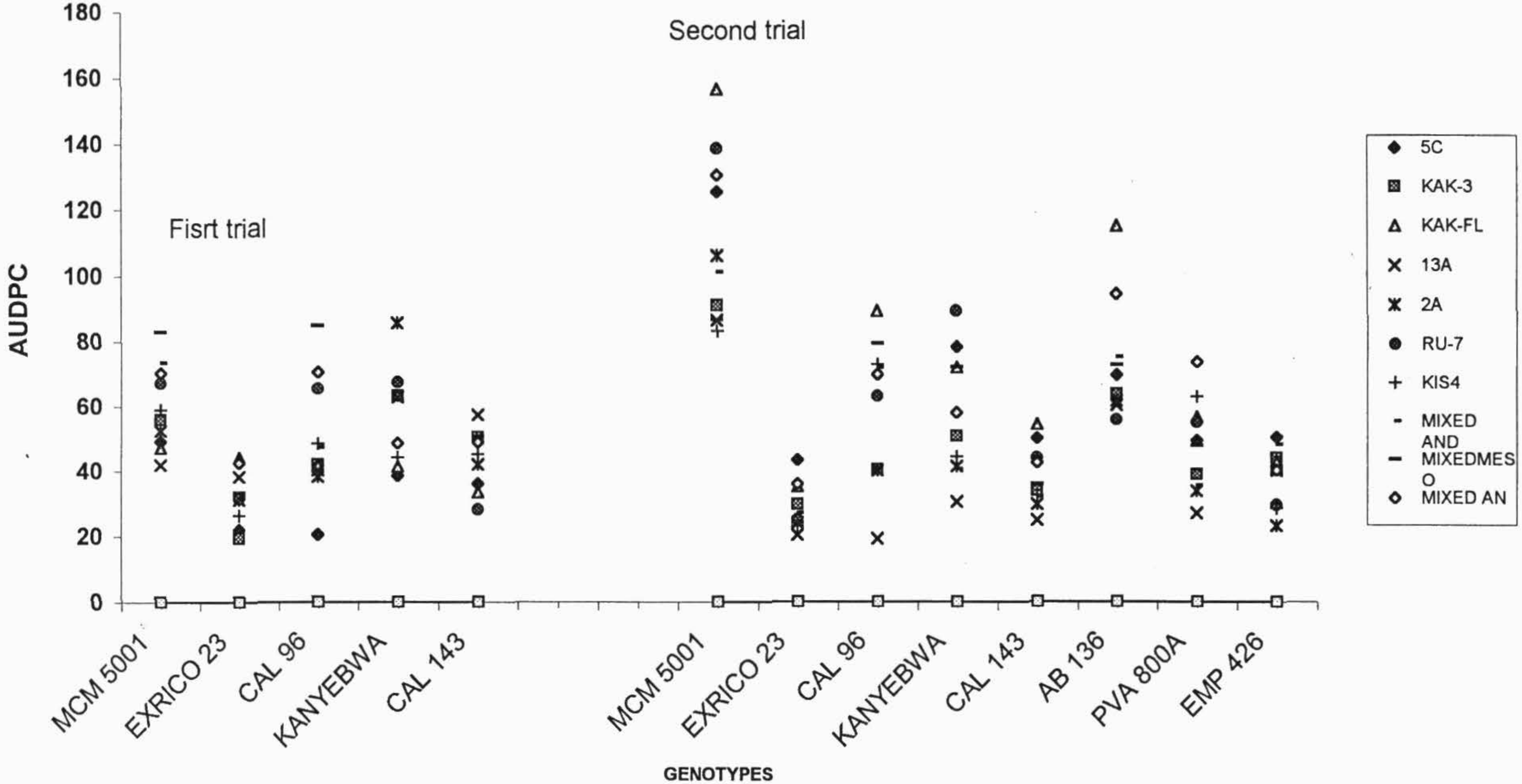
A mixture of Mesoamerican isolates gave double the AUDPC values of the Andean mixture during the screening of 33 previously selected resistant IBN. Unsurprisingly, there were no pathogen-cultivar interactions, as all entries except two were Mesoamerican genotypes less susceptible to Andean isolates. It was possible to identify entries resistant to both groups (Figure 1).

Contributors: R. Buruchara and B. Bosco

Sources of resistance against pathotypes of angular leaf spot pathogen

Rationale: Host resistance is an effective and practical strategy to manage angular leaf spot of beans for most small scale farmers in Africa, including women. In view of *P. griseola*'s wide pathogen diversity, it is therefore important to identify new and diverse sources of resistance to enable development of broad-based resistant cultivars. The objective of these evaluations was to identify entries with resistance to groups of pathotypes found in southern Africa.

Fig 1. Effect of individual components and mixtures of pathogen groups of *P. griseola* on AUDPC, Kawanda, 1998.



Methods: In South Africa, 39 potential sources of resistance were obtained from CIAT-Uganda and local bean breeders. They were inoculated in the greenhouse using a selection of three race groups each containing a mixture of three isolates (a total of nine races) from nine localities within southern African countries. The most promising materials were also evaluated in the field for ALS and general disease resistance and adaptation. In Tanzania, three nurseries, the CIAT Collaborative Bean Nursery of Potential Parents for Desirable Traits (VIFURE), African Leaf Spot Resistance Nursery No. 1 (AFALS) and the Core Collection, were evaluated under field conditions at a hot spot site for ALS. Natural infection was augmented with dry inoculum from ground infected leaves.

Results and discussion: The best sources of resistance among the large seeded germplasm tested in the greenhouse were G 5686 and CAL 143. Although neither was resistance to Mesoamerican races, both showed good resistance in the field. Among the small seeded types showing good resistance were A 286 (released as Nkuzi in South Africa), BAT 332, Cornell 49242, G 2858 and Mex 54. They gave good to moderate resistance in the greenhouse and excellent results in the field. Reaction of 39 entries to three mixtures illustrated the effect of pathogen diversity in germplasm screening: several entries were resistant to one or two groups while susceptible to others. A285, AFR 718, ANT51, DOR 660, G5653, G5698 showed good levels of resistance in the screenhouse and are being evaluated in the field.

Eighteen entries out of 50 AFALS entries gave a resistant reaction of less than 4 in CIAT's scale of 1-9, and 17 entries of VIFURE and 67 of the Core Collection gave a highly resistant reaction (≤ 2). All resistant entries but one in the VIFURE were small or medium seeded types; 61% of the 67 resistant entries of the Core Collection were small, 13% medium and 26% large seeded types.

Resistance genes in these and other sources are not known, but some of the best sources such as Mex 54 probably contain more than one resistant gene. Gene pyramiding is probably necessary in developing durable resistance against ALS disease.

Contributors: M. Liebenberg (ARC) and F. Ngulu (DRT).

Identification of bush lines with resistance to angular leaf spot

Rationale: Our objective is to identify or develop sources resistant to strains from both groups, in a range of seed types. Last year we reported identifying 24 small seeded Mesoamerican lines but only four large seeded Andean lines with resistance and good tolerance, respectively, to local strains of both groups amongst BCMV resistant lines. Selections have also been made in crosses from CIAT, Colombia, to identify more large seeded Andean material with resistance to both groups of strains.

Results and Discussion: Eighty-eight large seeded, Andean progenies derived from 14 crosses were sown in the field in 97b and 98a and inoculated three times with a mixture of local Andean and Mesoamerican strains of ALS. Disease pressure was insufficient in both seasons for effective selection, and further screening awaits arrival of a new screenhouse.

In related evaluations of materials assembled from CIAT by the Malawi program, about 12 lines showed a very good level of resistance to ALS across sites. It was encouraging to note that the large seeded Andean type, AND 279, maintained last year's high level of resistance, and its sister line AND 277 had a similar level of resistance; both have large red mottled seeds. With CAL 143, which has established resistance to ALS, we now have three good sources of resistance to ALS from the Andean gene pool. The other good lines resistant to ALS were A 222, A 240, A 686, DOR 390, UI 906 and MAR 3.

Contributors: H. Gridley, R. Buruchara and V. Aggarwal; R. Chirwa (DARTS)

Development of bush lines with multiple disease resistance

Rational: Most farmers consider yield and disease resistance as important criteria in adopting a new cultivar. Although NARS releases have shown notable yield improvements over local cultivars, many are susceptible to one or more important diseases. We are emphasizing the development of well adapted lines with multiple constraint resistance that can be evaluated by NARS for release or used in crossing programs to improve disease resistance and hence yield stability of existing cultivars.

Methods: Multiple parent crosses have been made for combinations of resistance to ALS, BCMV, CBB, root rots, bean stem maggot (BSM) and tolerance to low N and P and populations combining resistant sources to ALS, CBB and anthracnose (ANT) introduced from CIAT, Colombia (Project IP-1). In seasons 1997b and 1998a, 574 progenies derived from both sources were sown in the field at Kawanda and inoculated with ALS and CBB. A further 161 lines selected at CIAT, Colombia for multiple resistance against ALS, CBB and ANT were sown at Kawanda in 98a. Both sets of material were inoculated three times with ALS and CBB in the field.

Thirty-one progenies from crosses to combine BCMV and BSM resistance and introduce BCMV resistance into three BCMV susceptible but popular Rwandan cultivars were sown at Bukalasa, Uganda, a 'hot-spot' site for BCMV, together with rows of a susceptibe line infected with BCMV.

Results and Discussion: Disease development was so poor as to preclude any effective selection for ALS or CBB and we await the arrival of a new screenhouse to evaluate these progeny under controlled conditions with artificial inoculation. However, in 1998a selection for BCMV resistance was possible with over 500 apparently resistant single plant selections made for screening next season.

Contributor: H. Gridley
Collaborator: R. Buruchara

Identification of bush snap bean lines with superior disease resistance

Rational: ECABREN countries are placing more emphasis on commercial crops, including snap beans to satisfy local demand and for export. In Uganda the commercial cultivar, Paulista, being grown at the Mariye Estate near Kampala proved to be so susceptible to rust, CBB and ALS that export quotas could not be met; rust was the major problem as infection of newly sown crops started soon after sowing due to other earlier sown fields of this cultivar being grown closeby.

Methods: To search for sources of resistance, lines in the International Snap Bean Nursery from CIAT (Project IP-1) and introduced from Kenya were sown in a replicated trial to assess the disease reaction, together with the commercial cultivar Paulista and disease spreaders under irrigation in February at the Estate.

Results and Discussion: Five lines were identified with significantly lower disease ratings than Paulista for all three diseases and six with significantly lower rust ratings (Table 10). However, with Paulista so susceptible, not all these lines have good levels of resistance or tolerance. Accordingly, the lines with disease ratings ≤5 are also listed in table 10; these comprise two for rust, ten for ALS and two for CBB. Though, the pod quality of these lines needs assessing before being used in crosses to develop multiple resistance, they will be distributed in 1998 in a regional snap bean nursery.

Table 10. Snap bean lines[1] with significantly better disease ratings for rust, angular leaf spot (ALS) and common bacterial blight (CBB) than the commercial cultivar, Paulista, and tolerant (≤ 5) to these diseases.

Lines <s[2] Paulista for Rust + ALS + CBB	Additional lines <s Paulista for rust	Lines ≤ 5 for rust / score	Lines ≤ 5 for ALS / score	Lines ≤ 5 for CBB / score
HAB 402	HAB 173	HAB 433 / 2.3	HAB 54 / 5.0	HAB 433 / 4.0
HAB 455	HAB 465	HAB 455 / 5.0	HAB 415 / 4.3	A 20 / 5.0
BC 4.8	HAB 417		HAB 465 / 5.0	
J 12	HAB 424		HAB 451 / 5.0	
K 3	HAB 464		HAB 455 / 4.3	
L 1	HAB 414		A 20 / 3.7	
			BC 4.8 /5.0	
			J 12 / 4.3	
			K 3 / 4.3	
			L 1 / 4.7	
Paulista (check)		Rust	ALS	CBB
		8.9	6.0	8.3
LSD (P≤0.05)		1.18	0.99	1.15

1. 'HAB lines from the International Snap Bean Nursery from CIAT, Colombia; others developed by the breeding progamme at the National Horticultural Research Institute, Thika of the Kenya Agricultural Research Institute (KARI).
2. <s: lines with disease ratings significantly (P≤0.05) less than the check Paulista.

Contributor: S. Musaana (NARO)
Collaborator: H. Gridley

Identification of resistance sources against root rots of beans: The Lamb Collection

Rationale: Root rots are gaining importance as a result of intensification of land use in Eastern and Central African highlands. Pythium root rot is the most important disease, and use of integrated pest management (IPM) is the best strategy in its management. Our studies have shown that host resistance is an important component of IPM and one preferred by farmers. Unfortunately, out of several hundred entries in nurseries evaluated in the past, very few show good levels of resistance.

Methods: The Lamb collection consists of local Rwandan germplasm from different parts of the country, characterized in 1985 and conserved at CIAT. Two hundred and ninety-one entries were evaluated in a screenhouse under artificial inoculation; 45% of the entries were large (≥ 40), 44 % medium (25 - 39), and 16% small (≤ 24g / 100 seed) seeded types. Eighty percent were of climbing growth habits.

Results and discussion: Fourteen entries gave an intermediate reaction on the basis of plant mortality and disease severity on the root system (3.1-6.9) using a CIAT scale of 1-9. None gave a resistant reaction and the rest were susceptible. Entries that gave intermediate reactions are shown on Table 11. They include mainly small and medium seeded types. All but one are climbing types. On the other hand, susceptible entries included all the different seed and growth habit types. Given that very few entries show good level of resistance, the search for resistance need to continue in as much germplasm as possible.

Table 11. Origin, seed types and growth habits and reaction of the best entries from the Lamb collection to P

Entry	Origin in Rwanda (Prefecture)	Seed size	Growth habit	Reaction (CIAT 1-9 scale)
G 20744	Byumba	L	4	6.7
G 20739	Byumba	M	4	6.1
G 20762	Cyangugu	M	4	6.9
G 20751	Cyangugu	M	4	6.4
G 20769	Cyangugu	S	2	5.9
G 20766	Cyangugu	M	4	6.5
G 20758	Cyangugu	M	4	6.4
G 20754	Cyangugu	M	3/4	5.1
G 20787	Gikongoro	L	3	6.8
G 20783	Gikongoro	S	4	6.9
G 20895	Kibuye	M	4	6.4
G 22482	Kigali	M	4	5.8
G 20940	Kigali	M	4	6.4
G 20971	Ruhengeri	M	4	6.9

Key to growth habits: 2 = indeterminate bush; 3 = semi-climber; 4 = climber

Contributors: R. Buruchara and B. Bosco

Evaluation of the Regional Root Rot Nursery in Kenya, Uganda and Rwanda

Rationale: Following several evaluations made under screenhouse conditions, 33 entries were selected to constitute the first Regional Root Rot Nursery (RRRN#1). Its objective was to enable these materials to be more widely further evaluated under field conditions for resistance to root rots, adaptation and other constraints, and provide our partners with sources of root rot resistance.

Methods: Thirty-three entries constituting the RRRN #1 were distributed to and evaluated by partners in western Kenya (KARI), Rwanda (ISAR, WVI-Rwanda) and Uganda (NARO). In each country the nursery was evaluated at two sites. The sites in western Kenya are also good for low P, which is an important constraint. Plants were rated for plant mortality at different stages of plant growth, disease severity at flowering, general adaptation and yield

Results and discussion: Root rots were severe in western Kenya and Gikongoro (Rwanda), and average in southwest Uganda. Table 12 shows some of the entries which performed well in two or more sites. RWR 719 was the best and performed well in all six sites. Those that performed well in four sites were MLB-49-89A, MLB-40-89A and RWR 221. RWR 221 and MLB-49-89A have also been identified to be good for low P, and as some testing sites have both root rot and low P stresses, probably some other entries combine resistance or tolerance to both stresses.

Table 12. Best entries in regional root rots nursery for low plant mortality, vigor and yield in two or more sites.

	Western Kenya		Rwanda		SW Uganda (Kisoro)	
Entry	On-station, Kakamega	On-farm Vihiga	On-station Rubona	On-farm Gikongoro	On-farm Site A	On-farm Site B
MLB-49-89A	X	X	X	X		
MLB 40-89A	X	X			X	X
RWR 719	X	X	X	X	X	X
SCAM-80CM/15	X			X		X
RWR 1091		X			X	X
RWR 221		X	X		X	X
MLB-39-89A		X			X	X
DOR 710		X		X		
DOR 633		X			X	X
RWV 167		X	X	X		
MLB-69-89A			X	X		
AND 1064			X	X		
FEB 195			X		X	X
MLB-69-89A			X	X		X
RWR 1059			X			X
DOR 765				X	X	X

Contributors: R. Buruchara; R. Otsyula (KARI); J. Nderitu; A. Musoni (ISAR); E. Asante and F. Opio (NARO).

