ANNUAL REPORT 1999

Seed of Bean Varieties and Green Manure Species on a Small Farm in Uganda

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

The mission of the International Center for Tropical Agriculture (CIAT, its Spanish acronym) is to reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resource management.

CIAT is one of 16 international agricultural research centers sponsored by the Consultative Group on International Agricultural Research (CGIAR).

The Center's core budget is financed by 30 donor countries, international and regional development organizations, and private foundations. In 2000, the donor countries include Australia, Belgium, Brazil, Canada, Colombia, Denmark, France, Germany, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Peru, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Donor organizations include the European Union (EU), the Ford Foundation, and the Inter-American Development Bank (IDB), the International Development Research Centre (IDRC), the International Fund for Agricultural Development (IFAD), the Kellogg Foundation, the Nippon Foundation, the Rockefeller Foundation, and the World Bank. These and other donors also finance the Center's competitive projects.

Information and conclusions reported in this document do not necessarily reflect the position of any donor agency.

ANNUAL REPORT
1999

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

Table of Contents

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 associa-tions 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. National 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.	1.0 FTE each in Systems Agronomy, Social Science, Pathology, Entomology, Coordination; 2.0 FTE in Breeding.	Progress reports.	Two regional networks are also fully funded.

Highlights in 1999

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

ECABREN network partners applying a new research market-driven strategy developed a high proportion of new research activities and milestones for monitoring implementation. In several countries non-research partners are contributing financially to impact-oriented activities. At least six scientific papers were prepared by national agronomists attending a writing retreat.

The networks identified critical needs for specialized research input and support from CIAT, both within Africa and from Cali. A much appreciated example was a regional course on DNA extraction and molecular characterization of bean pathogens using procedures adapted to relatively unsophisticated facilities. This helped build confidence and vision in the use of molecular tools, was viewed as a first step in the their application and in a new division of responsibility between African scientists and advanced labs, as well as a tool enabling better characterization of pathogen diversity through cross-country movement of non-pathogenic forms.

To compensate for a sharp reduction in the level of international staffing, negotiations with partners are leading to novel arrangements for co-opting more time from the best NARS scientists to serve the region. A major external evaluation reported continuing high and unsatisfied demand for CIAT staff inputs in several areas, including those that lead most immediately to the wide-spread impact that governments and donors expect. Plans were developed together for focusing CIAT activities upon strategic research, with complementary proactive action by bean networks to meet the urgent downstream support needs of NARS, particularly in areas where CIAT's collaborative research has already indicated the way to go (e.g. in vigorous incorporation in national breeding programs of sources of disease resistance or tolerance to low soil N and P, and use of seed systems). These changes will require close monitoring and management.

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

Bean breeding priorities in Africa were established with NARS partners as being to improve 7 Andean and four Mesoamerican seed types, plus climbing types and snap beans; some constraints are associated with particular types through their dominant production agroecologies.

Three years ago we set ourselves two milestones for 1999, both in the area of genetic improvement: making available lines resistant to bean stem maggot (Africa's main bean insect pest, which is not found in Latin America and for which no genetic resistance was known 10 years ago) and the development of materials with multiple constraints resistance. The first milestone has been met. A nursery of new sources of resistance to stem maggot, including the first examples of bred resistance to this pest, was distributed to collaborators in six countries; initial results returned indicate confirmation of effectiveness in several cases.

Great strides have been made in developing multiple constraints resistance, although much remains to be done. Multiple-parent crosses made locally for combinations of resistance to angular leaf spot, the main viral diseases, common bacterial blight, root rots, stem maggot and tolerance to low soil nitrogen N and phosphate P, along with selection in segregating populations from CIAT, have produced promising materials this year. Thirty-two single plant progenies combined good tolerance to *Pythium* root rot with resistance to angular leaf spot (ALS), and further selection within progenies is expected to develop lines combining resistance to both constraints in acceptable grain types. Six segregating populations combined yield equivalent to an established check variety with significant resistance to ALS, one appeared more resistant to CBB, and two lines significantly outyielded controls across the low N and low P sites. Meanwhile, the single constraint resistance breeding program initiated in 1991 against the African version of common mosaic virus (BCMNV) achieved a mean annual yield increase of 8.5% against a standard variety.

Pythium root rot causes losses across ever wider areas of Eastern Africa, as soil fertility declines. Few additional resistant sources were identified from evaluating many nurseries, but results from selection among single plant progenies are more promising. Future screening of progenies should benefit from the observation that reductions in root and shoot weights (but not root length) are associated with reduced severity of root rot, and hence characters useful in selection.

Farmers showed great interest in participatory plant breeding (PPB) at several locations in Ethiopia, and selected a large number and wide range of bean lines with characters atypical of those commonly grown. This suggested that PPB may offer Ethiopian farmers opportunity to extend their limited on-farm bean diversity

OUTPUT 3: Sustainable bean production systems

Several years' work on sustainable crop and soil management culminated in recommendations, with collaborators in the region, on best options and niches among leguminous green manures and cover crops, and support to national agronomists in developing decision guides for their circumstances. Sesbania and tephrosia effectively improve fallow, fix much N and recover deep nitrate, but care is needed as both tree legumes were shown to be good hosts of rootknot nematodes. *Crotalaria grahamiana* and, to a lessor extent, mucuna and lablab should be useful in reducing infestations of these nematodes. The rotational benefits of the annual legume *Canavalia ensiformis* was related to its high biomass production, accumulation of soil P, N fixation and effectiveness in uptake of soil N, but this species also greatly depleted soil water.

Participatory research on IPM identified soil fertility options (e.g. combining half rates of farmyard manure and DAP) that enhanced crop vigor, tolerance to stem maggot, and yield, without unacceptable labor costs. Farmer field schools improved farmers' understanding of their pest problems, information base and abilities to design and evaluate potential solutions

Work on designing efficient methods for systems improvement focused on participatory research that links research stations with selected communities in six countries. In this third year, some farmer research groups had clearly been empowered to maintain records on their own initiative, well able to prepare posters explaining trial results, and make focused technical demands on the extension system. Social linkages and dynamics in collaborating communities are key factors in farmers' acquisition of technical knowledge and in their effectiveness at passing it on to others. Indicators of the path-breaking role of this activity area have been the frequency by which NARI managements direct donor teams to these sites, and our role in catalyzing similar sites within the African Highlands Ecoregional Program (AHI).