Studies to determine the nature of root rot resistance against *Pythium* spp.

Rationale: Although a number of lines have been identified as having good levels of resistance against Pythium root rot, several commercial and preferred, adapted varieties that susceptible. Their genetic improvement necessitates that the nature of resistance in possible sources of resistance be well understood.

Methods: Pythium root rots may variously cause pre-emergence seed rot, damping-off after germination or death of roots leading to chlorosis or wilt of plants. Plants may also respond in various ways against infection. The initial step was therefore to determine how entries with good levels of resistance expressed resistance. Fifty entries were artificially inoculated with *Pythium* spp in the screenhouse; the number of entries was narrowed to 25 and evaluations repeated. Pre-emergence rot may occur due to Pythium root rot but its cause is often not easy to establish the cause in the field, and we did not consider it. Soil conditions were manipulated such that germination was good, as usually is the case where root rots are prevalent.

***Results and discussion*:** Under screenhouse conditions, no entry was immune, although levels of infection varied. Characteristics that were associated with root rot resistant entries were: 1) lack or reduced post-emergence damping-off, 2) production of adventitious roots, 3) more fibrous root systems (more biomass), 4) long roots sometimes associated with 3 above, 5) low disease severity on the hypocotyl and roots, and 6) more shoot biomass. Different entries exhibited one or more of the above characteristics. These studies are continuing with fewer entries to further refine our understanding and determine more reliable criteria for resistance and its improvement.

Contributors: R. Buruchara, B. Bosco and H. Gridley.

Evaluation of lines for tolerance to bean stem maggot (BSM) in Malawi

Rationale: The Malawi national breeding program is one of the strongest in southern Africa, and serves as a valuable and widely representative testing site for the SABRN network. BSM is one of SABRN's priority constraints.

Methods: 25 lines from CIAT that had shown promise for other attributes (including released varieties and new on-farm trial varieties) but not previously evaluated for BSM were screened against this pest at Chitedze and Nchenachena (Malawi) in late-planted trials to ensure that heavy infestation.

Results and discussion: The delay in planting the BSM trials at Chitedze ensured high infestation rates, with a mean of 42% of plants dying from BSM was achieved at Chitedze. Mortality however was negligible at the other site. Based on motality at Chitedze, the materials G22501, Nyauzembe, EXL 52, BSM 28 and ZPv 292 showed tolerance to BSM. Of interest also was the performance of the local cultivar, Nyauzembe, which gave low mortality -- although it was very poorly adapted at Chitedze.

Contributors: V. Aggarwal; R. Chirwa and P. Mviha (DARTS)

Germplasm evaluation for further sources of resistance to aphid

Rationale: One of the key pests that constrain bean productivity in small scale production systems is the aphid. Current management strategies rely on timely planting and the application of various remedies such as plant extracts, ashes etc. This year a set of 690 accessions from the core collections (Project IP-1) were evaluated for resistance to this pest. Resistance was determined largely by the size of the aphid colony developing on the plants as well as plant reaction to the infestation, manifested as cupping of leaves. Check entries were *Lyamungu 90* protected with imidacloprid and *Lyamungu 90* unprotected as the resistant and susceptible checks respectively, and ZAA 12 (with the dominant I-gene) to monitor the presence of BCMNV among the population of aphids.

Results and discussion: Fourteen entries (2% of the accessions) showed moderate levels of resistance (not significantly different from the resistant check). These will be further evaluated under artificial infestation.

Contributor: K. Ampofo

Bean improvement for low fertility soils in Africa

Rationale: Bean productivity is much constrained by edaphic constraints. BILFA (Bean Improvement for Low Fertility in Africa) attempts to improve bean for N-limiting, P-limiting and acid soil conditions.

Methods: The third cycle consists of about 240 bush types and 40 climbing types previously identified by national and regional breeding programs in Malawi, Rwanda, Tanzania or Uganda as agronomically promising. It is being evaluated on acid soils at Mulungu in D.R. Congo; N-limiting conditions at Kawanda in Uganda, Selian in Tanzania and Rubona in Rwanda; and P-limiting conditions at Kakamega in Kenya, Bembeke in Malawi and Uyole in Tanzania, as well as by three other countries.

Results: Results from Malawi demonstrate the success of the earlier BILFA cycles, with BILFA lines giving more yield under nutrient-limiting conditions than the check varieties (Table 13). National breeding programs in Malawi and Tanzania have started to use the earlier BILFA I and II lines as parents. RAO 55 has yielded excellently in on-farm trials in Malawi and is expected to be released there. In D. R. Congo, farmers have adopted BILFA lines including Ubusosera and RWR 603 for low pH soils.

The most promising new line in BILFA III was DOR 764. This produced a mean yield of 1023 kg/ha over two locations in Malawi and performed much better than the three most promising varieties identified there in the past and now used as controls i.e. ARA 4 (722 kg/ha), RAO 55 (690 kg/ha) and XAN 76 (501 kg/ha). Other interesting lines were AFR 699, FEB 196, DFA 51and MCM 1015, most of which have an established record of producing high yields in other trials across bean growing areas.

Discussion: Some breeding programs are utilizing the BILFA lines with success. Most breeders have yet to use these materials but remain fully focused on biotic constraints and yield potential.

Table 13. Mean grain yields of promising BILFA lines under P-limiting conditions in Malawi (data of three seasons collected from four trials).

BILFA genotypes	*Grain yield (kg ha^{-1})*
RWR 221	828
XAN 76	1055
ARA 4	854
RWK 5	1015
RAO 55	906
Ikinimba	746
Check varieties	
CAL 143	698
Phalombe	386

Contributors: C. Wortmann and V. Aggarwal

Conservation of bush and climbing material collected under Seeds of Hope

Rational: One thousand three hundred seed samples were collected from farms and markets following the civil unrest in Rwanda, to examine the loss in genetic variation in the country during this period. Seed of these samples have been retained to form a national germplasm collection.

Methods: All samples have been multiplied over the last few seasons to provide 250g of large and medium seeded and 150g of small seeded samples, sufficient to fill two soda bottles used for low-cost low-moisture storage.

Results: To date over 1000 dupicate samples have been stored and the remainder are being multiplied in 1998b. After all samples have been stored, one will be sent to Rwanda and the duplicate retained in Uganda or at another site.

Contributor: H. Gridley

Germplasm improvement in Malawi

Rationale: A CIAT breeder posted in Chitedze, Malawi works with DARTS scientists under a bilateral project sponsored by DFID and the Government of Malawi. Malawi is one of the main bean producing countries in southern Africa, and is characterized by unusually high consumer prices for beans (e.g., in relation to maize).

Methods: As in the past years, the germplasm improvement in field nurseries included evaluation of segregating populations ranging from F_2 to F_{10} generations, germplasm, lines and elite cultivars with resistance to diseases, good seed quality (size and color), and high yield. The main sites were Chitedze (1100 masl) and Bembeke (1660 m) in central Malawi; yield trials at Bvumbwe (1190 m) in the south and Ntchenachena (1600 m) in the north represented the other important bean growing ecologies.

Segregating populations ranging from F_2 to F_{10} developed in Malawi and the materials received from CIAT (IP-1) were screened in unreplicated plots under natural disease infestations. Seletions were made for single plants or progeny rows. Out of 955 entries, 116 selections were made at Chitedze and they came from 32 different crosses. At Bembeke, out of a total of 746 entries, 315 selections were made representing 72 crosses. All selections from materials from F_4 will be yield evaluated in the 1998-99 crop season.

Results and discussion: The Preliminary Bean Yield Trial (PBYT) of 50 varieties, including five local checks, three Mesoamerican and two Andean, showed highly significant differences for yield between varieties and between varieties and locations (Table 14). Overall the yields were highest at Bembeke (1413 kg/ha) and lowest at Chitedze (427 kg/ha). The results at Chitedze were almost opposite to those obtained in 1996-97, mainly because of poor and highly variable soils showing severe symptoms of manganese toxicity. The yields at Bvumbwe, as usual, were moderate (843 kg/ha), but were quite low at Nchenachena, the new site in the north. A high infestation level of BSM was observed at this site which might have adversely affected the grain yield.

Among the individual varieties in the higher-yielding Mesoamerican group, XAN 76 and ARA 4 produced significantly higher yields than the highest yielding released Mesoamerican variety Kambidzi (A286). Both varieties were included after showing consistently high yields in low soil fertility experiments in Malawi and other countries. Their superior performance now in this trial is of great significance, with the prospect of farmers having varieties that can be grown on a range of soil types. In the Andean group, several varieties produced similar yields to the best yielding newly released check variety, Napilira, but none was significantly better. This creates a serious bottleneck in cracking the yield barrier in the Andean types.

The Advanced Bean Yield Trial (ABYT) had 30 entries, 19 from the Mesoamerican gene pool, 8 from the Andean gene pool and three improved checks. Two Andean (Napilira and Sapatsika) and one Mesoamerican (Mkhalira) produced higher yields at Bembeke (mean yield: 1230 kg/ha). As expected, the Mesoamerican types outyielded Andean types, by 23.8%. Most promising were DOR 715 (1356 kg/ha), OPS-GHI (1330 kg/ha), EXL 52 (1307 kg/ha) and DOR 814 (1239 kg/ha) among the Mesoamerican group based on seed characteristics and yield. No distinctly superior yielding lines were identified among the Andean group (Table 15). It was noteworthy that three interesting lines (EXL 52, G22501 and PAD 3) had already been selected for their tolerance to BSM, and therefore represent promise for the future. SUG 131, while not outyielding the controls, was one of the best lines identified so far in the cranberry seed type, and warrants further evaluation.

Table 14. Performance of promising lines included in the Preliminary Bean Yield Trial at four locations in Malawi, 1997/98.

	Angular leaf spot scores			Seed yield (kg/ha)				
Variety	BBK	CTZ	BVM	BBK	CTZ	BVM	NTN	Mean
Mesoamerican Lines								
DFA 51	8	6	3	2847	36	774	288	1219
DOR 764	5	7	2	1667	543	1354	460	1188
ARA 4	7	7	6	2066	550	1271	329	1296
XAN 76	2	8	7	2076	659	1444	492	1393
Controls								
RWR 221	3	6	4	1354	44	865	471	754
Mkhalira	4	7	3	1740	297	688	201	908
Kambidzi	7	9	5	1681	528	899	414	1036
Andean Lines								
FOT 29	8	8	9	1681	776	601	245	1019
PDA 8	7	9	9	1201	1096	625	631	974
C 30-P21	6	9	7	1646	422	837	517	968
Bolon Bayo	7	7	8	1083	244	813	459	713
Controls								
Sapatsika	7	6	8	1521	211	590	396	774
Napilira	3	3	7	1344	670	882	334	965
Means	6	8	6	1413	427	843	448	894
CV (%)	14	27	21	22	79	33	34	35
SE ± Location								62.6
Variety	0.5	1.2	0.8	175.9	194.8	162.8	87.5	80.2
L x V								160.4
Signif. Loc								**
Var	**	ns	**	**	*	**	**	**
L x V								**

Sites: BBK = Bembeke; CTZ = Chitedze; BVM = Mvumbwe; NTN = Nchenachena.

Table 15. Performance of elite lines included in the advanced yield trial at four locations in Malawi, 1997/98

	Angular leaf spot scores			Seed Yield (kg/ha)				
Variety	BBK	CTZ	BVM	BBK	CTZ	BVM	NTN	Mean
Mesoamerican lines								
OPS-GHI	3	7	2	1462	1308	1375	1175	1330
DOR 715	8	9	4	1382	1407	1826	809	1356
DOR 814	8	9	5	1056	1503	1490	908	1239
EXL 52	4	8	2	1222	1564	1208	1235	1307
Control								
Mkhalira	5	5	2	1017	465	1313	836	908
Andean Lines								
SUG 131	5	5	3	1313	779	787	456	834
CAL 160	5	7	3	1097	1086	865	901	987
PAD 3	7	8	7	1056	1033	1125	803	1004
G 22501	8	8	7	1389	773	925	891	994
Control								
Napilira	5	6	7	1292	908	828	813	960
Sapatsika	7	6	7	1243	376	719	748	771
Means	7	8	4	1230	875	1096	782	996
CV (%)	13	16	34	33	46	33	26	34
SE ± Location								72.3
Variety	0.5	0.6	0.7	235.9	200.3	180.7	100.9	97.5
L x V								195.1
Signif. Loc								**
Var	**	**	**	*	**	**	**	**
L x V								**

Sites: BBK = Bembeke; CTZ = Chitedze; BVM = Mvumbwe; NTN = Nchenachena.

Contributors: V. Aggarwal; Rowland Chirwa (DARTS)

On-farm varietal testing in Malawi

Rationale: On-farm trials broaden the testing of promising bean varieties to include dry season cropping and farmers' non-yield preferences.

Methods: Four new varieties were introduced: RAO 55 for low soil fertility tolerance; LSA 191 for large dark red seeds; AFR 619 a calima type; and EST 10 for white seeds. Two of the released varieties; Kambidzi (small seeded) and Napilira (large seeded) were used as experimental checks. Each farmer added one local variety. While all trials were managed by farmers, the ratio of farmer-designed (FD) to researcher-designed (RD) trials increased to 12:3 to ensure that evaluations better reflected typical farmers' practices such as intercropping. In Winter Season 1997/98, the number of farmers participating was maintained at 15 for each of the three locations of Bembeke, Kalira and Zidyana

INSTITUTIONAL ABBREVIATIONS

AHI	African Highlands Initiative (eco-regional consortium led by ICRAF)
ARC	Agricultural Research Corporation, Sudan
ARC/GCRI	Agricultural Research Council, Grain Crops Research Institute, South Africa
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU	Alemaya University, Ethiopia
CARE	(International NGO in Ethiopia, Uganda)
CIDA	Canadian International Development Agency
CIP	International Potato Center
CMRT	Crop Management Research Training Course, Egerton University, Kenya
CRSP	Collaborative Research Support Project (of USAID)
DARTS	Department of Agricultural Research and Technical Services, MoA, Malawi
DFID	Department for International Development (UK)
D.R. Congo	Democratic Republic of Congo [formerly Zaire]
DRT	Department of Research and Training, Ministry of Agriculture, Tanzania
ECABREN	Eastern and Central Africa Bean Research Network
EARO	Ethiopian Agricultural Research Organization
INIA	Instituto Nacional de Investigacao Agricola, Mozambique
ISAR	Institut des Sciences Agronomiques du Rwanda
FARM Africa	(International NGO in Ethiopia)
FOFIFA	Centre National de la Recherche Appliqué au Développement Rural, Madagascar
GoM	Government of Malawi
ICRAF	International Centre for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
INERA	Institut National des Etudes sur la Recherche Agronomique, D. R. Congo
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
ISAR	Institut des Sciences Agronomiques du Rwanda
KARI	Kenya Agricultural Research Institute
KSU	Kansas State University, USA
MoA	Ministry of Agriculture
MSIRI	Sugar Industry Research Institute, Mauritius
MU	Makerere University, Uganda
NARI	National agricultural research institute
NARO	National Agricultural Research Organisation, Uganda
NARS	National agricultural research system
NGO	Non-governmental organization
OMMN	Organic Matter Management Network, Kenya
PABRA	Pan-Africa Bean Research Alliance
PASOLAC	Programa de Agricultura Sostenible en las Laderas de América Central
PNL	Programme National Légumineuses, D. R. Congo
REDSO	Regional Economic Development Services Office (of USAID)
SABRN	SADC Bean Research Network

SACCAR	Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training
SADC	Southern Africa Development Community
SPAAR	Special Program for African Agricultural Research
SDC	Swiss Agency for Development and Cooperation
TSBF	Tropical Soil Biology and Fertility Program
UNIBU	Université National du Burundi
UoN	University of Nairobi
USAID	United States Agency for International Development
Wye	Wye College, University of London, UK
WVI	World Vision International

(i.e. 36 FDs and 9 RDs per location). These on-farm trials were repeated in Summer 1998, in six separate localities; the total number of FDs and RDs were 54 and 17.

Results and discussion: In the first season there were large and significant differences in mean bean yields across farmers in all three locations. In Bembeke, yields ranged from 599 to 1295 kg ha^{-1}, in Kalira from 379 to 1107 kg ha^{-1}, and in Zidyana from 1804 to 3250 kg ha^{-1}, reflecting farmers' management practices. Some promising varieties performed well above the farmers' local varieties, and the best varieties varied from one location to another: Kambidzi in Bembeke, Napilira in Kalira and RAO 55 in Zidyana. Overall, the best variety was RAO 55 with an average yield of 1703 kg ha^{-1}.

For the 29 successfully completed FD trials, mean yield among farmers differed significantly (P=0.01) only in Zidyana. Mean yields ranged from 357 to 798 kg ha^{-1} in Bembeke, 273 to 748 kg ha^{-1} in Kalira and 390 to 1882 kg ha^{-1} in Zidyana. The trend was again for wide differences in farmers' management practices. While varietal performance varied across farms, in general the top ranking varieties were: Kambidzi and RAO 55 in Bembeke; AFR 619 and Napilira in Kalira; and Kambidzi and Napilira in Zidyana.

Post harvest evaluations, recorded only in Bembeke and Kalira, showed that farmers liked RAO 55 for good seed colour, reaction to pests, high yield and early maturity, with over 60% of farmers' votes. The same variety scored poorly on seed size (26%) and leaf taste (44%). Two other new varieties, LSA 191 and EST 10, were liked for all characteristics except LSA 91 (53%) for leaf taste and EST 10 (44%) for reaction to field pests. AFR 619 was rated low for leaf taste (49%) and maturity (58%).

In the second season mean yields generally were much lower due to diseases, insect pest damage, poor soil fertility and poor crop husbandry management. In RD trials, the top ranking varieties were: Kambidzi and Napilira in Bembeke; RAO 55 and Napilira in Phoka north; local and RAO 55 in Chikwatula; and RAO 55 and Kambidzi in Nachisaka. Overall, RAO 55 and Kambidzi were the top two yielding varieties with yield advantage of 36% and 18% respectively over the farmers' local.

The FD trials yielded even less, mainly because most of the trials were intercropped and the plant population for beans was generally very low. Overall RAO 55 was the highest yielding, with an advantage of 26.0%, 27.0% and 35.3% over the farmer's local variety, Kambidzi (recent small-seeded release) and Napilira (recent large-seeded release).

Post harvest evaluations in seven locations again showed RAO 55 to be liked for all attributes except seed size. LSA 191 was liked for seed size, seed colour, high yield, and early maturity; but poor for reaction to pests. EST 10 was liked for seed size, seed colour and early maturity; but poor for reaction to pests, and yield. AFR 619 was liked for seed size, seed color, high yield and early maturity; but poor for reaction to pests. A general conclusion was that RAO 55 has potential for release.

Contributors: V. Aggarwal; Rowland Chirwa (DARTS)
Collaborators: Ms Temwani Ngwira and Mrs Martha Maideni (DFID/DARTS)

Activity 2.3 Cost effective innovative methods for variety development

Achievements:

- Low P tolerance in bean is most related to efficiency in acquisition; however, some genotypes rely on utilization efficiency which breeders might combine with acquisition efficiency. Promising parents were characterized.

- Bean genotypes rely on different N-efficiency mechanisms to achieve good performance under N-limiting conditions. Promising parents were characterized.

- Approaches were developed with NARS partners for identifying bean user groups for use in participatory bean breeding.

Efficiency of P acquisition and utilization by bean

Rationale: Knowledge of mechanisms of P acquisition and utilization efficiency, and good characterization of potential parents, can lead to enhanced effectiveness in selection of P-efficient genotypes.

Methods: Detailed data on 13 genotypes for various P acquisition and utilization characteristics were collected from P-limited field trials. Genotypes were grouped according to similarities in these characteristics using cluster analysis.

Results: Good performance on P-limited soils was more dependent on efficiency in P acquisition than efficiency in utilization. P acquisition efficiency was related to basal root length amongst indeterminate (Type II) bush bean growth types ($r = 0.65$). Cluster analysis placed the 13 lines in three groups with two out-lying genotypes (Table 16). Cluster I consisted of lines with high yield and high P uptake prior to podfill as well as high P remobilization and P utilization efficiency (PUE) at physiological maturity, and moderately high P harvest index (PHI). Another cluster had average performance for all traits considered, but moderately high P acquisition during pod fill and low P remobilization. Yield for the third cluster was relatively low, while P acquisition, PUE at R9, and PHI were low.

Discussion: P-efficient genotypes rely on different efficiency mechanisms presenting breeders with opportunities to integrate different mechanisms for the development of genotypes with superior tolerance. XAN 76 is outstanding for P acquisition in the aboveground part of the plant during the podfill stage; this P may have been taken-up from the soil and/or remobilized from nodules and roots. XAN 76 might be crossed with lines which take up much P before podfill and are efficient in remobilization (Cluster I), and with lines that have high PUE for growth at R9 and for grain formation (Clusters I and MCM 5001). Pre-screening Type II genotypes for total basal root length at 3 weeks after planting appears feasible for Type II genotypes; the relationship between root characteristics and P acquisition efficiency needs to be verified for other growth habits.

Table 16. Grouping of lines by cluster analysis and notable characteristics of clusters.

Cluster	Lines	Notable characteristics of clusters	Mean yield
I	UBR(92)13 UBR(92)29 BAT 85 MLB-45-89A	High P uptake prior to podfill, high PUE at R9, high P remobilization, moderately high PHI, and greater basal root length (MLB-45-89a excepted).	1344
II	UBR(92)12 UBR(92)05 ACC 433	Average performance, low P remobilization.	1094
III	UBR(92)26 MMS 243 CAL 96,K 20	Low P uptake, low PUE at R9 and low PHI.	982
IV	XAN 76	Moderately high early P acquisition, and very high P acquisition during podfill. Moderately high allocation of P to seed, but with moderately low remobilization.	1082
V	MCM 5001	Very low P uptake, but high PUE at R9 and in seed formation. Moderately high PHI.	960

PUE and PHI are P utilization efficiency and P harvest index, respectively.

Contributors: C. Wortmann; G. Rachier (KARI); and J. Tenywa (MU)

Efficiency of N acquisition and utilization by bean

Rationale: Knowledge of mechanisms of N acquisition and utilization efficiency, and good characterization of potential parents, can lead to enhanced effectiveness in selection of N-efficient genotypes.

Methods: Detailed data on 12 genotypes for various N acquisition and utilization characteristics were collected from N-limited field trials. Genotypes were grouped according to similarities in these characteristics using cluster analysis.

Results: Genotypic differences were significant for most N-efficiency traits, including N-fixation. Genotype interactions with growing conditions were generally not significant for these traits, but were significant for grain yield.

The genotypes fell into two clusters, with four outlying genotypes (Table 17). N acquisition during podfill, N remobilization, N utilization efficiency at R9 and N utilization efficiency in seed formation were significant ($P < 0.05$) determining variables of the clusters; N_2 fixation, N harvest index, total N acquisition and N utilization efficiency at R8 were not significant determinants.

Discussion: Bean performance under soil N-limiting conditions might be enhanced through improved N acquisition and utilization characteristics, and by combining mechanisms. The high repeatability of performance for N-efficiency characteristics should favor breeding efforts.

Improved N acquisition efficiency might be achieved through breeding using UBR(92)20 as one parent and another parent from clusters I or II. N fixation might be improved through crosses of members of cluster I with UBR(92)17. Crosses of CNF 5513 with members of Cluster I should yield progeny of high N utilization efficiency, combining efficiencies in N remobilization and N allocation. Plant breeders may wish to focus on individual entries rather than clusters in selecting parents, however, due to variation in yield within clusters I and III.

Table 17. Two clusters of genotypes, and four independent genotypes, based on similarities in N acquisition and utilization characteristics.

Cluster	*Entries*	*Mean yield*	*Notable cluster characteristics*
I	XAN76, MCM 5001, UBR(92)25, IBR(92)43	1055	Much N_2 fixation and remobilization of N (NRM) but low plant N at R9.
II	MORE 90040, RWK 5, MLB(45)89A, CAL 96	1245	Little N_2 fixation and low N acquisition during podfill.
III	UBR(92)12	1269	Little N_2 fixation, moderately low NRM, but efficient N use (NUE) in seed formation.
IV	CNF 5513	1447	High N harvest index (NHI), moderately low NRM, and high NUE for plant growth at R9.
V	UBR(92)17	810	Acquired much N, both from the soil and the atmosphere, before podfill but little during podfill. NUE was low.
VI	UBR(92)20	826	Acquired much N during podfill resulting in high total plant N at R9. NRM was low resulting in low NHI.

Contributors: C. Wortmann; M. Silver-Rwakaikara (MU)

Participatory bean breeding

Rational: Bean production in Africa ranges from high-potential to low-potential or marginal areas, more often the latter, and it is increasingly recognised these areas require different breeding approaches. The low potential areas usually constitute a myriad of micro-environments which no breeding program can expect to address effectively with multi-site trials on station. More decentralised breeding approaches are needed that exploit rather than avoid genotype by environment interaction, making use of specific adaptation and the active participation of farmers and their indigenous knowledge. On-farm trials of advanced breeding lines go some way towards this, but are often comprised of relatively limited and elite genetic diversity, often being conducted to obtain yield data rather than as a selection 'pool' for farmers to exploit.

Method: A three-year provisional plan was developed with NARS breeders of proposed participatory plant breeding (PPB) activities for three sites in Ethiopia and three in Tanzania. Funded by DFID started in October 1998. Sites were selected to build on existing linkages with NARIs and local communities developed through the PRIAM participatory activities, and the PR experiences of local researchers and farmers. Plans for each site will finalized at a PPB regional workshop in Ethiopia in October, 1998.

In Ethiopia breeders and farmers (farmer-selectors) at each of the three sites will select lines on-station in a diverse germplasm pool. The breeder will follow 'classical' breeding approach whilst the farmers will evaluate their selected lines on their own farms. In the last season the best lines identified by the breeders and farmer-selectors will be evaluated by the breeder in multi-location trials and by other farmers (farmer-evaluators).

In Tanzania selection will follow the same pattern but will be initiated in populations segregating for locally important biotic constraints, viz ALS, BSM and low nitrogen.

Contributor: H. Gridley
Colloborators: NARS breeders in Ethiopia and Tanzania

Identification of bean user groups for participatory plant breeding activities

***Rationale*:** Previous participatory plant breeding activities have paid little attention to farmers' differentiated needs and interests.

Methods: Ethiopian researchers from Melkassa and Awassa Research Centers and CIAT scientists identified and tested two approaches for identifying bean user groups. User groups are defined as producers/consumers with similar socio-economic and agronomic circumstances who share selection criteria and preferences for bean characteristics.

Results: The approaches identified include: 1. to develop a broad typology of bean users using participatory rural appraisal (PRA) techniques with groups and key informants (extension, local leaders, traders, farmers); and 2. to identify user group specific selection criteria through group screening of diverse germplasm nurseries, PRAs with individuals to evaluate current materials and formal surveys.

Contributors: S. David; D. Dauro, Y. Chiche, A. Tesfaye (EARO); L. Sperling (CIAT Project PE1)

Activity 2.4 Distribution of improved germplasm to network participants

Achievements:

- A first ECABREN climbing bean and multiple constraint nursery was formed and distributed.
- The first bred lines for bean stem maggot (BSM) resistance were selected and distributed to NARS for evaluation and further deployment. Crosses were initiated by breeders in South Africa and Tanzania to transfer BSM resistance to local materials, and two BSM resistant lines "Beshbesh" and "Melkie" were released in Ethiopia.
- About 500 kg of clean seed of sources of resistance to angular leaf spot, Regional Root Rot Nursery, sources of resistance to anthracnose and promising root rot resistant materials were multiplied and distributed national partners and NGOs.
- Several CIM lines originating from crosses made in Malawi were found promising in in several SADC countries collaborating in the southern Africa SARBEN nursery.

First ECABREN multiple constraints nursery (MCN) distributed.

Rational: In recent years the yield improvements being obtained by NARS from introduced CIAT (Colombia) over released cultivars has been diminishing, especially amongst the large seeded, Andean material. The 2nd breeders working group meeting agreed that greater attention should be given to developing lines with multiple resistance to important constraints and, to initiate this, an ECABREN MCN should be formed with contributions from national programs and CIAT and distributed amongst network participants for evaluation.

Method: At the meeting CIAT's IP-2 breeder agreed to undertake the multiplication and distribution. Purported MCN lines were received from Rwanda, Kenya and Ethiopia, multiplied and distributed in 1998a to five countries, viz Uganda, Rwanda, Madagascar, Ethiopia and Tanzania. When available, results will be compiled across countries to identify stable sources of resistance.

Contributor: H. Gridley
Collaborators: NARS breeders in Ethiopia, Rwanda and Kenya

Distribution of first ECABREN climbing bean nursery

Rational: Farmers at higher altitude can achieve far higher levels of productivity (and income, that help alleviate poverty) through the cultivation of climbing as compared to bush beans. The national programme of ISAR based at Rubona station in Rwanda has a long and successful record in developing climbing bean technology and in particular of breeding new climbing lines. Many of the first set of Rwandan climbing cultivars distributed to Uganda, Kenya and Tanzania proved to be widely adapted and were enthusiastically adopted by farmers. To sustain the distribution of such material a first ECABREN climbing bean nursery was formed.

Method: Twenty-three advanced breeding lines from Rwanda were selected for the nursery and 200 hundred seeds of each distributed to NARS breeders in Tanzania (two sites), Kenya, Madagascar and Ethiopia in 98a.

Contributor: H. Gridley
Collaborator: A. Musoni (ISAR, Rwanda)

Multiplication and distribution of climbing and bush lines

Rational: Many farmers at higher altitude are achieving far higher levels of productivity and income through the adoption of climbing beans. As CIAT's regional base at Kawanda is too low at 1100 masl for climbing bean cultivation, the development of new climbing lines is conducted in conjunction with the national program of ISAR based at Rubona in Rwanda. Although this program has a long and successful history of breeding climbing lines, introductions help widen the genetic base to sustain yield improvements.

Methods: Sixty-one climbing lines introduced from CIAT (Project IP-1) and 33 BCMV resistant climbing lines bred in Uganda were multiplied and sent to Rwanda in March 1998. Here they are being evaluated in 1998b for disease reaction and yield. Superior lines will be tested in multi-location trials in Rwanda and superior lines distributed to NARS in 1999.

The regional breeder also introduced from CIAT the last International Bean Nursery of 1996 (comprised of 1,100 predominantly bush lines) and arranged its distribution to NARS in Uganda, Rwanda, Burundi and Congo.

Contributor: H. Gridley
Collaborator: A. Musoni (ISAR)

Multiplication and distribution of various sources of resistance

Rationale: Sources of resistance have potential value for network members in that they can be used in genetic improvement, or directly.

Methods: Limited seed multiplication was carried out for the following nurseries or sources of resistance:

a. Sources of resistance to angular leaf spot (60 lines).
b. Regional Root Rot Nursery (33 entries)
c. Sources of resistance to anthracnose (70 entries)
d. Promising root rot resistant materials (23 entries)

Results and discussion: A combined total of 500kg of the above germplasm were multiplied and distributed. The Root Rot Nursery was distributed and evaluated in Kenya, Uganda, and Rwanda. Some of the anthracnose sources of resistance contributed to form the Regional Anthracnose Nursery, evaluated in Kenya, Madagascar, Rwanda, Ethiopia and Uganda. The sources of resistance to angular leaf spot were distributed to South Africa and Kenya for evaluation. Promising root rot entries, which formed the bulk of the multiplication, was distributed to Kenya, Uganda and Rwanda; some recipients of the latter were NGOs collaborating in on-farm trials of root rot management.

Contributors: R. Buruchara and B. Bosco.

Southern Africa regional trial and nursery

Rationale: The Malawi Bean Program continued to coordinate two sets of trials on behalf of the SADC Bean Research Network. These trials share germplasm within the network so that each participant can benefit from the research carried out by others. Particular beneficiaries are the weaker national programs who are not able to run a full scale breeding program. These trials also provide a mechanism to monitor the occurrence of new and old diseases and insect-pests, thus allowing the network participants to take corrective measures.