We propose that in future our research related to the management of natural resources be more closely linked with CIAT Headquarters projects, while recognizing that much of the technical interaction will continue to be with partners, including other Centers, within the region. At present, participatory research approaches (with multiple applications), systems intensification and IPM (both often combining germplasm with crop/soil management), rather than soil fertility *per se*, are our comparative advantages in this area. The definition of strategic areas appropriate for involvement of a Center could change rapidly, as NARS gain experience with systems thinking and participatory approaches.

OUTPUT 4: Technology adopted

Support to and research on scaling up of innovations has taken several forms. Bean integrated disease management in Rwanda was assisted through support to training by local institutions of 53 extension staff and 23 representatives of farmer associations from all prefectures of the country. In Tanzania, support to IPM took the form of desk-top production of posters and making available compact discs for translation by national institutions to local languages.

In Uganda, experimental distribution was made of 3,000 minikits including seed of leguminous green manure species and a decision guide, which generated much interest from NGOs and further demand from farmers. This activity is also expected to contribute towards quantifying next year's milestone of achieving adoption of green manures and other agronomic practices.

These activities will be monitored for lessons, in much the same way as our past documenting of what makes seed systems function effectively has contributed to the recent immense growth in seed dissemination activities throughout the region. An intensive case study this year in Ethiopia suggests that understanding how farmers learn about management-intensive innovations appears to need a combination of methods –not limited to group interviews.

A study of impact at household level among a sample of Ugandan adopters of new bean varieties found that two bush bean varieties accounted for 74% of bean area just four years after their introduction. One of these varieties now accounts for 90% of bean earnings, and some farmers report improved food security during the dry season due to increased production.

Applying information from the Atlas of Bean Production in Africa, the value of the 40% of bean production marketed in sub-Saharan Africa was estimated as US$226 million at farm gate and $452M retail, with 6 countries each exceeding US$ 50M in retail value

Progress Report 1999

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

Activity 1.1 Develop new partnerships within regional networks

Achievements:

- ECABREN partners started applying a new research market-driven strategy, including involvement of other research and non-research institutions in technology development and dissemination.
- A high proportion of research activities supported by ECABREN are new, and in several countries non-research partners are contributing financially to impact-oriented activities.
- The SABRN network started to implement its new strategy, with a modest increase in emphasis to crop management and impact assessments.

New partnerships developed within the ECABREN network

Rationale: Technologies developed by research institutions will create impact on rural and urban populations only if relevant research and non-research institutions, farmers and the private sector work together in their development and dissemination. Previously, partnerships were undeveloped in several areas of Network research.

Methods: In 1998 ECABREN developed a new five-year strategic plan that emphasizes technology development and adoption in partnerships with research and non-research institutions, farmers' associations and other beneficiaries. With this stronger mandate, ECABREN has encouraged its national research members to enter into partnerships for creating impact from in the region. An example is to formalise the links with non-research institutions in both the non-governmental and government sectors for the promotion of bean technologies to benefit communities. The ECABREN Steering Committee also encouraged the funding of research projects in which farmers are directly involved, such as evaluation and transfer of climbing bean technology in peri-urban areas and in the highly populated highlands.

Results and discussion: In several countries including Burundi, DR Congo, Ethiopia, Rwanda, and Uganda, non-research institutions participated in funding seed production and multiplication. In Burundi, Catholic Relief Services (CRS) is providing financial support to ISABU in seed production and multiplication for distribution to farmers who lost seed stocks in civil unrest. In Congo, Food for Hunger International (FHI-Congo) funded seed production and multiplication of popular bean varieties that are then distributed to the national seed company (SENASEM), the national extension service (SNV) and to farmers in southern and northern Kivu provinces. Seed management units under Ethiopian research centers have been receiving funds from the federal government for production of basic seed of improved varieties to satisfy national demand.

In Uganda, the Gatsby Charitable Organization is involved in seed multiplication and distribution to diverse groups. Finally, churches and farmers' associations in Kenya have been involved in informal seed distribution channels of improved climbing bean varieties. A meeting of bean breeders and socio-economists is planned to discuss next steps in sustaining breeders' seed production.

The ECABREN Steering Committee annual meeting, comprising representatives of all member countries and from CIAT, approved 32 new sub-projects in addition to 46 on-going sub-projects. Priority was given to research activities likely to improve productivity, commercialization and farmers' income and food security in the region. As usual, most sub-projects (82%) came from national agricultural research institutes (NARIs) and from universities (12.5%). One subproject was approved for World Vision International in Rwanda (including technical assistance from CIAT Project IP-2 sociologist and from the national research institute ISAR); and another links national scientists from seven ECABREN countries with CIAT's regional agronomist. Involvement of universities in technology development has increased, with the participation of scientists from universities in Burundi, DR Congo, Kenya, Rwanda and Sudan. Makerere University in Uganda is collaborating with scientists from NARO in diverse research areas including bean entomology and the development of new bean products.

Dry bean for regional and export markets, seed bean, snap bean and new bean products constitute the priority bean products on which research is concentrating (Table 1) The research areas include variety development for multiple constraints resistance (diseases, pests, soil fertility and drought), dissemination of climbing beans and participatory research.

Contributor: M. Pyndji
Collaborators: ASARECA; NARS, Steering Committee members and scientists from Burundi, DR 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, was coordinated by Tanzania's national bean coordinator until his tragic death in mid-1999. Malawi's coordinator has network responsibility for germplasm exchange, and also acts as network coordinator. The DR Congo, following its accession to SADC, plans to be represented in the SABRN for the southern part of the country, which fits in the SABRN ecology.

This Network continued to be constrained by lack of a special project donor. However, the Southern Africa Center 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) and raised project finance from the African Development Bank. 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.

Table 1. Regional research by ECABREN countries in 1999, based on product chains.