Methods: The Southern African Regional Bean Evaluation Nursery (SARBEN) contains 100 promising breeding materials contributed by network members. The majority (88) came from Malawi, and the remaining from South Africa (7), Zimbabwe (2) and Tanzania (3). The number of entries contributed by other countries remained low due to lack of generation of new breeding materials by these countries. Majority of entries contributed by Malawi originated from crosses (CIM= CIAT Malawi) made locally between 1992 and 1994 using the locally adapted and the best performing materials received from CIAT-HQ at that time. 18 sets of the SARBEN nursery were sent to 9 countries: Angola (1), Lesotho (1), Malawi (4), Mauritius (1), Mozambique (3), Tanzania (2), Zambia (2), Zimbabwe (2), South Africa (2) and Swaziland (1).

The Southern African Regional Bean Yield Trial (SARBYT) contains varieties in the final stage of national screening. Participating members of the network included both the private sector and national bean programs of SADC member states. The SARBYT comprised 16 entries contributed by Malawi (9), Zimbabwe (1), South Africa (3) and Tanzania (2), plus a local check (two local checks in Malawi). As we ran out of seed of four varieties received from outside Malawi (Jenny, Majuba, OWK 1 and LB 842-1), these entries were replaced by CIM entries in Malawi locations. Twenty sets of the trial were distributed to 10 countries: Angola (1), Lesotho (1), Malawi (5), Mauritius (1), Mozambique (3), South Africa (20), Swaziland (1), Tanzania (2), Zambia (2) and Zimbabwe (2). So far, results have been obtained from 9 locations in five countries.

Results and discussion: Since these trials were initiated six years ago, several countries have benefited: Zambia has released two varieties initially distributed through the regional trials; Malawi released varieties based partly on their wider performance in the region; and Angola plans to release one or two varieties. Furthermore, resistance in CAL 143 (Napilira) to ALS was confirmed in various countries through the regional trials.

At the time of writing SARBEN data was available from nine locations in Malawi, South Africa, Mozambique, Lesotho and Zambia. Yields were exceptionally good at Bembeke in Malawi and Delmas in South Africa. The other locations had low and highly variable yields. When data from Lesotho was removed from the analysis, the varietal differences became significant.

Some of the top yielding entries were common at three out of five locations, indicating that certain varieties have wider adaptation; among these were several CIM numbers, especially those from the cross CIM 9314 (originating from RWR 221 x AFR 520). CIM 9227-5, from a cross between CAL 113 x Canadian Wonder, also looked promising across locations, and several other CIM selections performed well in at least one location. It is expected that the participating national programs will further test these entries, all of which belong to the Andean gene pool and have broadly desirable seed characteristics. A white seeded canning type, PC 788-SW2 from South Africa, also did very well and may have potential in commercial production.

In the SARBYT, differences among varieties were highly significant except at Chitedze (Malawi) and Maseru (Lesotho). Delmas in South Africa produced the highest mean site yield, followed by Bembeke in Malawi. Low yields at two locations in Zambia and at Nchenechena (Malawi) were thought to be caused by BSM, but reasons could not be ascertained elsewhere.

As usual the Mesoamerican types produced higher average yields (913 kg ha^{-1}) than the Andean types (687 kg ha^{-1}). The highest yielding Mesoamerican was FEB 196, but its performance was very similar to other Mesoamerican types. Among Andean types, AFR 699 was the best yielding overall; otherwise, all the non-CIM varieties produced equally good yields (Table 18). Making use of these materials is now up to national programs.

The Malawi program also continued to participate in the Seeds of Freedom Project for Angola, and provided more than 1500 sets of on-farm trials and 4000 kg bulk seed of improved varieties. Funding for the Angolan activities came from USAID through the International Crops Research Institute for the Semi Arid Tropics (ICRISAT).

Contributors: V. Aggarwal; Rowland Chirwa (DARTS)
Collaborators: National programs of the SABRN region

Table 18. Performance of advanced cultivars in the SARBYT in southern African countries, 1997/98.

Variety	Seed yield Kg/ha									
	BBK	CTZ	BVM	NTN	DLM	MSR	LCH	MSE	MIS	MEAN
Mesoamerican lines										
DOR 72	1404	1280	1372	415	1422	1163	417	408	711	955
FEB 196	1495	1358	1393	329	2354	1323	471	243	418	1043
DOR 705	940	1250	1279	489	1664	1234	370	543	580	927
SEA 12	1563	1683	1482	624	1959	482	445	346	705	1032
DOR 808	1060	703	1000	489	1238	845	444	448	545	752
SEA 4	1641	870	1227	505	1992	733	555	540	785	983
BRB 172	1240	1053	1120	483	1738	875	462	157	453	842
BRB 80	1172	501	813	382	1772	634	379	159	360	686
Patrys	1612	798	688	319	1753	921	268	241	328	770
Andean lines										
AFR 699	1719	686	1279	467	2179	1284	495	332	503	994
Jenny	1250	-	-	-	1587	1136	289	305	188	793
Majuba	1052	-	-	-	1609	1033	352	246	400	782
OWK 1	672	-	-	-	1162	1095	279	231	320	626
G 14369	1208	1071	555	356	1348	991	465	419	405	758
LB 842-1	1156	-	-	-	1433	1121	561	416	438	854
CIM 9415	-	921	604	193	-	-	-	-	-	572
CIM9417	-	669	500	270	-	-	-	-	-	479
CIM 9419	-	712	714	344	-	-	-	-	-	590
CIM 9423	-	637	760	545	-	-	-	-	-	647
Local Control	859	719	466	258	1565	594	410	252	610	637
Control (Nyauzembe)	630	893	477	137	1160	0	0	0	0	366
Mean	1216	930	925	388	1643	910	392	311	456	797
CV (%)	32	63	36	39.92	22	56	40	40	32	45
SE ± Location										29.0
Variety	192.0	292.8	165.1	77.5	184.0	256.2	79.1	62.4	73.6	50.8
L x V										179.4
Signif:Loc										**
Var	**	ns	**	**	**	ns	**	**	**	**
L x V										**

Key to Sites: BBK = Bembeke, CTZ = Chitedze, BVM = Bvumbwe and Nchenachena (all in Malawi); DLM = Delmas (South Africa); MSR = Maseru (Lesotho); LCH = Lichinga (Mozambique); MSE = Msekera and MIS = Misamfu (Zambia).

Activity 2.5 Enhanced NARS capacity to use new sources of germplasm

Achievements:

- A few of the stronger NARS have started to react to the reductions in germplasm support from CIAT by initiating or reinforcing crossing programs, and embarking on participatory breeding with farmers.

***Rationale*:** The termination in the supply of breeding lines from CIAT, Colombia and its likely effect on cultivar release has been highlighted (section 2.2). Aside from the breeding programs in Rwanda and Congo (and perhaps Tanzania), none have crossing programs that can adequately compensate for this loss and it is imperative that NARS quickly increase their crossing capacity for yield improvement and resistance.

Methods: NARS are encouraged to exchange improved germplasm informally and via regional nurseries, in both ECABREN and SABRN networks. NARS are also being encouraged to initiate crossing programs to generate segregating material for yield improvement, and to develop multiple constraints resistant lines. Through our multilocation testing of a BSM nursery distributed from Arusha to collaborating NARS scientists, a number of programs have engaged in BSM resistance breeding to transfer resistance to locally adapted varieties.

Results and discussion: Two lines "BSM 04" and "BSM 28" from the Tanzania Program are showing good performance against the pest in multilocation trials. This year breeders at PANNAR, a South African Seed company, have also started to use some of the materials identified as tolerant in their environment (e.g. G 22501 and ZPv 292) in crosses to generate commercial materials for small scale producers in that country. In Ethiopia two BSM tolerant lines from the CIAT breeding program were formally released as "Beshbesh" and "Melkie". This is a welcome development as such activities have long been recommended by CIAT breeders with little effect, and we hope the loss of breeding and constraints resistant material from CIAT, Colombia will stimulate action in more countries.

The southern Africa SARBYT trial is reported in Section 2.4 above. An ECABREN multiple constraints and a climbing bean nursery were established this year. Once NARS are generating a significant number of lines from their crossing activities, an annual ECABREN 'Elite' nursery will need to be established to provide for exchange of elite bush lines between network participants. Informal exchange of lines bred for a particular characteristic(s) will also be encouraged.. A newer initiative is the catalyzing within stronger NARS of participatory plant breeding activities. This has been covered under Outputs 1 and 2.

Contributors: H. Gridley and K. Ampofo; Tsedeke Abate (EARO)

Output 3. Sustainable bean production systems

Activity 3.1 Sustainable crop and soil management practices

Achievements:

- Fallows improved with *Tephrosia vogellii* are a promising soil management alternative for the highlands of southwestern Uganda.
- Delayed N application favors bean productivity and N_2 fixation without reducing the productivity of the maize-bean intercrop.
- Farmer experimentation confirms that vetiver grass barriers have a role in erosion control.
- Increasing soil K availability without increasing P availability results in increased competitiveness of bean with annual weeds.
- Climbing bean can result in increased productivity of the subsequent crop.

Tephrosia fallows for highland areas

Rationale: Various studies indicate that 20 - 30% of arable land is typically in natural fallow in the highlands of southwestern Uganda offering opportunity for improved fallows.

Methods. The NGO CARE provided farmers with information of tephrosia and its potential role as an improved fallow. They also provided seed and encouraged farmers to experiment on their own. Similarly, they encouraged farmers to experiment with *Sesbania sesban.* Later, plant samples were collected with which to estimate the amount of N_2 fixed using the ^{15}N natural abundance technique. After one year, CARE staff interviewed farmers about their experiences with improved fallows.

Results: Farmers find the tephrosia fallows to be preferable to the sesbania fallows. Tephrosia fallow was effective in weed suppression and in improving soil tilth and productivity. Tephrosia is easy to establish from seed, easy to manage and prolific in seed production. Farmers noted with appreciation that tephrosia rids their fields of mole rats. The tephrosia is not disturbed by livestock which graze freely during the dry season. Use of the ^{15}N natural abundance technique indicates that tephrosia acquires a larger proportion of its N from the atmosphere than does *Sesbania sesban* on these low pH (4.5) soils. A disadvantage of tephrosia is that it does not produce stakes suitable for support of climbing beans.

Contributors: C. Wortmann; Mwebasa (CARE-Uganda); N. Matheson and K. Giller (Wye)

Fertilizer N application for the maize-bean intercrop system

Rationale: The productivity of the maize-bean intercrop is often constrained by inadequate N availability, but early N application inhibits nodulation of bean.

Methods. The effects of early and late applications of N to the maize-bean intercrop were compared in field trials for productivity.

Results: Similar levels of intercrop equivalent productivity (maize yield plus two times the bean yield) were achieved by applying 5 and 20 kg ha^{-1} N and P at sowing time and applying 35 kg N at the second weeding, as with application of 20 kg N at sowing time and 20 kg again at second weeding (Table 19). Applying a small amount of N at planting time and the major part of the fertilizer N at the second weeding favored productivity of bean, and is expected to favor N_2 fixation (Data for estimation of N_2 fixation is not yet available but other experiences indicate that N_2 fixation is more with delayed N application. The intercrop equivalent was similar for broadcast application and spot-application of N to maize, but spot-application favored maize.

Discussion: With low to medium input levels, application of the major proportion of fertilizer N can be done at the second weeding. This favors bean in the system, and presumably N-fixation, while maintaining over-all productivity. An exception may be where root rots are problematic; then, increased N availability at seedling stage may be necessary for good yield of bean as well as of maize.

Table 19. Mean yields (kg ha^{-1}) for N fertilizer application practices in the maize-bean intercrop.

Fertilizer treatment	Maize	Bean	Intercrop equivalent
No N and P applied	2097 C	435 C	2968 B
20 kg P ha^{-1} at sowing; 40 kg N ha^{-1} at 2nd weeding	2130 BC	479 BC	3088 B
5 N and 20 P at sowing; 35 N at 2nd weeding	2412 AB	593 A	3598 A
20 N and 20 P at sowing; 20 N at 2nd weeding	2284 BC	579 A	3442 A
20 N and 20 P at sowing spot applied to maize; 20 N at 2nd weeding	2632 A	507 B	3647 A
Planting pattern			
100:50 maize:bean plant ratio	2690 A	424 B	3538 A
50:100 maize:bean plant ratio	1933 B	613 A	3159 B

Fertilizers were broadcast applied unless indicated. The results include those of a dry season when mean maize and bean yields were only 1037 and 340 kg ha^{-1}.

Contributor: C. Wortmann

Vetiver grass in living barriers for erosion control

Rationale: Farmers identified soil erosion as a cause of declining soil fertility. As livestock are few in southern Iganga District of Uganda and the living barriers are not expected to be a source of fodder, vetiver grass barriers seemed a likely option.

Methods: Researchers provided farmers with information on vetiver grass and living barriers. They also provided planting material and encouraged farmers to experiment with this option. After 5 seasons, farmers were interviewed to assess the effectiveness of this erosion control option.

Results: All farmers acknowledged the effectiveness of the barriers citing: accumulation of soil in front of barriers and in grass crowns; reduced run-off; less rill formation; and less damage to crops by erosion. Vetiver grass established easily, but in a few cases it was damaged by termites after planting. Farmers appreciated that vetiver did not become strongly competitive with adjacent crops. A few farmers indicated a preference for a grass palatable to livestock. Farmers complained of difficulty in cutting the grass and in up-rooting the crowns to be used as planting material. These difficulties were inhibiting adoption; most farmers had not disseminated the grass to other farmers. Only three farmers had significantly increased the amount of barriers on their farm but they were continuing to plant.

Discussion: Adoption of extensive use of vetiver barriers for the rolling lands of central and eastern Uganda is unlikely. However, there appears to be good potential for use of short barriers to protect the more erosion-susceptible parts of farms. Thrash barriers, and possibly micro-catchments, may be more acceptable for more extensive protection. Work is underway to determine the effects of different types of barriers on soil water dynamics and productivity.

Contributors: K. Kaizzi (NARO); M. Fischler (PASOLAC); and C. Wortmann

Dry bean-annual weed competition as affected by soil nutrient availability

Rationale. Beans often must compete with weeds due to labor and cash constraints in fields of resource poor farmers. Soil fertility management practices may cause bean to be more or less competitive.

Methods. The effects of different fertilizer treatments on the competitiveness of bean with three species of annual weeds (*Galinsoga parviflora*, *Bidens pilosa* and *Solanum nigrum*) was determined. The treatments were NPK, OPK, NOK, NPO, and OOO with broadcast application at rates (kg ha^{-1}) of 50 N, 50 P, and 60 K. Weed treatments included: weed-free, bean + annual weed species for 3 species, and the weed species in sole stand. The field trials were conducted at Cornell University (1996) and in Uganda at NARO Namulonge in 1997 seasons.

Results. Application of K, in the absence of applied P, most favored bean in competition with weeds(Table 20). Bean plants were more erect and tall, and presumably more suppressive of weeds, with these treatments. Bean maturity was also delayed which may have favored yield. Weed growth was more reduced by the absence of P fertilizer than was bean growth.

Preliminary investigations give evidence of high myccorhiza with the NOK treatment.

Discussion. The results are interesting but present a dilemma. Good P nutrition is important for good bean growth and N_2 fixation, while K is not often the most limiting nutrient in bean production areas of Africa. In cases where farmers do not weed beans, the information may be applicable.

Table 20. The effects of nutrient treatments on the yield of dry beans (kg ha^{-1}) in competition with annual weeds for the 1996, 1997A and B seasons.

Fertilizer Treatment	Bean yield (kg ha^{-1})		
	1996	1997a	1997b
000	406 a	172 a	643 a
0PK	1151 b	162 a	624 a
N0K	1574 c	188 a	914 b
NP0	400 a	166 a	668 a
NPK	1052 b	170 a	669 a

Means followed by the same letter are not significantly different at 5% level using LSD

Contributor: M. Ugen Adrogu (NARO)

Nutrient dynamics in climbing bean systems

Rationale: Climbing beans are much more productive than bush beans. Therefore, more nutrients are removed in the harvest, especially if the whole plant is removed. However, climbing beans fix more nitrogen than do bush beans. This research evaluates the sustainability of climbing bean systems in terms of field level productivity.

Methods: Sorghum was used as a test crop in the Kabale highlands (2200 m asl) to compare the effects of alternate crops on the productivity of the subsequent crop. The treatments sown in the first and alternative subsequent seasons were: 1. climbing beans with only the pods harvested; 2. climbing bean; 3. bush bean; 4. Wheat; 5. Non-nodulating bush beans. For treatments 2-5, the whole plant is harvested. Sorghum was sown in the seasons following planting of these treatments. Two of three years of experimentation have been completed, although nutrient analyses for plant samples have been delayed.

Results: Much of the nutrients in stover were in the pod hulls rather than in the stem (Table 21), with relatively little removal in the stem of climbing beans.

Climbing beans produced approximately 1 t /ha more grain than did bush beans in 1996b (Table 22). In 1997b, the trial was mis-managed and the yield results are not reported here. Sorghum yield of 1997a and 1998a was heaviest following climbing beans with harvest of the pods only, and least with climbing bean with harvest of the whole plant. Sorghum yield was more following bush bean than following wheat and the non-nodulating bush bean although productivity of the non-nodulating line was low. The results suggest a significant improvement in N balance where pods only of climbing beans were harvested.

Table 21. Nutrients removed in the harvest in 1996a season by the bean and wheat crops.

	Grain plus stover			Grain		
Treatment	N	P	K	N	P	K
Climbing bean, pods only	113.8	20.3	73.3	89.0	14.5	52.2
Climbing bean, whole plant	121.6	25.2	87.3	101.4	17.4	61.8
Bush bean, nodulating	87.9	16.5	77.1	53.5	8.8	31.9
Wheat	66.4	19.0	53.9	NA	NA	NA

Table 22. Grain yield for bean and wheat in 1996b and the mean yield of sorghum for 1996&7a seasons.

Treatment	Bean , 1996b	Sorghum
Climbing bean, pods only	2714 a	2900 a
Climbing bean, whole plant	2972 ab	2597 b
Bush bean, nodulating	1709 b	2753 ab
Bush bean, non-nodulating	na	2615 b
Wheat	na	2622 b

Contributor: C. Wortmann

Activity 3.2 Development of IPM components

Achievements:

- Through participatory approaches, IPM strategies for bean foliage beetle (*Ootheca* spp.) were developed with farmers in northern Tanzania, better understanding of the pest's biology and phenology was diffused, and this knowledge helped farmers to develop simple management strategies.

- In collaboration with Tanzanian researchers and extension staff, posters on bruchid management in farmers' stores, BSM management and *Ootheca* management were finalized.

- Integration of resistant varieties with organic and inorganic amendments significantly improved yield and reduced root rot severity in Western Kenya. Soil fertility played an important role in crop tolerance to these two constraints.

- The feasibility of controlling root rats with tephrosia has been verified through farmer experimentation.

Participatory development of bean pest management strategies in northern Tanzania

Rationale: IPM approaches are essential for bean stem maggot and for *Ootheca* foliage beetle, since inadequate or no varietal resistance is available. Crop management interventions often require complex decisions by farmers on their own resource allocations, and therefore participatory research (PR) is needed to develop and evaluate options.

Method: We used clusters of farming communities in northern Tanzania in a pilot study of participatory approaches to IPM development and extension with farmers. Elements of these studies are reported also under Output 4.3. For developing strategies for bean foliage beetle (BFB) management, we continued collaboration with the Tanzania national program, farmers and the extension system.

Results and discussion: Last year's activities led to an increase in farmers' understanding of the BFB problem. This knowledge enabled them to identify potential control methods that will suit their circumstances, and to participate actively in the generation of strategies for BFB management (summarised in Tables 23 and 24. The strategies included post harvest tillage, crop rotation, delayed sowing of beans and the application of pesticides such as neem. Experiments this year are summarised in Figures 2 and 3.

Table 23. Farmer group discussion, research activities and research need as identified by farmers

Phase	Discussion points	Activities	R & D needs
1	Discussion on cropping history of sampling sites	Problem identification and analysis. Field sampling of plants, roots and soil for the cause of above ground symptoms.	➢ Pest identification ➢ Life cycle and ecology ➢ Pest distribution
2	Results from research in Phase 1. Potential control strategies	Field visits to monitor on going research activities.	Evaluation of potential control strategies ➢ Post harvest tillage ➢ Crop rotation ➢ Host plant resistance ➢ Insecticide application ➢ Post harvest flooding ➢ Delayed sowing of beans ➢ Insecticide (neem) application.
3	General research results. Strategies for area wide management	Request to local administration to enforce community adoption of area-wide management strategies.	Extension of management strategies with posters, bulletins and farmer to farmer activities.

Table 24. A summary of farmer group discussion on possible control strategies

Strategy	Views for:	Views against:
Post harvest tillage	BFB is not a problem in commercial production system where this is practised.	Hai soils are rocky and post harvest tillage may be difficult.
Insecticide application	➢ Needs research on use of neem. ➢ Needs research on insecticides that can be applied at planting. Use of insecticides will require a collective approach so all farms will be sprayed simultaneously to avoid migration to other fields.	
Delayed planting	May be useful in monocrop beans.	Rainfall distribution may not allow crop to grow to full maturity.
Crop rotation	A potentially good strategy.	May not be practical where fields are small.
Biological control	No knowledge available needs some research to identify possible natural enemies.	

Post harvest tillage (PHT) (Figure 2) reduced adult populations compared with late tillage (LT) and subsequently plants within the caged PHT plots suffered less damage. However, migrants from neighboring LT plots infested and caused more damage to plants outside the cages. Farmers observed that commercial growers that practice post harvest tillage do not have the BFB problem. The deduction was that post harvest tillage exposed the subterraneous form of the insect to the elements and predators and reduced the residual population of the pest. Tillage just before planting facilitated the emergence of the pest from the soil as compared to zero tillage. The following recommendation was reached that PHT should be adopted communally as the pest's ability to fly will render the practice ineffective if applied in isolation.

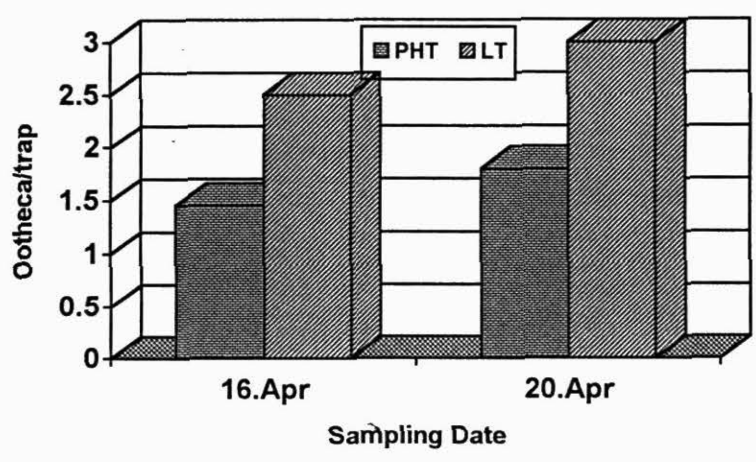


Figure 2. Effect of time of tillage on *Ootheca* abundance in farmers' fields at Hai (PHT - Post harvest tillage, LT - tillage just before sowing)

Crop rotation effects (Figure 3): Maize, beans, cowpeas and soybeans were planted after beans in a plot known to have a high level of residual BFB infestation. BFB emergenced in response to the germinating beans and cowpeas but not to the maize and soybeans (non-hosts) Further evaluation of the potential of BFB larvae to develop on soy bean roots indicated no survival of the larvae. This was a clear indication that growing beans after beans in the same plot permitted the continuous development of BFB and that rotation with non-hosts will help break the cycle.

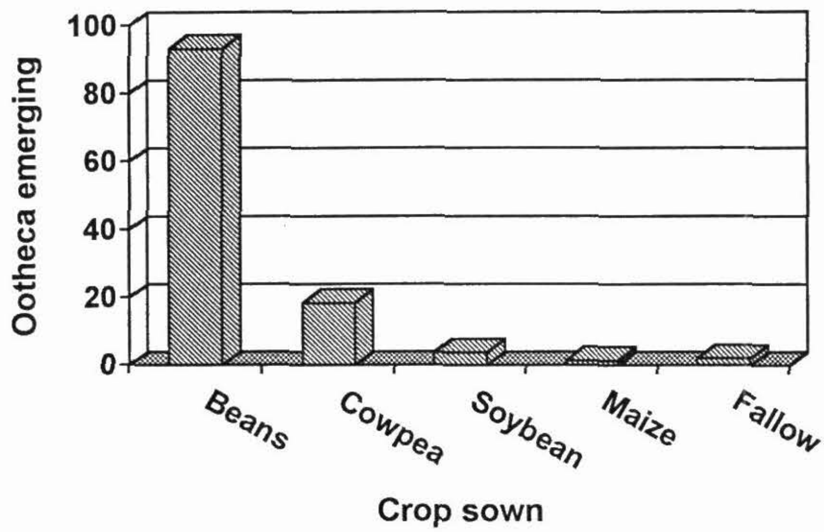


Figure 3. Effect of crop rotation on *Ootheca* abundance in farmers' field.

Delayed sowing of beans to mid-April missed the peak infestations of BFB and were less attacked compared to the March sown crop.Two commercial formulations of neem (Neem Seed Oil and Neem Seed Powder) were evaluated against bean foliage beetles by farmers at Hai as foliar sprays. Both products were very effective in reducing BFB infestation levels for up to 5 days per application.

The farmers worked with us and the Zonal Communications Centre of the National Extension System to present their experiences and strategies for BFB management in a poster for dissemination to other farming communities where BFB is a problem.

Contributor: K. Ampofo

Collaboration with NARS in diffusing IPM strategies to farmers

Rationale: The lack of appropriate information about IPM limits the diffusion of technology. Tanzanian farmers who participated in IPM technology generation observed this and collaborated with researchers and the extension agents to develop extension materials for diffusion to other farmers.

Methods: IPM posters on management strategies for BSM, BFB and storage pests were developed. As an experimental approach for northern Tanzania, Rural Information Centers (depositories for extension information) were created to provide access to information for farmers.

Results and discussion: A local-level farmer led extension service developed, with lead farmer groups helping to set up farmer groups in villages and schools. Such groups were trained in bean production practices, including pest and disease management. For instance, the Patanumbe Traditional Farmers Group set themselves up as seed producers and sold seed of BSM tolerant varieties (e.g. G 11746, PAD 3, Mlama 49) and other released varieties to other farmer groups and also trained them in crop production methods. The Communication Center of the Zonal Extension Service in northern Tanzania is collaborating with us and the National Program to develop a video for use in training extension agents and farmers elsewhere in the region, in crop production and IPM methods developed in northern Tanzania.

Contributor: K. Ampofo

Nutrient sources to enhance crop tolerance to root rot and stem maggot in western Kenya

Rationale: Tolerance to root rots and bean stem maggot is enhanced by improvement of soil nutrients. These studies in Vihiga district of Western Kenya, in association with KARI and AHI, evaluated effects of organic and inorganic soil amendments and their interactions with varieties in the management of bean root rot (BRR) and bean stem maggot (BSM).

Methods: Organic and inorganic sources of soil nutrients were evaluated for effects on crop tolerance to BRR and BSM. Kenyan bean varieties were used: GLP 585 as susceptible to BRR and BSM and GLP x92 and KK-8 tolerant to BRR and BSM. Organic sources of nutrients were 10 tons/ha of green manure (Sesbania) and farmyard manure (FYM), while the inorganic sources were 60kg/ha urea for the supply of N, TSP for supply of P, and DAP for the supply of P and N. The study was conducted in farmers' fields with high levels of BRR and BSM over three seasons using a split plot arrangement where nutrient sources were the main plots while varieties were subplots. Evaluation was based on plant mortality, root rot severity on a scale of 1-9. Larvae and pupae of BSM were counted from 10 plants sampled at 3, 4, and 5 weeks after emergence.

Results and discussion: There was no significant difference in yield between GLP x92 and GLP 585, though both yielded less than KK-8.There was no significant difference between the varieties for root rot and adventitious root score. The bean stem maggot attacked KK-8 more than GLP x92 and GLP 585.

There was significant variety by nutrient interaction for yield, BSM score and BRR scores (Table 25). Significantly higher yields were obtained when FYM was applied on KK-8. Nutrient application significantly improved yield, reduced root rot severity and played an important role in crop tolerance to BRR and BSM. Plant mortality was less with organic sources of nutrient than with inorganic. Nutrients did not significantly affect root rot scores, adventitious root scores and the number of bean stem maggot. The effect of organic amendments may be due to microbial activity encouraging antibiosis, resulting in higher plant survival. Plant survival for GLP X92 and GLP 585 was reduced by more than 55% and 47% respectively when urea was applied. Urea as a source of N was not effective in enhancing crop tolerance against root rots. Root rots, adventitious root development and bean stem maggot were not significant for variety nutrient interaction. Both organic and inorganic sources affected variety performance under root rot conditions.

Table 25. Interaction between varieties and nutrients[1] in the enhancement of plant resistance to root rot and bean stem maggot, western Kenya.

Treatment	Yield (kg/ha)	% plant survival	Root rot severity[2]	BSM count
FYM + KK-8	1098.0	91.3	2.2	1.3
DAP + KK-8	976.5	89.5	4.6	1.1
FYM +GLP x92	924.8	78.7	3.5	1.8
DAP + GLP x92	894.2	56.1	4.0	0.5
GM + KK-8	747.0	83.7	4.8	2.0
DAP +GLP 585	711.8	55.5	5.3	0.6
FYM-GLP585	667.7	84.6	4.0	0.5
TSP + KK-8	638.2	87.2	3.9	2.0
GM +GLP x92	598.3	76.9	3.5	0.6
GM +GLP 585	543.3	77.6	3.8	0.6
TSP + GLP x92	536.8	73.2	3.5	1.0
Urea + KK-8	525.5	69.6	4.0	1.7
Control + KK-8	473.2	71.2	3.9	2.6
Urea + GLP x92	461.2	65.9	4.1	1.0
TSP + GLP 585	363.0	60.6	4.4	0.5
Control +GLP x92	357.0	67.0	3.7	0.8
Urea + GLP 585	325.4	48.7	4.5	0.3
Control + GLP 585	288.9	38.8	4.0	1.0
LSD (0.05)	254.0	6.9	0.7	0.4
CV (%)	15.9	14.4	23.6	48.6

[1] FYM = Farmyard manure; DAP = Di-ammonium phosphate; TSP = triple super phosphate; GM = Sesbania green manure.

[2] Root rot severity at R6 on a scale of 1 - 9 where 1 = resistant, and 9 represents 75% or more of the hypocotyl and root tissues with lesions and advanced decay.

Contributors: R. Otsyula (KARI); J. Nderitu and R. Buruchara

Integrated management of root rots in southwest Uganda

Rationale: Bean root rots have become the most important disease affecting beans in densely populated highland areas including south western Uganda, where in some seasons complete crop failures have resulted. Control measures are needed that are effective, environmentally safe and economical for subsistence farmers. These studies aimed to identify the organisms involved and evaluate cultural and varietal components of IPM.

Methods: A survey was carried out in collaboration with NARO in 10 sub-counties in Kisoro District, Uganda, where root rot incidence and severity were assessed. Root rot causing organisms were isolated from samples collected for identification. Cultural practices evaluated in farmers' fields included application of organic amendments (Calliandra, Sesbania or Acanthus as green manure and farm yard manure (10 tons/ha), and DAP. Other practices tested were planting on ridges, earthing-up and seed treatment with fungicides and/or insecticides. Local and introduced germplasm, and combinations of variety, organic amendments and cultural practices were evaluated for root rot control.

Results and discussion: The survey indicated that root rots alone affected 90% of the plants sampled. *Pythium* spp was identified as the major pathogen causing root rots in Kisoro; *Fusarium* and *Rhizoctonia* were also prevalent. Application of FYM was the most effective practice in improving tolerance of a susceptible variety, based on plant survival and grain yield (Table 26). Inorganic NPK fertilizer was the next best and demonstrated the importance of soil nutrients to plant tolerance of root rots.

Table 26. Effect of soil amendments and cultural practices on root rots in Kisoro, Uganda.

	Plant survival			Grain yield
Management Practice	3 WAP	Pod filling	Root Severity	(kg/ha)
FYM	68	62	7	785
NPK	64	57	7	744
Fungicide + insecticide	52	50	6	415
GM – Calliandra	51	46	7	520
Fungicides	51	48	6	400
GM – Acanthus	44	33	8	425
Ridging	28	16	8	320
Earthing-up	16	12	8	305
Insecticide	8	4	8	225
Control	4	0	9	110

[1] FYM = farmyard manure; GM = green manure.