Product Chain and Sub-Project Title	Country	Institution/Station	Startup
Dry bean for local, regional & export markets			
Development of bean lines with multiple constraint resistance	Kenya	Univ. of Nairobi	1998
Multiple disease resistance for low altitude areas	DR Congo	INERA Gandajika	1993
Anthracnose resistance	Madagascar	FOFIFA Tana	1996
	Rwanda	ISAR Rubona	1996
Anthracnose regional nursery	Ethiopia	EARO Ambo	1997
	Rwanda	ISAR Rubona	
	Kenya	KARI Thika	
	Uganda	NARO Namulonge	
	Madagascar	FOFIFA Tana	
	Burundi	Univ. de Burundi	1998
Integrated management of root rots	DR Congo	INERA Mulungu	1999
Effect of nematodes and stem maggot on fusarium wilt	DR Congo	INERA Mulungu	1998
Charcoal rot nursery	Kenya	KARI Katumani	1996
Viral diseases of beans in northern Sudan	Sudan	ARC Hudeiba	1999
Screening of bean germplasm against luteo-virus	Sudan	Univ. of Gezira	1999
A backcross programme to improve disease resistance of released varieties and landraces	Uganda	NARO Kawanda	1999
Common bacterial blight: use of resistance sources	DR Congo	INERA M'vuazi	1995
Pathogenic variability and host range of *P. griseola* in Ethiopia	Ethiopia	EARO Ambo	1999
Screening for resistance to major diseases	Rwanda	UNR/ISAR Rubona	1999
Farmer evaluation of integrated disease management in Karutu	Tanzania	DRT Selian	1999
Collection/characterization of local climbing bean germplasm	Ethiopia	EARO Nazareth	1999
Genetic diversity at farm level	DR Congo	INERA Mulungu	1993
Genetic improvement	Madagascar	FOFIFA Tana	1997
Farmer participatory development of IPM of major bean pests	Uganda	NARO Namulonge	1999
Population dynamics and resistance to bean stem maggot	Kenya	KARI Katumani	1999
IPM strategies against bean stem maggot	Tanzania	DRT Selian	1998
Dissemination of stem maggot management	Rwanda	U.N.R. Butare/ISAR	1999
Integrated pest management of dry bean	Sudan	ARC Hudeiba	1999
Characterization of pests and bean losses in eastern Congo	DR Congo	Univ. Cath. Bukavu	1999
Crop loss to cutworm (Agrotis ipsilon) in the high plateaux	Madagascar	FOFIFA Tana	1999
Leaf beetle epidemiology	Uganda	NARO Namulonge	1996
Apoderus effect on seed yield	Madagascar	FOFIFA Tana	1997
Adaptation of climbing beans to Rwaandan agro-ecologies	Rwanda	ISAR Rubona	1997
Adaptation of climbing beans in eastern and central highlands	Kenya	KARI Embu	1996
Adaptation of climbing beans in Kagera region	Tanzania	DRT Maruku	1997
Adaptation of climbing beans in Kilimanjaro region	Tanzania	DRT Selian	1997
Climbing beans for Southern Ethiopia	Ethiopia	EARO Awassa	1997
Adaptation of climbing beans to lowland systems of Uganda	Uganda	NARO Namulonge	1999
Promotion of climbing beans: Calliandra stakes and farmers	DR Congo	INERA Mulungu	1994
Production and use of stakes for climbing beans	Rwanda	ISAR Rubona	1996
Bean intensification in corridor agroforestry	DR Congo	INERA Gandajika	1999
Promotion of climbing beans in low-elevation zones	DR Congo	INERA M'vuazi	1999
Selection of climbing beans by participatory plant breeding	Rwanda	ISAR Rubona	1998
Evaluation and dissemination of climbing bean genotypes among small farmers in southwestern Uganda	Uganda	NARO Namulonge	1999
Promotion and dissemination of bush and climbing beans among urban farmers in Kampala, Uganda	Uganda	NARO Namulonge	1999
Bean intensification in valley bottoms of Katanga	DR Congo	INERA Kipopo	1999
Improvement of common bean production in northern Sudan	Sudan	ARC Hudeiba	1999

Participatory Research for Improved Agro-Ecosystem Management (PRIAM)	Madagascar	FOFIFA Antsirabe	1999
	DR Congo	INERA Mulumgu	1999
		EARO Melkassa	1999
Developing integrated crop management for drought areas	Tanzania	DRT Selian	1998
Development of farmer decision guides to soil fertility	Uganda	NARO Namulonge	1998
Development of decision guides to use of organic and inorganic soil amendments	Kenya	KARI Kakamega	1998
	Tanzania	DRT Selian	1998
	Madagascar	FOFIFA Antsirabe	1999
Tithonia, basalt & fertilizer for soil fertility management in Kivu	DR Congo	INERA Mulungu	1998
Biological fixation of nitrogen	Burundi	ISABU Bujumbura	1992
Farmer participatory research for soil productivity	Ethiopia	EARO Nazareth	1994
Improved utilization of local materials in soil management	Uganda	NARO Kawanda	1995
Using household wastes for bean fertilization	Burundi	ISABU Moso	1994
Effect of lime and rock phosphate	Rwanda	ISAR Rwanda	1996
Nodulation of climbing bean varieties	Burundi	ISABU Bujumbura	1996
Green manures for sole and associated bean crops	DR Congo	INERA Mulungu	1995
Optimizing efficiency of applied P for bean production	Tanzania	DRT Selian	1998
Rotating upland rice with bean for acidic and ferralitic soils	Madagascar	FOFIFA Antsirabe	1999
Travertin et *Tithonia* for bean productivity in acid soils	Rwanda	ISAR Rubona	1999
Nitrogen contribution by bean in maize-bean intercropping	Tanzania	DRT Selian	1999
Assessing constraints to N fixation by bean under small-holder production conditions in eastern and southern Africa	DR Congo	[coordinated by	1999
	Ethiopia	CIAT Kawanda]	
	Kenya		
	Madagascar		
	Rwanda		
	Tanzania		
Bean Improvement for Low Fertility Soils in Africa (BILFA3)			1995
Low N	Ethiopia	EARO Nazareth	
Low N	Madagascar	FOFIFA Antsirabe	
Low P	Tanzania	DRT Selian	
Low P	Kenya	KARI Kakamega	
Low N & P	Rwanda	ISAR Rubona	
Low pH complex	DR Congo	INERA Mulungu	
Eliciting food bean preferences in Areka, southern Ethiopia	Ethiopia	EARO Areka	1998
Evaluation of preferences of urban consumers in Kampala	Uganda	NARO Namulonge	1999
Field management of the storage bruchid *A. obtectus*	Uganda	NARO Kawanda	1997
Back-cross breeding for bruchid resistance	Kenya	Univ. of Nairobi	1998
Seed Bean			
Production and dissemination of seed by women associations	DR Congo	INERA Gandajika	1998
Participatory selection for seed dissemination	Burundi	ISABU Moso	1998
Adoption studies of new bean varieties	Madagascar	FOFIFA	1998
Farmers' constraints for seed production	DR Congo	INERA M'vuazi	1996
Diffusion of improved bean varieties in Rwanda	Rwanda	World Vision Int'l	1999
New Bean Products			
Popularization and promotion of bean dishes	Ethiopia	EARO Nazareth	1997
Development of a composite flour from cassava and bean	Uganda	NARO/FSRI	1998
Regional bean recipe book	-	-	1996
Snap Beans			
Breeding French beans	Uganda	NARO Kawanda	1998
High yielding climbing snap bean varieties for N. Tanzania	Tanzania	DRT Selian	1999
Evaluation and dissemination of bean stem maggot resistant snap beans in northern Tanzania	Tanzania	DRT Selian	1999
Thrips management in snap beans through crop association	Kenya	KARI-NHRC Thika	1999