[2] Root rot severity at R6 on a scale of 1 - 9 where 1 = resistant, and 9 represents 75% or more of the hypocotyl and root tissues with lesions and advanced decay.

There was significant difference among varieties tested. Out of 21 varieties evaluated, those with least plant loss included RWR 719, G 685 (Vuninkingi), G 2333 (Umubano), RWR 1092, Flor de Mayo and MLB- 49-89A. In the later trials to evaluate combination of these resistant varieties with cultural practices, root rots were not particularly severe, but the highest yields were obtained from the climbing beans G 685, G 2333 and Flora when combined with FYM. Among bush beans, RWR 719 gave the highest yield followed by MLB-49-89A and RWR 1092. There was no significant difference between FYM and inorganic fertilizer effects on yield. The best management strategy is the use of tolerant varieties together with soil fertility amendments.

Contributors: . F. Opio (NARO) and R. Buruchara

Farmers in Uganda verify that tephrosia is effective in root rat control

Rationale: Farmers in Eastern Africa identified root rats (mole rats, *Tachyoryctes splendens*) as a priority problem due to feeding damage to sweet potato and cassava, as well as other crops.

Methods: Researchers advised Ugandan farmers of the possible potential of using tephrosia (*Tephrosia vogellii)* in root rat management and encouraged farmers to experiment with it. Farmers collected the seed and proceeded to try it. After five seasons, researchers returned to interview farmers of their experiences.

Results: Farmers planted the tephrosia either as barriers around their fields or as scattered plants in the field. They found it easy to establish, although some farmers experienced damage by goats and chickens. Once established, it survived for years with little maintenance. Most farmers reported that control was achieved within 6 months after planting tephrosia, but some said it may take as long as a year. Lack of damage to crops, root growth into old tunnels, and exposed tunnels left unplugged indicated the absence of root rats from the field. Some farmers were convinced that the tephrosia was killing the root rats; 43% observed dead root rats in the vicinity of the tephrosia. Others suggested that the root rats simply migrated to unprotected fields. All farmers said that they were offering the tephrosia technology to other farmers by informing them of its usefulness in root rat control and by providing them with seed.

Discussion: The tephrosia technology is highly promising and needs to be promoted. Questions arise of the potential of fallows improved with tephrosia for mid-altitude areas, especially on sandy soils where recovery of leached nutrients might be an important benefit of fallows. Success in use of the species in root rat control may facilitate its adoption as an improved fallow.

Contributors: K. Kaizzi (NARO), M. Fischler (PASOLAC) and C. Wortmann

Activity 3.3 Design efficient methods for systems improvement

Achievements:

- A dynamic methodological framework for community-led participatory research has been developed over the past two years.

- Cost-effective research on soil fertility management is achieved through judicious use of alternative research approaches and methods, with varying farmer participation.

- Criteria to be considered in selection of a research approach have been identified.

Test and evaluate participatory research methods within PRIAM sub-projects

Rationale: Methods for collegial participatory research are poorly developed and understood in the region, tend to be expensive and static, and are often confused with demonstrations. The objectives of the PRIAM project are to implement community-based participatory research projects in collaboration with NARIs, extension services and NGOs, to facilitate the institutionalization of participatory research approaches within collaborating institutions, and to refine and develop participatory research methods.

Methods: As farmers manage the multiple components of their farming system in an integrated and dynamic manner, in the PRIAM project we emphasize the need to understand and manage systems in a holistic manner, and emphasize "agro-ecosystem management". Rather than focussing on any specific commodity or thematic interest of the participating researchers, farmers are encouraged to identify and prioritize the problems to be addressed within the research program; the only constraint to addressing a highlighted problem is the availability of the relevant expertise. At each of the nine sub-project sites there is a NARI-based PRIAM research team established to co-coordinate sub-project activities, and a farmer research committee (FRC) was formed to co-coordinate activities. Farmers continued to conduct adaptive testing of a wide range of crops (e.g., bush beans, climbing beans, maize, teff, rice, sorghum, millet, wheat and various vegetables), crop management (e.g., ox-drawn implements, row planting, botanical pesticides) and soil-related (e.g., agroforestry hedgerows, mulching, composting) practices. Among NGOs, CARE and FARM-Africa have been special collaborators.

Results and discussion: A dynamic and "evolutionary" methodological framework for PRIAM has been developed over the past two years to improve collaboration among researchers, farmers and other stakeholders. This framework is characterized by five stages: 1) Participatory Agroecosystem Characterization and Diagnosis (PAC&D), 2) Participatory Research Planning and Experimentation (PRP&E), 3) Participatory Monitoring and Evaluation (PM&E), 4) Participatory Information and Technology Dissemination (PI&TD), and 5) Participatory Analysis of Experience (PAE). So far, most PRIAM refinement of methods has been in the early stages 1-3. Papers analyzing the project's experiences are currently in draft form and will be published collectively by the end of 1998 as the Proceedings of the PRIAM Synthesis Workshop.

Challenges are many. All researchers and extension staff have multiple obligations, but as PR remains a low priority among many institutions, reward systems for those involved in PRIAM sub-projects tend to encourage conventional research and publication of results regardless of relevance to farmers. Innovative researchers interested in PR are often also very competent within their respective disciplines, and find their skills in high-demand from multiple areas ("competition for competence"). While multiple researchers are involved in the implementation phase of a sub-project, just two or three individuals tend to shoulder the responsibilities and NARS have few social scientists available to support any form of PR. The majority of researchers interested in PR are junior level staff, often accorded lowest priority in the allocation of operational resources and in influencing institutional meetings.

Further institutionalization of PR needs: support for the development of national policies supporting PR; formalizing of NARI commitment to PR; and continued support for the evolution of the PRIAM teams, FRCs and the community-based programs; scaling up beyond the pilot sub-projects through efforts led by NARIs, NGOs and communities. Methodological and technical support visits to sub-projects by a PR facilitator are still required in most cases; visits also encourage participating researchers and help to validate or legitimize their efforts within an often non-supporting professional environment.

Refining of PR methods becomes more pronounced the further one progresses through the stages of the PRIAM framework. All stakeholders need encouragement to experiment with PR methods rather than looking for a PR blueprint. Characterization and diagnosis already has a well-developed training workshop and community-based exercises; planning and experimentation has a set of planning exercises but needs additional work on participatory experimentation; monitoring and evaluation requires well-developed exercises drawing on both outsider and farmer knowledge; dissemination requires considerable research on a diversity of channels and means; participatory analysis of experience needs more opportunities for beneficiaries to assess and influence research programs sooner.

Contributor: C. Farley

Cost effective soil fertility research through the integration of methods

Rationale: The substance and levels of knowledge of farmers and researchers vary for different aspects of soil fertility management, and this needs to be considered in determination of the most efficient research approach.

Methods: Experiences gained in Eastern Africa through the use of diverse adaptive research approaches and methods in soil fertility management were subjectively accessed.

Results: In some areas, such as in the integration of plant species into their cropping systems, farmers have much knowledge which can be treated as an essential element of an efficient adaptive research activity. An example is work on the use of tephrosia for improving fallows (reported on elsewhere in this document). The researchers may have a role in providing information and planting material to farmers, and then later evaluating the results for the sake of extending the information more widely.

In other areas, the knowledge base of farmers is very weak and has little to contribute to a research effort. In Uganda, we found this to be the case with use of fertilizers and inocula. In such cases, researchers lead the effort and designed the trials, while farmers participate in implementation and evaluation of the results.

Our experience indicates that the integration of approaches is most cost-effective, but also strengthens the participatory research effort.

Contributors: C. Wortmann; K Kaizzi (NARO)

Criteria for selection of a research approach

Rationale: More or less participatory approaches may be most appropriate for different situations. Researchers must select an approach which is efficient and effective.

Methods: Experiences in more and less participatory research approaches were assessed to identify and elaborate on eight conditions that influence the effectiveness of participatory approaches.

Results: The eight conditions to consider are:
1. The extent of farmer knowledge of a topic.
2. Transparency of the problem to farmers.
3. The genetic diversity of a species in the farming system.
4. Complexity of environmental conditions and farming system.
5. Reliability of rainfall.
6. Dynamism of the agroecosystem.
7. Time required to address a problem.
8. Availability of institutional support.

Discussion: A challenge is enable researchers to better choose amongst possible research approaches and methods in consideration of these conditions.

Contributors: C. Wortmann and C. Farley

Activity 3.4 Inter-center and ecoregional linkages

Achievements:

- CIAT, TSBF and IBSRAM have initiated a DFID-funded project to improve the utility of information of organic resources for soil fertility management.

- Participatory approaches and skills were initiated between selected communities and research teams at most benchmark sites of the African Highlands Initiative (AHI), the ecoregional consortium for Eastern Africa.

- Three-year plans for enhancing the performance of seed systems of priority crops, forage and tree species at three AHI sites are being catalyzed with site partners.

Development of a decision support system for using organic resources in soil management

Rationale: Much information on organic resources has been collected. The resources differ in quality, decomposition and nutrient release rates, and in how they might be used in soil management. Adequate decision support is expected to lead to greater success in the use of organic resources either through use of the decision support system by producers and extensionists, or through use by researchers in the development of better area-specific recommendations.

Methods: Data on organic resources available from TSBF has been compiled in collaboration with Wye College. Additional data from Latin America (CIAT) and Asia (IBSRAM) will soon be incorporated into the database. A decision support system is to be developed and verified.

Results: Forthcoming.

Discussion: Integration of information of organic resources and their use, is expected to elucidate future research priorities. The decision guide will be useful in conducting adaptive research aimed at developing area-specific guidelines for integrated nutrient management.

Contributors: C. Wortmann; C. Palm (TSBF); R. Delve (CIAT Project PE1)

Participatory research and seed systems in the African Highlands Initiative (AHI)

Rationale: AHI, the ecoregional program for Eastern Africa led by ICRAF and operating as a network under the auspices of ASARECA, focuses collaborative work by IARCs and local partners on solving soil degradation and other natural resource management problems at 8 benchmark sites across five countries. Partners agreed that in the second phase starting this year, more emphasis should be placed upon community-level research, and CIAT has taken responsibility for catalysing this aspect as well as providing support to the development of functioning seeds systems.

Methods: Training workshops in participatory research methods are being conducted this year with selected communities and the research teams at three AHI sites: Kabale (Uganda), Lushoto (Tanzania) and Areka (Ethiopia). These workshops are being modeled on those successfully used in starting up PRIAM sites, with added emphasis on identifying farmers' knowledge of NRM. A concept paper for guiding PR work within AHI is also an expected product this year.

Stakeholder planning meetings for designing seed system interventions and to identify research needs for filling information gaps especially in crops other than beans, are being conducted this year for Embu and Kakamega areas of Kenya, Areka and Ginchi areas of Ethiopia, and Kabale in Uganda. The commodities of immediate interest for seed system development include beans, potato, forages, agroforestry species and high-value trees, in collaboration with CIP, ILRI and ICRAF.

Results: To follow, since field activities start in October 1998.

Discussion: Leadership for these technical themes within AHI represents a very important and visible capitalization upon our traditional bean commodity mandate, and an extension of many of the experiences and lessons learned with bean in a systems context to a broader definition of systems and a wider set of partners.

Output 4. Technology adopted

Activity 4.1 Document local diffusion systems for technology and develop innovative seed systems

Achievements:

- Malawi Bean Program's dissemination activities for new varieties is already being seen as a model by other countries. Smallholder farmers having valley bottom land suitable for winter (dry season) production have very successfully produced good quality seed. Seed sales through grocery stores, extension staff and NGOs have been promoted though an aggressive advertising campaign.
- Approximately 750 tons of seed for four bush bean varieties, released since 1995, were produced and marketed by the formal seed sector in Uganda.
- Uganda stockists are selling tephrosia seed for root rat control

Seed multiplication and dissemination strategies in Malawi

Rationale: To accelerate adoption of new bean varieties within Malawi and provide a successful case study for the many other countries in Africa where the formal sector has no commercial interest in, or cannot be relied upon, for addressing farmers' legume seed needs.

Methods: The BIP increased the number of smallholder farmers contracted for winter-season seed multiplication of improved bean varieties from 45 in1996 to 145 in1997. In Winter 1998, BIP continued contract multiplication of seed in Nkhotakota and Salima Rural Development Projects (RDP); farmers in Tembwe participated for the first time.

The seed produced was disseminated using a range of methods, which this year were strengthened by various promotional strategies. The BIP produced brochures, leaflets and posters, which were distributed to all the selling points and all extension areas. Brochures were given to all field assistants, providing technical production information and attributes of the six released varieties, to assist farmers in choice of varieties.

Results and discussion: Remarkable, nearly 40 tonnes of seed, almost five times more than the previous year, were produced, for five of the six released varieties (Maluwa, Kambidzi, Mkhalira, Napilira, and Sapatsika). A further 25 tonnes are expected.

Table 27 summarizes the distribution of leaflets, posters and brochures. Posters, and separate leaflets on each released variety, were given through the Agricultural Development Divisions (ADDs). Brochures were to be given to every field assistant in the country. Apart from these publicity materials, the BIP used radio messages through the existing agricultural programs, and special radio advertisements to create awareness among farmers of the existence of seeds of improved bean varieties at specified selling points. The radio programs were conducted to reach as many people as possible, particularly those who cannot read.

Table 27. Distribution of promotional materials on new bean varieties in Malawi, 1997-98.

Agricultural Development Divisions	Posters	Leaflets [1]	Brochures
	Numbers in Tumbuka language		
Karonga	15	90	130
Mzuzu	19	114	234
Kasungu	4	24	0
SCA	4	24	23
Member of Parliament	100	0	0
	Numbers in Chichewa language		
Kasungu	25	150	249
Lilongwe	35	210	400
Salima	16	96	149
Machinga	32	192	339
Blantyre	66	396	277
Shire Valley	14	84	181
Member of Parliament	400	0	0
Total (both languages)	588	1128	1595

[1] Equal numbers of leaflets produced for each of six varieties

For sale, the seed was packaged in three packet sizes (100g, 250g and 500g) to accommodate needs and capacities of people of different socio-economic status. The seed was treated with copper oxychloride to protect it from pre-emergence fungal attack; its color also deterred people from using the bean seed as food. The number of selling points has been increased since 1996, in order to bring seed closer to the farmer. Besides selling points in bean growing areas where the BIP was conducting on-farm trials, some independent areas were identified by the project itself or by collaborators in the ADDs. Seed dissemination was also carried out through research stations, government agricultural extension agents, NGO extension agents, grocery shops, village groups, a maize mill and schools in the four ADDs of Blantyre, Lilongwe, Kasungu and Mzuzu.

The number of selling points varied from one ADD to another, and was decided by the collaborators. Mzuzu ADD had 29 selling points of which 15 were small traders, 4 were NGOs and 11 were extension staff. Kasungu ADD had 6 selling points: 2 were extension staff, one grocery shop, one school, one village group and one maize mill. Lilongwe ADD had 9 selling points: 5 were extension staff, 3 grocery shops and one village group. Blantyre ADD had 4 selling points: 3 extension staff and one grocery shop. Some seed was sold directly from the BIP office (8.7 tonnes), particularly for large quantities requested by NGOs and medium scale farmers. Some NGOs gave the seed out on loan to their beneficiaries for further multiplication; the seed recovered from these beneficiaries was given to other farmers in subsequent seasons, helping the acceleration of the transfer. Lunyangwa Research Station in the north and Bvumbwe Research Station in the south were additional sites where seed was sold.

The seed was delivered to selling points by the BIP, and was supplied on loan to the seller on condition that the seed remained the property of the BIP and the seller was accountable for the seed. Deliveries were made from the middle of November, 1997 for the summer crop, through to April, 1998 in some areas having a winter crop. Posters and leaflets were delivered to each selling point in order to provide more detailed information about the varieties, and radio advertisements created awareness of the availability of seed at idenified selling points.

In total, more than 12 tonnes of seed for the six released varieties was distributed to the selling points in the 1997-98 crop season. More than 51% of the seed (6.1 tonnes) was sold. Small seeded varieties, which are less popular among farmers, were slower to sell; thus only one-third of the seed had been sold for the small-seeded Kambidzi and Mkhalira.

Contributors: V. Aggarwal; M. Maideni, T. Ngwira and R. Chirwa (DARTS)

Provision of seed of improved varieties to Ugandan farmers

Rationale: Several improved varieties have been released in Uganda. Seed of these varieties need to reach farmers and enter the local systems of seed increase and distribution to achieve the benefits associated with the varieties genetic potential. CIAT's interest in following this activity is due to its being one of the few formal seed systems interested in beans in Africa.

Methods: Seed has been produced and supplied to farmers using a variety of approaches. Not least are the efforts of the Uganda Seed Project which contracts small-scale farmers to produce the seed on the foothills of the Rwenzori Mountains. The seed is then processed and marketed either directly to various organizations or through a system of 120 seed agents. The seed is expected to find its way into local seed systems.

Results: Gradually increasing supplies of bean seed have been supplied to farmers (Table 28). The Uganda Seed Project estimates that about 50% of the seed is purchased by organizations and associations for development or seed relief efforts, and the remainder is sold to farmers through seed agents. This achievement has not been without problems, i.e. the Project needed to replace much seed of K132 in 1998 due to poor quality.

Discussion: The Uganda Seed Project is to be privatized soon. We hope that sufficient basis has been established that formal sector bean seed production and marketing, which is unusually active in Uganda, will be sufficiently lucrative for the future seed company to continue with beans. If they continue, a challenge will be to further improve the integration of the large-scale seed sector with local seed systems and other seed supply activities. These include small-scale activities of farmer groups, as well as other medium-scale efforts which tend to be NGO-lead (e.g. Irish Aid Foundation in Rakai and Masaka Districts).

Table 28. Seed supplied by formal seed sectors to Ugandan farmers of four varieties released since 1995.

Year	K131 to farmers	K132 to farmers	MCM 2001	MCM 1015
1993	0.1	0.1	0.02	0.02
1994	2.0	0.6	0.04	0.04
1995	8.5	2	0.8	4.6
1996	80	10		
1997	205.5	44.5	4.5	5.9
1998	275	100[1]	10	25

Contributors: C. Wortmann, H. Gridley; and F. Muhuko (Uganda Seed Project)

Dissemination root rat management technology

Rationale: The shrub Tephrosia has been verified as effective in the management of root rats, which burrow in crop fields and have been identified as a priority problem by farmers in several areas of Eastern Africa. Demand for the technology is high.

Methods: In collaboration with the USAID-funded IDEA Project in Uganda, the root rat management technology is being promoted by providing stockists of agricultural inputs with simple brochures and tephrosia seed (50 g packets).

Results: Demand for the seed far exceeds the current supply. Five thousand copies of the brochure have been printed. Overall the adoption rate appears to be very high.

Discussion: This achievement may soon offer opportunity to explore with farmers the use of tephrosia in improved fallow for mid-altitude areas. In using tephrosia for root rat control, farmers will gain experience with the species and seed supply will improve, setting the stage for adaptive research on improved fallows.

Contributors: C. Wortmann; K. Kaizzi (NARO)

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[1] In 1998, much of the K132 seed was of poor quality. In the calculations, I have used 70 t supplied to farmers, assuming that 30 t were bad.

Activity 4.2 Promotion of crop and pest management options

Achievements:

- Participatory research between farmers and agricultural engineers in an Ethiopian PRIAM site has resulted in local acceptance of a row planter, a modified-moldboard plow and an inter-row weeder adapted for use with the traditional ox-drawn wooden plough.

- Valuable lessons in promoting farmer-to-farmer extension have been learned from monitoring a farmer group in northern Tanzania that has been involved in IPM research and then assisted other groups to organise and to acquire bean technologies.

- Drama shown to be an effective approach for extending messages to large audiences and changing agricultural practices.

Available technical options are promoted and tested within participatory research projects

Rationale: The PRIAM project is concerned with improving the research process and empowering farmers, but can only sustain the interest of farmers if they find it useful in practice.

Methods: We highlight here only one technical case of participatory research products from the PRIAM sub-project with EARO at Wulenchiti, Ethiopia, in a farming system characterised by labor constraints, broadcast seeding and low-output monocropping.

Results and discussion: Researchers formed a dynamic partnership with a farming community to evaluate and refine agricultural implements. A range of simple implements have been adapted for use with the traditional ox-drawn *maresha* plough, including a row planter, a modified-moldboard plow and an inter-row weeder (which also can be used as a sub-surface weeder that helps to conserve soil moisture). These implements have been developed and refined through an iterative research process, whereby researchers have provided farmers with prototypes to be field tested, and then modified the implements according to farmer observations and preferred criteria.

Successive generations of the implements have been produced and tested, and acceptable versions are now available. Now opportunities to mass-produce the three implements locally are being sought, and there is interest in testing them with farmers in other PRIAM sites.

Farmers at a number of the PRIAM sites have begun to adopt new crop varieties, which tended to be their first preferred area for cooperation with researchers before mutual confidence had been established. Crops included climbing beans, sorghum, teff and maize for improved yields, and bush beans for resistance to root rot.

Monitoring and evaluation of IPM development with small farmers in Tanzania

Rationale: IPM approaches usually involve a judicious integration of complementary components, of which many details must necessarily be selected by farmers themselves according to their resources and are likely to be situation specific. Participatory methods are needed for both IPM research and extension.

Methods: We worked in collaboration with farmers in Mbuguni Division of northern Tanzania, as a possible pilot study. The initial farmer research group (see also Section 3.2 above) was formed spontaneously as the Patanumbe Traditional Farmers Group (TFG), to share their newly acquired technology with other farmers in the community. They appointed an individual to work closely with CIAT to diffuse technology to other farming communities in the Mbuguni Division. In the process 12 farmer research groups (including four based around local schools) formed to participate in IPM technology generation. Among the activities this year were yield evaluation of BSM tolerant lines (market potential was as important to them as yield enhancement) and further identification of production constraints in the wider community (farmers recognizing low quality in bean yield were assisted to identify their pest and disease constraints as BCMV, spiny brown bugs (*Clavigralla* spp.) and aphids). Thus extension training led back to new participatory trials.

The involvement of rural schools in technology diffusion will help increase the rate of diffusion as each student will take the new technology to their homes and teach their parents. It also helps to create a new set of better-informed farmers for the future. The teachers could also use the new information to train the village community.

The farmer trainers were trained and supported with training materials. Training in bean production practices and IPM strategies were initiated in three local schools. Seed of BSM tolerant lines were multiplied and sold to other farmers through smallscale farmer seed enterprises. Village Information Centers were established as depositories of extension information that furnish farmers with extension information on IPM and other crop production activities.

At the end of the season a participatory performance analysis was carried out on all activities of the season. The result of the analysis is summarised in Table 29. The approach used was to enable the farmers to understand problems that affect productivity in their farming systems and help them to develop solutions through research. This approach stimulated farmers' initiative and confidence in themselves, and initiated further activities to share experiences with other farmers.

Farmer-to-farmer extension emerged as a feature from this study. Farmers were willing to share useful information and encouraged other farming communities to experiment with the new technologies they had acquired. They invited village communities to visit and rate the performance of the new technologies. Visiting farmers requested seed of varieties that they selected, and Patanumbe -TFG multiplied and sold seed to them and offered them practical training in bean production. This free advice was apparently offered to ensure that the purchasers obtained the advertised yields.

Contributor: K. Ampofo

Table 29. Participatory evaluation of production performance by farmer groups in northern Tanzania.

Aspect	Performance	Follow up actions
Crop growth	Crop growth was vigorous and productive, due to good management strategies (timely weeding and irrigation)	Need information on fertility management for stable production
Pests	BSM tolerance was better than in the local variety and in Lyamungu 90. Other pests e.g. pod sucking bugs, were not controlled, which affected quality of the harvest (seeds sunken, scarred and blemished). Rat damage more severe than expected, affecting some varieties more than others	Need information on pests: identification, damage and management, esp. pod sucking bugs and BSM
Diseases	Crop generally disease free but some varieties suffered from white mold; this was attributed to dense crop canopies in affected varieties. BCMV attack was high in some personal fields	Need information on diseases: identification, damage and management, esp. BCMV. Rogue BCMV infected plants
Yield	Yields were increased beyond expectation, but could have been better if pests and diseases had been adequately controlled	Take actions to improve yield and seed quality
Sale of produce	Could have been better. Quality of seed was poor. Much seed was sold cheaply after harvest; offers at double the price later in the season met little availability. Nearly all seed of G 11746 was sold in response to demand, not a good practice	Improve seed quality and manage seed sales efficiently. Do not sell seed from BCMV infected plots. Always separate seed for next season's planting from seed for sale.

The appropriateness and effectiveness of drama as an extension tool in Uganda

Rationale: Non-conventional, culturally appropriate communication methods and tools are needed to popularize improved agricultural practices. Drama has rarely been used in Africa as an agricultural extension tool and few studies investigate the effectiveness of the method. In 1996, CIAT and ICRAF initiated a drama project in Uganda in collaboration with Ndere Dance Troupe, a professional Ugandan drama group and two local farmer groups, and support from AHI and a USAID/CIP-supported regional technology transfer project. This study with University of Guelph, which received financial support in Canada from the Environmental Capacity Enhancement Project (ECEP) and was supplemented by an AHI grant to CIAT, investigated the impact of that project.

Methods: In 1997-98, formal surveys were conducted with 70 farmers in four communities in Kabale District and with the Abekundire women's group (the group trained by the Ndere Troupe) to assess the impact of the plays on farmers' behavior and on community capacity building. Technical messages focussed on climbing beans and the use of agroforestry.

Results: An estimated 13,000 people watched six performances of the play developed by the Ndere Troupe and the Abekundire group. The majority (68%) of farmers surveyed reported learning something new from the play and 65% adopted at least one of the relevant agricultural practices. Adoption of climbing beans was greatly hampered by the limited availability of seed. Men valued the entertainment aspect of the performance primarily, while women, the principal farmers in this area, emphasized the technological messages. Considerable support (financial, training in acting and management) is needed to develop local capacity for drama.

Discussion: Drama can be a powerful, effective complementary tool for promoting agricultural messages. Three conceptual models: researcher-driven, farmer-driven and community driven, based on linear or interactive communication models, are relevant to agriculture but would involve different partnerships.

Contributors: J. Munro (University of Guelph); S. David

Activity 4.3 Develop improved methods for documenting social and environmental impacts

No progress made this year.

Activity 4.4 Adoption and impact of bean research

Achievements:

- Climbing beans are now widely adopted in highland areas of Kenya and Uganda, and have continued to grow in popularity in Congo and Rwanda; this milestone for 1998 has been achieved.

- Modest adoption of the variety Lyamungu 90 was achieved in Bukoba District, Tanzania, six years after limited seed distribution. The varieties Lyamungu 85 and 90 are well established in markets in Northern Tanzania.

- Adoption of Lyamungu 85 is expected to save Tanzanian farmers 10% of annual fuelwood consumption.

- New bush bean varieties improve food security and lessens women's work in Mbale, Uganda

Climbing bean systems are widely adopted in Kenya and Uganda

Rationale: A milestone for the Project in 1998 was to be widespread adoption of climbing beans in Kenya and at least one other country.

Methods: Adoption of climbing bean varieties originally diffused in Rwanda has been monitored primarily by national program partners, through subprojects of ECABREN.

Results: A followup study in Western Kenya in 1996 showed that 1000 farmers were growing one or more of the set of five climbing bean varieties first disseminated there four seasons before. A similar study this year in Central Kenya, where seed dissemination started only in 1996, showed approximately 1700 farmers across six districts now growing them and finding such demand that individuals were able to sell on at a price of KES 1 (US$0.02) per seed!

Discussion: The same varieties are starting to be adopted in Tanzania and Zambia, are being evaluated with farmers in Ethiopia, and introductions are being made in Malawi and elsewhere in southern Africa. Widespread adoption based on a set of only five varieties also brings risks. The first new regional nursery of climbing materials since 1993 was distributed by Rwanda and CIAT this year. Breeding capacity to address diversity in climbers is still a concern, however, since the Rwanda program is still emerging from the genocide and most bean breeders, including CIAT's, are not located in environments conducive for climbing beans.

Contributors: R. Kirkby and S. David; J. Muthamia, R. Otsyula and B. Salasya (KARI)

Adoption of Lyamungu 90 in Bukoba District, north-west Tanzania

Rationale: As an intermediate indicator of research impact, varietal uptake needed to be assessed six years after 120 kg of seed of the bean variety Lyamungu 90 was distributed to three districts in Kagera Region of Tanzania.

Method: A formal survey was conducted among 300 randomly selected households in six villages in Bukoba District. Half of the sample was drawn from villages where seed was distributed to farmers directly or through on-farm trials conducted in the late 1980s and early 1990s; the rest came from neighboring villages.

Results: Eleven percent of the sample planted Lyamungu 90, a Calima seed type, in the second season of 1997. Adoption was higher in villages where trials or seed distribution had taken place than in neighboring villages (15% compared to 7%). The major reason for disadoption (16% of the total sample) was lack of market, seed loss due to storage pests and household consumption. Households growing Lyamungu 90 mentioned increased income (55%) and improved food security (22%) as important benefits. In the second season of 1997, surveyed households accrued a mean income of $16 from the sale of Calima types (Lyamungu 90 and/or Rosecoco) compared to $13 for other bean varieties.

Discussion: Though modest, this level of adoption is commendable in view of several factors: a strong preference by Bukoba farmers for small seed bean varieties rather than calimas, limited seed distribution and the lack of systematic promotion of the new variety. Modest adoption rates of an appreciated variety like Lyamungu 90 emphasize the need for repeated seed distribution efforts and the importance of putting in place sustainable seed provision systems. Results also suggest that demand for a new, marketable variety may be depressed when only a few farmers produce small quantities due to limited seed availability.

Contributors: S. David; L.Mukandala and J.Mafuru (DRT)

Adoption of Lyamungu 85 and environmental impact in northern Tanzania

Rationale: To assess the adoption, diffusion and environmental impact of Lyamungu 85 in Northern Tanzania, as part of the ECABREN network's strategy to assist member countries in documenting the value of investing in bean research.

Methods: A survey was conducted of 164 randomly selected farm households in Arumeru and Babati Districts in 1995. Seventy-five households had been involved in on-farm varietal trials or had been given seed of the variety in the late 1980s/early 1990s. Data from on-farm varietal trials and other farm surveys were also used.

Results: Adoption was significantly higher in villages where trials had been conducted. There was limited spread of the variety from villages where trials had been conducted. Bean production in northern Tanzania is predicted to increase by 473 tons if only 10% of farmers switch from planting Canadian Wonder to Lyamungu 85. Adoption of Lyamungu 85 was estimated to save rural households in northern Tanzania 176 kg per annum of fuelwood, a savings of approximately 10% of annual fuelwood consumption.

Contributors: E. Nkonya, P. Ndakidemi and C. Mushi (DRT); D. Norman (KSU); S. David

A market survey to assess the adoption of Lyamungu 85 and 90 in Northern Tanzania

Rationale: Several household surveys have been conducted on the adoption of Lyamungu 85 and 90 varieties in Tanzania. A market survey is a cost-effective, indirect way of assessing adoption nearly a decade after the release of the two varieties.

Method: Twelve markets in Arusha and Kilimanjaro Districts were visited and 74 sellers interviewed in August 1997. Data from other surveys of farmers and consumers were also collected. The study was commissioned by ECABREN.

Results: Preliminary results indicate that Lyamungu varieties were well established in markets in Arusha and Kilimanjaro: 31% and 44% respectively of traders interviewed stocked the variety. In Kilimanjaro, the varieties commanded 14% of traders' market share compared with

4% in Arusha. Traders in Arusha gave varying accounts of ease of marketing the varieties, while the majority in Kilimanjaro (60%) rated the varieties as fast selling.

Discussion: We generally take market availability of a new variety as the point at which the variety can be considered established, without need for further seed distribution.

Contributors: M. Kamau (KARI); S. David; with staff of Tanzanian Bean Program

Impact of K132 and K131 on household food security in Mbale District, Uganda

Rationale: Few studies examine the impact of new crop varieties on household food security and food consumption patterns. The study sought to investigate the impact of two distinct CIAT-bred bean varieties released by Uganda in 1994: a highly marketable calima type (CAL 96, released as K132) and a carioca type (MCM 5001, released as K131) having limited market demand.

Methods: Twenty-one randomly selected households which had grown the two bean varieties for 6 or fewer seasons were surveyed in April 1998. Twenty-two non-adopting households in a neighboring village were also interviewed. The study forms part of a wider strategic study on social impact initiated in 1995.