Despite the low level of funding to SABRN, 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 90 tons since 1996. The strategy of producing and selling small seed packs of new bean varieties in Malawi has been quite successful. In areas where the packs were available, many farmers had purchased the seed. The majority of these farmers were satisfied with the new varieties that they acquired and the are interested in purchasing other small seed packs. The merchants who have participated in the scheme are enthusiastic and wish to continue to sell the small packs.

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 and exported to neighboring countries. Revised regional priorities, established by the Network and reported in 1997, were fully effected during the Steering Committee (SC)'s annual meeting in October, 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	MoA	1995
	Malawi	DARTS	
	Mozambique	INIA	
	Tanzania	DRD Selian	
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
First and secondary multiplication of two varieties	Angola	MoA	1997
Evaluation of BSM resistant lines in S. Highlands	Tanzania	DRD Uyole	1997
Ootheca management in S. Highlands	Tanzania	DRD Uyole	1997
Mass rearing for resistance breeding against bean stem maggot	South Africa	ARC/GCRI	1997
Dissemination of new bean varieties	Zambia	MoA	1997
Farmer participation in selection and seed multiplication	Zambia	MoA	1997
Beanflies and bean insects	Malawi	DARTS	1996
On-farm seed multiplication	Swaziland	MoA	1998
Farmer oriented decision guide to soil fertility	Tanzania	DRD Uyole	1998
Farmer based selection of elite multiple resistant lines	Tanzania	DRD Uyole	1998
On-farm evaluation of bean genotypes	Lesotho	MoA	1998

Contributors: R. Chirwa (DARTS/SABRN)

Collaborators: SACCAR; NARS, SC members and scientists from Angola, Lesotho, Malawi, Mauritius, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

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

Achievements:

- Plan developed for greater focus of CIAT's declining funding upon strategic research wit complementary action by bean networks to meet downstream needs for supporting NARS

- Negotiations with partners on novel arrangements to co-opt excellent NARS scientists to serve the region.

Rationale: The ECABREN and SABRN networks are self-governing under the policy direction of ASARECA and SABRN, their respective regional NARS associations, with CIAT being an active member of each grouping. Many important constraints and opportunities occur across the boundaries of the bean networks, and efficiencies can be expected from well coordinated activities. While coordination has been mediated by CIAT, this is not an optimal arrangement institutionally. Also, the stronger NARS are in a position to undertake some of the strategic research otherwise expected of CIAT, a shift that should reduce costs and increase sustainability.

Methods: The second Annual Meeting of the steering committee of the Pan-Africa Bean Research Alliance (PABRA), in Kisumu, Kenya in April 1999, again brought together representatives of the two networks, CIAT and principal donors to bean research in Africa. A primary agenda item this year was consider a recently completed external evaluation of PABRA.

Results and discussion: The evaluation report commended PABRA for its farm-level impact in Eastern Africa. However, donors wanted to see more measurement of these achievements at two scales: economic data across the region (and/or more detailed assumptions upon which current calculations of impact are based), and household impact including the tracking of socio-economic change in selected communities over time (see Section 4.4 for a recent study).

The evaluation focussed on the need to maintain a strong alliance while increasing its leadership by the African partners. A process of progressive decentralization of much of CIAT's current agronomy, breeding and crop protection in Africa was envisaged. All of this work has been funded through special projects under PABRA and within Project IP-2. The evaluation noted, as a positive indicator, that demands upon CIAT staff for support to African NARS are still high, in these and other areas. Southern Africa has become progressively less well served in recent years. This year we lost the bilaterally funded breeding position in Malawi that the donor considered to have achieved much of its purpose in catalyzing development of a productive national breding capacity — but this position was also a vital contributor of fixed lines into the many small national programs of that region. Anticipated decline in current sources of funding (some now in at least their 13th year) also make unsustainable the current levels of reliance upon internationally recruited staff (IRS).

Consequently, we entered a transitional period during the course of 1999, with phasing out of two more IRS positions. Reinstatement of a CIAT breeding capacity to serve southern Africa was seen as a priority, and fund-raising efforts would be necessary for this and other key areas. At the same time, negotiations were entered with national and regional institutions aimed at securing more of the time of a few of the best scientists from NARS to serve the region through secondments or shared positions under PABRA auspices. These new arrangements should be in place by the start of 2000. We also planned a further shift towards focussing CIAT's reduced resources upon key areas of strategic research, while the networks will need to become more proactive in developing their own strategies for meeting the needs for downstream support in areas where CIAT's collaborative research has already indicated the way to go (e.g. in seed systems). Most partners recognize the significant risks inherent in these changes, which will require close monitoring, management and perhaps adjustment. Several aspects of CIAT's future roles and areas of technical focus within PABRA are still the subject of discussions with network partners.

As in previous years, coordination of annual workplans among networks and CIAT was achieved by coordinators' identifying opportunities for merging activities, and by applying PABRA funds to permit participation of one network in an activity led by the other.

Contributor: R. Kirkby
Collaborators: M. Pyndji (CIAT/ECABREN); R. Chirwa (DARTS/SABRN); ASARECA; SACCAR; donors to PABRA

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

Achievements:

- The networks identified critical activities focussed on research support needs, and CIAT provided specialized technical assistance upon request.

- Practical training including a regional course on DNA extraction and molecular characterization of bean pathogens using procedures adapted to unsophisticated facilities.

- ECABREN scientists developed milestones for monitoring implementation of the Network's new strategic plan

- At least six scientific papers prepared by national agronomists attending a writing retreat

Workshops, monitoring tours and training by ECABREN, SABRN and CIAT

Rationale: Achieving impact from each network's portfolio of regional research sub-projects depends upon adequate research capacity within member NARS, partnerships beyond the NARS, and effective means for exchanging information among those responsible for network activities so that all benefit from this specialization. This also implies improvement of management and coordination skills within and between countries.

Methods: Steering committees of the two bean regional networks developed and approved annual workplans that included workshops, monitoring tours and training. Several activities were pan-African in scope, with coordination across regions being provided under auspices of PABRA. Due to SABRN's coordination and funding constraints, most activities were led by ECABREN, or by a CIAT scientist at the networks' request.

Results and discussion: In partnership with CIAT and universities of the region, the networks organized working group meetings on bean entomology, bean improvement for low fertility soils in Africa (BILFA), soil fertility and bean breeding. These meetings served to review research results and determined outputs and indicators (network milestones) for their disciplines and, in the case of ECABREN members, to do this in the context of the Network's new strategic plan emphasizing income and food security in the region (see summaries immediately below, except for bean breeding in Section 2.1). CIAT staff organised, at the request of networks, monitoring tours to review field research activities in the areas of entomology and community-based participatory research(Table 3).

To enhance and strengthen research and research management capacities of national programs, newly-hired young scientists were trained by senior scientists from the University of Nairobi and from CIAT (both Headquarters- and Africa-based). Areas of training included research methods in entomology, molecular techniques, screening for multiple constraints and bean crossing techniques. Training in designing and implementing on-farm experiments collegially with farmers was provided to a group of researchers from PRIAM and AHI sites. Four national bean program leaders were selected to follow a two-week training course in agricultural research management organized by ISNAR in Burkina Faso and Swaziland for French and English speakers, respectively.

This year both networks and CIAT IP-2 developed independent (but closely linked) strategies for taking gender aspects more specifically into account in planning and evaluating their activities. Elements of the strategy include a requirement to include gender analysis in the research design of each sub-project, and in the evaluation of beneficiaries of research and of capacity building.

To remedy the lack of reporting of research results in the region, several scientific writing retreats were planned and budgeted by ECABREN in collaboration with CIAT staff. Although scientists in the fields of agronomy, social science, breeding and pathology were invited, only agronomists responded by submitting draft papers and/or research results to be used for writing their manuscripts. The event for agronomists is reported below. Among participants in workshops held this year, only 16% were female, reflecting the reality that most experienced NARS scientists are male. A higher proportion of participants in training courses, generally intended for younger staff, were female (26%).

Contributors: M. Pyndji and R. Kirkby
Collaborators: NARS members of ECABREN and SABRN; ASARECA and SACCAR; ICRAF/ AHI; CIAT Project IP-1

Table 3. Principal information exchange and training events of bean network partners in 1999.

Event	Venue
Study Tours and Working Group Meetings	
Pan-African Entomology Working Group and Monitoring Tour	Tanzania & Uganda
BILFA Working Group Meeting	Tanzania
Soil Fertility Working Group Meeting	Tanzania
Scientific Writing Retreat (Agronomists)	Tanzania
Pan-Africa Working Group Meeting on Bean Breeding	Kenya
Monitoring Tour to PRIAM and other Participatory Research	Kenya
Capacity Building of NARS	
Field Training for Young Entomologists	Tanzania
Training Course for Young Breeders	Kenya
Training Course on Participatory On-Farm Experimentation [with ICRAF]	Kenya
Short Course on Molecular Techniques	Uganda
Agricultural Research Training for NARS Program Leaders in Sub-Saharan Africa (French & English) (led by ISNAR)	Burkina Faso Swaziland

Pan-African working group meeting on bean entomology

Rationale: Bean pest problems tend to be common to many producing environments within Africa. Sharing information across countries and between regional networks leads to greater research efficiency by creating an effective critical mass of scientists, favoring specialisation and avoiding unnecessary duplication of effort.

***Method*:** This pan-African working group last met in 1996. Most members of the previous group have moved up to administrative positions or moved to international positions. The new group that was convened this year, comprising mostly fresh BSc holders, came from DR Congo, Ethiopia, Kenya, Madagascar, Malawi, Rwanda, Sudan, Tanzania and Uganda.

***Results and discussion*:** Members' lack of experience with beans and research in general was a different situation to that of most working group meetings held in recent years for this or other research areas. Consequently, this meeting focused on methods and participatory planning for sub-project research in this field, and sharing of IPM information relevant to their individual circumstances.

Posters on IPM strategies for BSM, BFB and storage pests developed by CIAT, farmers and the extension service in northern Tanzania were multiplied on CDs and distributed to this group and others in NARS. The materials, designed in Microsoft Word, were set up for easy translation into local languages while conserving the illustrative materials. Dissemination strategies through the individual national extension systems were discussed at the Working Group meeting and at Network steering committee meetings.

The posters have already been translated into Kiswahili by the extension service of Tanzania, which is seeking funds for wider dissemination. The Bean Program in Malawi is also in the process of translating the IPM information into the local language.

Contributor: K. Ampofo
Collaborators: ECABREN, SABRN

Working group on Bean Improvement for Low Fertility Soils in Africa (BILFA)

Rationale: Genetic variation for reaction to varying soil fertility conditions was confirmed in earlier years. BILFA is an on-going collaborative effort to improve bean genetically for low fertility soils and for nutrient use efficiency.

Methods: A meeting of the BILFA working group was chaired by Lunze Lubanga and Rowland Chirwa, coordinators of BILFA for ECABREN and SABRN, respectively. Sub-groups compiled data for BILFA II and III germplasm sets and made selections. Promising lines for use by breeders were identified from BILFA II. Tolerance characteristics were related to varietal characteristics.

Results and discussion: Forty-eight BILFA III lines were selected by the working group for more extensive multi-location testing.

Tolerant to acid soils, a Rwandan landrace variety Ubososera and the bean line ACC714 are now common in local markets in parts of eastern DR Congo. After identifying Ubososera as promising for acid soil conditions, Lunze gave seed to his wife. She tried it, liked its performance and seed type, and gave seed to her neighbors. The line quickly became popular and farmers named it after Lunze's, wife, mwaSole.