Results: Preliminary analysis of the survey data suggests that adoption of both new varieties, but K 131 in particular, had improved food security during periods of food shortage. A higher percentage of adopters compared to non-adopters had beans in storage in April (a period of food shortage) and expected their stored beans to last for a longer period (Table 30). This difference may be attributed to the higher yields of the new varieties as well as to other unrelated factors (e.g. the higher proportion of poor households among the sample of non-adopters). K132 is estimated to have a 36% yield advantage over K20, a widely grown calima type. Adopters of the new varieties reported an increase in the frequency and amount of beans consumed due to higher yields (Table 31). The latter was confirmed by significant differences between adopters and non-adopters in per capita bean consumption ($P < 0.001$) and the mean amount of beans cooked in mixture dishes ($P < 0.03$). Some farmers grew K131 specifically as a food security crop due to its high yields and low market demand. Others used income from K132 to diversify their diets or to buy more beans. The variety fetches a farm-gate price of US$ 0.28 to 0.33/kg compared to U.S$0.23 to 0.28/kg for K20. Both new varieties, but K131 in particular, have reduced women's work load in gathering wild vegetables during the dry season (Table 32).

Discussion: The results suggest that a non-marketable, unfamiliar seed type may have greater positive impact on household food security and women's labor than a more marketable variety. In Mbale, women have shown a greater interest than men in growing K131. There is evidence also that in some cases the introduction of marketable new varieties such as K132 may lead to increased sale of beans if higher prices are offered, with negative implications for household food security. Increased commercialization of bean production stimulated by a new variety may lead to increased male involvement in bean production and control over income from beans.

Table 30. Availability of beans among adopters and non-adopters of two new bean varieties in Mbale, Uganda, in April, 1998 (per cent).

	Adopters (N=21)	Non-adopters (N=22)
Has stored beans	76	54
Stored beans sufficient for 2 months	69	100
Stored beans sufficient for >3 months	31	0

Table 31. Farmers' perceptions of the impact of new bean varieties on food security in the dry season, Mbale, Uganda (per cent).

	K 132 (N=18)	K 131 (N=11)
Have stored beans during dry season, before had none	56	73
Eat beans more frequently	56	55
Eat larger quantities of beans	28	36
Use sale of new variety to buy other food	39	0
Use sale of new variety to buy beans	6	0
Other	39	9

Table 32. Impact of new bean varieties on women's labor in gathering wild vegetables during the dry season, Mbale, Uganda (per cent).

	K 132 (N=20)	K 131 (N=16)
Spent less time gathering wild vegetables	50	38
Stopped gathering wild vegetables	5	13
Can't comment yet	10	31
No change	35	19

Contributor: S.David

The impact of K132 and K131 in Mbale, Uganda

Rationale: Assessing the impact of new crop varieties is a complex exercise, which requires going beyond documenting change in yield and production. In the absence of reliable national production statistics and recent information for characterizing producers and consumers, both qualitative and quantitative baseline data are needed.

Methods: In 1995 baseline information was collected on bean production, consumption, sales, household organization of production in two impact monitoring sites in central (Mukono District) and eastern (Mbale District). Farmers were also involved in identifying impact indicators using participatory rural appraisal techniques. Between 1995 and 1997, over 800 kg of seed of K132 and K131 were sold to farmers in 8 communities. In September1998, 100 adopters of the new varieties were surveyed in Mbale District to assess their impact. A second sample of 100 households in 3 neighboring villages was interviewed to investigate the rate of varietal adoption.

Results: Not yet available

Contributor: S.David

Adoption of K131 in Iganga District, Uganda

Rationale: Adoption studies are often hampered by the lack of extensive seed distribution. In 1996, the USAID-sponsored IDEA Project in Uganda distributed 22 tons of K131 seed to 250 women's groups in Lukaa County, Iganga District; approximately 4100 farmers received 5 kg of seed. This large-scale seed distribution effort provides a rare opportunity to study the uptake of a new bean variety in Uganda.

***Method*:** A formal survey will be conducted in October 1998 by an MSc economics student from Makerere University, to investigate the adoption of K131 and assess the distribution method used.

Results: Not yet available

Contributors: E. Kato; S. David; and T. Hyuha

Activity 4.5 Propose policy reforms that facilitate technology adoption

No progress made this year, but several contributions have been made to the development of the strategy and longterm workplan of the new Eastern and Central Africa Policy and Planning Network (ECAPAPA) of ASARECA. Areas of common interest include national seed policies and regional transfer, and impact assessment methods.

Activity 4.6 Investigate and publicize new market opportunities and products

This activity has been developed and is being carried out entirely within the ECABREN network, which reinforced these aspects in its new five-year strategy (see Section 1.1 above for rationale and activities).

PUBLICATIONS

Refereed publications

Abebe, A., M.A. Brick and R.A. Kirkby. 1998. Comparison of selection indices to identify productive dry bean lines under diverse environmental conditions. Field Crops Research 58:15-23.

Allen, D.J. and R. A. Buruchara (eds.), 1998. Proceedings of the 2nd Pathology Working Group Meeting on fungal diseases. Kakamega, Kenya, 5-8 June 1995. CIAT African Workshop Series No 37. 165 p.

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Ampofo J.K.O. and Said M. Massomo, Some Cultural Strategies for the Management of bean stem maggots (Diptera: Agromyzidae) on Beans in Tanzania. Accepted by the African Crop Science Journal.

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Buruchara, R.A. 1998. Regional collaboration checks bean root rots in Kenya. AgriForum No 3:14-15.

David, S. and L.Sperling. Improving technology delivery mechanisms: lessons from bean seed systems research in Eastern and Central Africa (accepted by Agriculture and Human Values). OK

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Musoni, A. and R. A. Buruchara. 1998. Transfer of root rot management technologies in Rwanda. Paper presented in the 3rd Pathology Working Group Meeting. Thika, Kenya, 25-28 May 1998.

Wortmann, C.S. 1998. An adaptation breeding strategy for water deficit in bean developed with the application of the DSSAT3 Drybean Model. African Crop Science Journal (in press).

Wortmann, C.S. and C.K. Kaizzi, 1998. Nutrient balances and expected effects of alternative practices in farming systems of Uganda. Agriculture, Ecosystems and Environment (in press).

Wortmann, C.S., M. Silver-Rwakaikara[1] and J. Lynch. 1998. Efficiency of nitrogen acquisition and utilization in common bean (*Phaseolus vulgaris* L.): mechanisms and genetic variation. African Crop Science Journal (in press).

Wortmann, C., Buruchara, R. A. and C. Eledu. 1998. Distribution of common Bean root rots in Sub-Saharan Africa. Bean Improvement Cooperative 41: 212.

Other publications

Annual Report of the Malawi Bean Improvement Project. 1996-97.

Ampofo J.K.O. and S.M.S. Massomo, Participatory IPM development and extension in northern Tanzania, PRIAM Synthesis Workshop, Nazreth, 16-22 August, 1998.

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Invited Book Chapter

Allen, D. J., Buruchara, R. A. and J.B. Smithson. 1998. *Diseases of Common Bean.* pp 179-265. In D.J Allen and J.M. Lenne (eds.). The Pathology of Food and Pasture Legumes. CAB International, Wallingford. 750 p.

WORKSHOPS AND CONFERENCES

Annual Plenary Session of Special Program for African Agricultural Research (SPAAR), Arusha, Tanzania, 22-27 February 1998.

Consultative Workshop on Seed Relief in Kenya, KARI, Nairobi, Kenya, 13 March 1998.

Natural Resources Management Workshop, ICRAF, 27-29 April 1998.

Implementation Workshop on Participatory Research for Agro-Ecosystems Management (PRIAM), Mulungu, D.R. Congo, 11-20 May, 1998.

Bean Pathology- Breeding monitoring tour, Rwanda, Uganda and Kenya. 17-24 May 1998

BILFA and Soils Research Monitoring Tour. Congo, Rwanda, Uganda, Kenya, 17-24 May 1998

AHI Steering Committee Meeting, ICRAF, Nairobi, Kenya, 12 May 1998.

Review Workshop for FARM-Africa Farmers' Research Project. Soddo, Ethiopia, 18-23 May.

3rd Pathology Working Group Meeting, Thika, Kenya. 25-28, May 1998.

AHI Technical Support Group Meeting, Embu, Kenya, 29-30 June 1998.

Monitoring Tour to Uganda for staff of ActionAid/Malawi Seed Project, 29 June – 3 July 1998.

7th International Conference on Plant Pathology, Edinburgh Scotland, 8-16 August 1998

PRIAM Synthesis Workshop, Nazreth, Ethiopia, 16-22 August, 1998.

African Highland Initiative Stakeholders' Seed Workshops, in Embu (Kenya), Areka (Ethiopia), Kakamega (Kenya) and Kabale (Uganda), September-November 1998.

AHI Technical Support Group Meeting, Embu, Kenya, 1-2 October 1998.

Regional Workshop on Participatory Plant Brèeding, Nazreth, Ethiopia, 12-17 October 1998.

Meeting of Across-Networks Working Group on Social Science Research in Eastern Africa, Thika, Kenya, 26-28 October 1998.

Annual Meeting of IARC and NARS Training Group (INTG), ILRI, Addis Ababa, Ethiopia, 3-5 November 1998.

Stakeholders Workshop for Bean Research in Kenya, Machakos, Kenya, 11-13 November 1998.

MANAGEMENT COMMITTEE MEETINGS FOR BEAN NETWORKS

Eastern and Central Africa Bean Research Network (ECABREN), Annual Meeting of Steering Committee, Kigali, Rwanda, 25-30 January 1998.

ASARECA-Donors-Networks Meeting, Entebbe, Uganda, 9-12 February 1998

Pan-Africa Bean Research Alliance (PABRA), Annual Meeting of Steering Committee, Arusha, Tanzania, 3-4 March 1998.

Eastern and Central Africa Bean Research Network (ECABREN), Planning Meeting of First Generation ASARECA Networks, Entebbe, Uganda, 8-13 June 1998.

SADC Bean Research Network, Annual Meeting of Steering Committee, Arusha, Tanzania, 5-7 October 1998.

ASARECA Committee of Directors, Annual Meeting with Networks, Entebbe, Uganda, 6-9 October 1998.

SACCAR Board of Directors, Annual Meeting with Networks, Harare, Zimbabwe, 12-15 October 1998.

TRAINING EVENTS

CGIAR workshop on leading and managing for collaborative advantage, Nairobi, Kenya, January 1998.

CGIAR Women's leadership and management training course, Nyeri, Kenya, January 18-25.

Seminar for Ugandan-based NGOs on establishing farmer seed enterprises, Kawanda, Uganda, 10 March 1998.

Practical training for two technicians from the Rwanda bean program on bean pathology-breeding research methods, Kawanda, Uganda, March/April 1998.

Training workshop for staff of Appropriate Technology, Uganda on farmer seed enterprises, 11-15 May 1998.

Regional Management Course for Program Leaders, ISNAR, CIAT, IITA. Egerton University, 17-31 October 1998.

DONORS

Donor	Project	Duration of current funding
AHI/ICRAF	Ecoregional research on IPM, seed systems and systems intensification	1995-98; 1998-99
CIDA (Canada)	Pan-Africa Bean Research Alliance	1995-99
DFID (UK)	Malawi Bean Project	1994-98
	Participatory Plant Breeding	1998-2001
ICRISAT (from USAID)	Seeds of Freedom (Angola)	1997-99
SDC (Switzerland)	Pan-Africa Bean Research Alliance	1995-98; 1998-2001
	Associate Expert in Agronomy (Tanzania)	1998-2000
The Rockefeller Foundation (USA)	Participatory research for the improvement of agro-ecosystem management (PRIAM)	1995-98
	Social Science Research Fellowship	1996-98
	GIS service at Kawanda Uganda; Publication of Bean Atlas	1996-98
USAID (USA)	Eastern and Central Africa Bean Research Network	1997-98
	Study of Seed Relief in Kenya	1997-98

Note:

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SADC Bean Research Network (SABRN): activities reported here are supported financially by SACCAR, the member Governments of SADC, and by the donors to PABRA.

STAFF LIST

Principal staff

Aggarwal, Vas Dev, PhD, Plant Breeder, Site Coordinator (stationed in Lilongwe, Malawi)
Ampofo, Kwasi James, PhD, Entomologist, Site Coordinator (stationed in Arusha, Tanzania)
Buruchara, Robin, PhD, Plant Pathologist (stationed in Kampala, Uganda)
David, Soniia, PhD, Sociologist (stationed in Kampala, Uganda)
** Delve, Robert, PhD, Postdoctoral Fellow (TSBF/CIAT SWNM) (stationed in Kampala, Uganda)
Farley, Cary, PhD, Rockefeller Foundation Social Science Research Fellow (stationed in Kampala, Uganda)
Gridley, Howard, PhD, Plant Breeder (stationed in Kampala, Uganda)
Kirkby, Roger, PhD, Agronomist, Project Manager (stationed in Kampala, Uganda)
Mukishi, Pyndji, PhD, Plant Pathologist, ECABREN Coordinator (stationed in Kampala, Uganda)
* Nderitu, John, PhD, Entomologist, AHI Regional Research Fellow (stationed in Kakamega, Kenya)
* Ross, Sally, MSc, Entomologist (Associate Scientist, DFID)
Wortmann, Charles, PhD, Crop/Soil Productivity Specialist, Site Coordinator (stationed in Kampala, Uganda)

Research assistants

Bashieja, Henry, Laboratory Technician (stationed in Kampala, Uganda)
Bua, Bosco, MSc, Research Assistant (stationed in Kampala, Uganda)
Eledu, Charles, MSc, Research Associate (stationed in Kampala, Uganda)
Kasozi, Sarah, BSc, Research Assistant (stationed in Kampala, Uganda)
Kumwenda, J.M.T., MSCE, Entomology Technician (stationed in Lilongwe, Malawi)
Lyimo, Jackson, Field Assistant (stationed in Arusha, Tanzania)
Mafuta, M.M.B., MSCE, Pathology Technician (stationed in Lilongwe, Malawi)
* Maideni, Martha, BSc, Assistant Social Scientist (stationed in Lilongwe, Malawi)
Massomo, Said, BSc, Research Assistant (stationed at Arusha, Tanzania) (on study leave)
Mbewe, M.P., Cert. Agri., Technical Assistant (DARTS/Project)
Mbvundula, Austen, Dip. Agri., Technical Officer (stationed in Lilongwe, Malawi)
* Musa, Suleiman, Dip., Field Assistant (Systems) (stationed in Kampala, Uganda)
Mwase, A.B., Jnr. Cert., Technician, Bembeke (stationed in Lilongwe, Malawi)
Nalukenge, Grace, Dip., Field Assistant (Systems) (stationed in Kampala, Uganda)
Ngwira, Temweni, BSc, Assistant Social Scientist (stationed in Lilongwe, Malawi)
Nyirenda, A.W.N., GCE, Technical Assistant (stationed in Lilongwe, Malawi)
Suleiman, Sebuliba, Field Assistant (stationed in Kampala, Uganda)

Administrative staff

Amuza Babi, Driver/Mechanic (stationed in Kampala, Uganda)
Baguma Athanasio, Driver/Office asst. (stationed in Kampala, Uganda)
Chima, M.A., MCE, Secretary/Admin. Assist. (stationed in Lilongwe, Malawi)
Gumbo, Abdalla, Watchman (stationed at Arusha, Tanzania)
Kamulindwa Julius, B.Com., Regional Finance and Administration Officer (stationed in Kampala, Uganda)
Kauwa, A.M., Mechanic/Driver (stationed in Lilongwe, Malawi)
Laizer, Emeseiki, Watchman (stationed at Arusha, Tanzania)
Nampeera Teo, Dip. Acc., A/cs Assistant (stationed in Kampala, Uganda)
Ndowa, Miraji, Driver (stationed at Arusha, Tanzania)
Ngalo, Eva, Secretary (stationed at Arusha, Tanzania)
Shirima, Julita, Cleaner (stationed at Arusha, Tanzania)
Tembo, M., Dip. Acc., Accounts Officer (stationed in Lilongwe, Malawi)
Tibalikwana Mabel, Exec. Secretary (stationed in Kampala, Uganda)
Travas, Betty, Administrative Assistant (stationed at Arusha, Tanzania)

* Left CIAT during 1998
** Joined during 1998