UBR(92)25, a Navy bean with high N fixation capacity and tolerance to low N conditions, was released in Uganda in 1999. Already the farm-gate value of added annual production is estimated to be US$55,000, and is projected to exceed US$900,000 in 2001 with adoption increasing until 2004.

Several BILFA lines are being used as breeding parents and others are being considered for re-lease. RAO 55 is widely adapted to low N and low P conditions and its release in Malawi is anticipated.

Contributor: C. Wortmann
Collaborators: Lunze Lubanga (INERA/ECABREN), Rowland Chirwa (DARTS/SABRN) and other BILFA collaborators from ECABREN and SABRN. The event was funded through the Networks.

Meeting of working group on soil fertility research

Rationale: Conceptual frameworks can be a useful tool for integrating information from various sources and applying it to the diverse and complex situations of farmers. Fertilizer application rates as affected by soil type, farmer wealth, recent cropping history and sowing date, and fertilizer substitution values for organic resources can be estimated. Deficiencies and adequacies in the information are determined; priority research and extension activities can then be identified.

Methods: Participants came with information for principal bean production areas where they collaborate with farmers. Working alone or in pairs, they first characterized the AEZ. They then developed a conceptual framework for INM, using a decision guide format. The adequacy of information for various estimates was assessed. Priority research and extension activities were proposed. Tentative logical frameworks were partially developed with the intent of participants' finalizing these with their colleagues and collaborating farmers later.

Results: AEZ descriptions and conceptual frameworks (see Table 4 for example for Western Transect of Mt. Meru) were developed for:
The Bukoban High Rainfall Zone in northwestern Tanzania
Sandy Loams of Western Transect of Mount Meru, Arusha, Tanzania
Mbozi Plateau AEZ in the Southern Highlands, Tanzania
Dedza Hills AEZ in Malawi
Four AEZ's of South Kivu, DR Congo
Areka District, southwestern Ethiopia
Antsirabe AEZ, Andranomanelatra, Madagascar
Crete Congo – Nil AEZ, in Gikongoro, Rwanda
Lake Victoria Crescent, Uganda
Northern Moist Farmland AEZ of Uganda
Vihiga District, Western Kenya

Contributor: C. Wortmann and Kaizzi Kayuki (NARO)
Collaborators: Other ECABREN and SABRN collaborators. The event was funded through the Networks.

Table 4. Example of an AEZ description and conceptual framework, from Mount Meru Western Transect – Northern Tanzania.

a) Description of the AEZ

Altitude:	1000 – 1500 masl; Biomodal rainfall (600 – 900 mm).
Soils:	Volcanic, Black/greyish, Loam – sandy loams.
Farming Systems:	Crop farming (maize/bean); Livestock keeping (cattle, small ruminants).
Fertilizer:	30 kg N + 26 kg P/ha (beans); 30 kg N + 26 kg P/ha (maize/beans); 100 kg N/ha + 26 P (maize).
Resources:	Inorganics: TSP, NPK, S/A, urea, CAN, Minjingu PR.; Organics: FYM, Tithonia, Vernonia
Farm Gate Prices:	50 TShs/kg maize; 200 TShs/kg beans
Prices of Fertilizers:	8,000 TShs S/A, 10,000 CAN/urea, 14,000 TSP/NPK, 3,000 MPR
Constraints:	N, P, Mg – deficiencies; farmers not using inorganics nor manure; low maize/bean yields.

b) Priority activities proposed after development of the conceptual framework
(See conceptual framework on the following page)

Manure management:	training and extension
Improved fallows:	seed increase and extension
Interaction of inorganic and organic fertilizers:	verification of substitution ratios for Minjingu rock P, tithonia, vernonia
Limiting nutrient trials:	esp. diagnosis of Mg deficiencies
Hard pan:	on-farm verification of deep tillage; promotion

Table 4 (continued)

c) Conceptual INM framework for maize or beans on sandy loams

Condition	*Maize, sole crop*	*Bean, sole crop*	*Maize bean intercrop*
Adequate money available	Apply 125 kg/ha TSP and 30 kg/ha urea at planting. Apply 95 kg/ha urea after weeding	Apply 125 kg/ha TSP and 65 kg/ha or 115 kg/ha CAN urea at planting. Inoculate with 300g of Rhizobia/60 kg of seed	Apply 125 kg/ha TSP and 30 kg/ha urea at sowing. Apply 95 kg/ha urea after weeding
Money inadequate	Apply 65 kg/ha urea after first weeding	Apply 62 kg/ha TSP at planting. Inoculate seed.	Apply 65kg/ha urea after weeding
Green manure produced previous season and money available	Don't apply inorganic fertilizers	Don't apply inorganic fertilizer	Don't apply inorganic fertilizers
Green manure in previous season; money inadequate	Don't apply inorganic fertilizer	Don't apply inorganic fertilizer	Don't apply inorganic fertilizer
Tithonia, Vernonia available	Reduce application of inorganic fertilizer by 10% for each ton of fresh leafy materials applied	Reduce application of inorganic fertilizer by 10% for each ton of fresh leafy materials applied	Reduce application of inorganic fertilizer by 10% for each ton of fresh leafy materials.
Sowing after April 1st	Reduce the inorganic fertilizer rate by 50%	Do not reduce the inorganic fertilizer	Reduce the inorganic fertilizer rate by 50%
Sowing after April 15th	Plant in sunken beds or tie ridges Apply 25-50% at planting and 25-50% urea after weeding	Do not reduce the inorganic fertilizer rates	Plant in sunken beds or tie ridges Apply 25-50% rate at planting and 25-50% urea after weeding
Farm yard manure available (and of good quality)	Apply 5 t/ha	Apply 2.5 t/ha	Apply 5 t/ha
Farm yard manure (poor quality)	Apply 2.5 t/ha + 25% of inorganic fertilizers	Apply 2.5 t/ha + 25% of inorganic fertilizer	Apply 2.5 t/ha + 25% of inorganic fertilizer
FYM 5 t/ha applied last season (good quality)	Apply 25% of inorganic fertilizer	Don't apply inorganic fertilizer	Apply 50% of inorganic fertilizer
FYM 2.5 t/ha applied last season (poor quality)	Apply 2.5 t FYM, or 50% of fertilizer	Apply 2.5 t FYM, or 25% of fertilizer	Apply 2.5 t FYM, or 50% of fertilizer

Multiple constraint resistance breeding course for new NARS breeders

Rationale: National programs in Africa have been dependent upon CIAT for fixed lines for selection and release to farmers. The stronger programs need to develop breeding abilities.

Method: The networks requested the two experienced NARS bean breeders who last year initiated programs in multiple constraint resistance breeding to train a cadre of younger scientists.

Results and discussion: Under the supervision of Professor Paul Kimani of the University of Nairobi, seven breeders from several ECABREN countries followed a three-week training in breeding techniques. These breeders will now be able to start crossing programs in their countries.

Contributors: M. Pyndji and H. Gridley; P. Kimani (UoN).

Course on simple molecular methods to characterize diversity of key bean pathogens

Rationale: Characterization of disease pathogens is important in developing effective management strategies. However, some pathogens are difficult or slow to characterize using morphological or pathogenic characteristics and require time-consuming laboratory and/or greenhouse tests. For example, characterizing *P. griseola* by virulence is often slow and limits the number of isolates that can be handled. While molecular methods have increased the number of options and speed of tools for specific pathogens, their use in Africa is limited by lack of expertise and facilities, as well as by a common belief that this can only be done in better equipped or sophisticated laboratories. Given the generally good correspondence between molecular and virulence methods for some bean pathogens, there are opportunities and interest to develop expertise and adapt some molecular methods to conditions in national programme laboratories, especially if research responsibilities could be shared between ECABREN and SABRN countries and more advanced laboratories.

Methods and Materials: A four-day course supported by ECABREN, SABRN, PABRA and CIAT Project IP-1 was held at NARO's Kawanda Research Institute, Uganda. There were eight participants (including four women) from Burundi, DR Congo, Ethiopia, Kenya, South Africa, Tanzania and Uganda. Designed to be a hands-on training, the primary emphasis was on DNA extraction from *P. griseola*, *C. lindemuthianum* and *X. campestris*. PCR amplification procedures were also tried out. DNA extraction was based on modified procedures to adapt to available facilities.

Results and Discussion: Successful extraction of DNA using relatively unsophisticated facilities helped to build confidence among participants and change the widely held notion that biotechnology is only possible in advanced labs. The course generated much interest among participants for molecular tools, which they felt confident could be put into practice in their institutions with little or no extra facilities. Some laboratories may not be self-sufficient but sharing of facilities among departments and programs should be possible with modest support for expendable supplies. Follow-up training to extend this biotechnology adaptation to PCR analysis and marker assisted selection in breeding is necessary. A training manual was developed and used for the course. These outputs should find wide application in the multiple-constraint resistance projects now being supported by the bean networks, and later enable further sharing of responsibilities between African national programs and advanced laboratories.

Contributors: R. Buruchara and George Mahuku. (IP1) (Jointly with PE1)

Scientific writing retreat for agronomists and soil scientists

Rationale: Scientists often lack a good environment for proper processing and reporting of information derived from their research. They are faced with diverse demands and distractions, and often lack opportunities for consultation on their research findings. This retreat gave an opportunity for them to focus on the analysis of their data, interpretation of the results, preparation of manuscripts, and to seek technical support.

Methods: Nine NARS scientists participated. Unfortunately, not all came well prepared as advised. Dispersed access to computers and power cuts hindered the work.

Results: Six, and possibly seven, papers have been submitted. Submission of an eighth is anticipated. Two other works showed promise but the retreat time of one week was too short to fully prepare these.

Discussion: Scientific writing retreats are valuable learning exercises for scientists, as they improve skills in biometrics and data analysis, critical interpretation of results, scientific writing, and fitting their papers to the guidelines of the journals. Too often, research activities are left incomplete; critical interpretation and reporting of the results is an essential part of the research process, as is applying the information to farmers' situations. The Networks are giving increased attention to both aspects.

Contributor: C. Wortmann
Collaborators: NARS scientists. The event was funded through ECABREN, SABRN, PABRA and SACCAR.

Activity 1.4 Efficient modes of managing networks

Achievements:

- Coordination of an effective network for bean research warrants dedicated staff time from the region and incurs costs that cannot readily be circumvented

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 a steering committee (SC) of national coordinators advised by specialized working groups 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; a regionally hired coordinator; mechanisms for collaboration across African regions where problems cut across; and IARC support increasingly for solving strategic issues of producers and consumers.

Results and discussion: The bean networks, along with the potato networks catalyzed by CIP, have been referred to as organizational models and, indeed, they have been emulated by many others and continue to serve bean farmers well. Minor modifications focus on increasing market approach and making more overt the long-standing involvement of extra-NARS partners, such as NGOs and community-based organizations (see Section 1.2 above).

Experience with keeping the costs of bean network coordination down to a modest proportion of total costs has differed between the regions. ECABREN's arrangements for a fulltime coordinator hired by CIAT in close consultation with ASARECA have proven effective, particularly once the merger between the originally separate sub-regional networks for the Great Lakes and for Eastern Africa was successfully consumated. This is one of ASARECA's largest networks in terms of country and scientist membership, and the range of outputs, partnerships and activities to be coordinated is wide (Section 1.3). The proportion of funds available for research after meeting fixed coordination costs has fortunately remained high, due to multidonor support within PABRA. Nevertheless, over the course of 10 years, funding availability has never come close to satisfying demand from proposals submitted by network members. An element of internal competition has probably been helpful in maintaining quality, and the SC has consistently made clear choices in favor of research, with only a modest proportion of funding directed to capacity building and information exchange.

The southern Africa network has been coordinated for the past five years, as a cost-saving measure following completion of a special project, by one member country on a part-time and unpaid basis, with another national coordinator taking responsibility for regional exchange of germplasm. While the regional nurseries have proven very successful (see Section 2.4), the considerable additional demands made by network coordination inevitably limited the network's scope of activities; The recent PABRA evaluation and subsequent SC meeting recommended that the task warrants greater attention. In full agreement with SACCAR we are therefore now recruiting a full-time position for that network, although in recognition of its distinct nature, the position description is for 50% network coordination and 50% breeding (development of multiple constraints resistance for southern Africa's monomodal rainfall environments).

Contributors: R. Kirkby
Collaborators: M. Pyndji (CIAT/ECABREN), R. Chirwa (DARTS/SABRN)

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

Achievements:

- Agro-ecological zones of Uganda redefined and mapped for rural planners and policy makers; a report on methodology and the database on CD-ROM also made available
- Food security is the main reason for the importance of beans to urban farmers in Kampala, Uganda

Definition of agro-ecological zones for Uganda

Rationale: Much information on Ugandan agriculture exists, but most is not easily available or is in old documents that are difficult to obtain. The data are of variable quality, and the former zonation of agro-ecological systems in Uganda left much room for improvement. There was a need to compile and interpret available information, to zone and define the agro-ecological systems, and to avail this to a wide audience of rural planners and policy makers.

Methods: Data were complied and subjected to statistical and agronomic analysis. Agro-ecosystems were zoned and defined.

Outputs: A guide for planners and policy makers in the form of an A5-size manual, and a report on the methodology and data used, have been published and widely distributed, especially in Uganda. The database in ACCESS files and in an ArcView3 project, together with map images in .gif format, have been written to CD-ROM and distributed.

Contributor: C. Wortmann and C. Eledu

A baseline and diagnostic study of bean production by urban farmers in Kampala, Uganda

Rationale: In Africa urban agriculture is a growth industry due to the current high rate of urbanization. For the most part, agricultural researchers have ignored this sector and, consequently, urban farmers have benefited little from modern crop varieties. Yet, given the urban location of many agricultural research institutes, popularization of new varieties among urban farmers can achieve much impact with limited input. Because the growing literature on urban agriculture tends to be general and not crop and production oriented, there is little detailed crop-specific information to guide interventions for improving production.

Methods: Rapid appraisal techniques with groups (diagramming, ranking, transect walks) were used to collect information on urban farming in two Kampala communities with emphasis on bean production. A formal survey will be conducted to provide quantitative information on bean and sweet potato production.

Results: Urban farming is widespread in Kampala and is legal for most annual crops. Beans were among the top two most widely grown crops in the study communities. Others included sweet potatoes, maize and cooking bananas. The major reasons cited for urban farming were: improved household food security, provision of fresh produce and income generation. Beans have several advantages as an urban crop: high nutritional value (especially for children and nursing mothers), quick maturity and versatility as a food and cash crop. Beans are typically harvested early and eaten fresh, both as a strategy to avoid theft from plots that are usually located away from the homestead and due to the lack of space for threshing and drying. Urban farmers tend to be predominantly female but cut across the wealth spectrum. Major production problems for beans include land shortage, diseases and pests (root rots, bean stem maggot, aphids, chickens and birds). Although land shortage makes crop rotation problematic, few farmers practice soil improvement methods.

Contributors: S. David and S. Kasozi
Collaborators: M. Ugen and F. Opio (NARO)

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

Activity 2.1 Targeting of bean germplasm

Achievements:

- Africa's breeding priorities established with NARS partners as: 7 Andean and four Mesoamerican seed types, plus climbing types and snap beans
- New activities for networks programmed in biotic constraints nurseries, lines with multiple constraints resistance (MCR) and a new range of climbing and snap bean cultivars
- Characteristics which differentiate user groups for participatory bean breeding can differ even within a country
- Isolates of the angular leaf spot pathogen (*P. griseola)* from Madagascar showed occurrence of the Mesoamerican pathogen group on the island
- Variation in pathogen virulence in African isolates of *Xanthomonas campestris* account for unexpected susceptibility of CIAT-bred lines having high resistance in Latin America

Pan-African working group meeting on bean breeding

Rationale: Some farmer/consumer preferences for bean seed characteristics are common to large tracts of Africa, while others are more localised. The main biotic and abiotic constraints also cut across national and regional network boundaries, and often are associated with specific varietal types. Efficient regional and pan-African collaboration in this field depends upon shared vision and overall priorities on the part of national bean breeders, network coordinators and CIAT breeders. Convening periodic meetings of specialists is a key component in our strategy to catalyse cost-effective collaboration among national partners and to ensure that CIAT activities address their needs in a transparent manner.

***Methods*:** This working group meeting on bean breeding, the first in this field to be organized at pan-African level (discounting a pan-African workshop), involved 21 NARS breeders and pathologists from ECABREN and SABRN networks, with CIAT (Africa and Headquarters) scientists. Background reports covered current workplans of the networks and CIAT, highlights of the last bean pathology-breeding working group meeting, outputs of South Africa's backcross breeding program, and progress in marker assisted selection in beans.

***Results and discussion*:** Participants identified the importance by country of Andean and Mesoamerican seed types, climbers and snap beans, together with their principal production constraints. Seven Andean and four Mesoamerican seed types were considered to be of particular importance, with angular leaf spot (ALS), anthracnose (ANT), root rots (RR) and tolerance to low soil notrogen (N) and phosphorous (P) being the most frequently noted constraints (Table 5) Few climbing cultivars have been developed for regions outside the Great Lakes, and demand exists for more information on different types of snap beans.

Suggestions for future research priorities for funding by the Networks were made by reference to jointly developed protocols for Andean and Mesoamerican seed types, climbers and snap beans. New activities for networks funding covered principally the development and dissemination of biotic constraints nurseries, the selection of lines with multiple constraints resistance (MCR) and the breeding of a new range of climbing and snap bean cultivars (Table 6). Considerable interest was expressed in training support by CIAT in use of marker-assisted selection, with development and provision by CIAT of the appropriate markers.

Table 5. The most important biotic, abiotic and other constraints of bush, climbing and snap beans by seed type and country in sub-Saharan Africa.

Gene pool / type	Seed types	Countries where seed type(s) important[1]	Constraints in order of importance[2]		
			Biotic	Abiotic	Other
Andean – bush	Calimas, Large red, Purple	DRC, ETH, KYA, MAD, MLW, RWA, TZA, UGA, ZAM	ALS, ANT, RR	N, P, drought.	
	Speckled sugar, Cream-beige	DRC, ETH, KYA, MLW, MOZ, RSA, ZAM (+LES, SWZ, ZIM)	Rust, CBB, ALS.	N, P.	
	Large white	DRC, MAD, SDN	Rust, ALS.	N, P.	
	Yellows	ANG, BUR, DRC, RWA, TZA, ZAM.	ALS, ANT, RR.	N, P	
Meso-american-bush	Red-pink small	ETH, KYA, MAD	Rust, ALS, RR	N, P	
	White small	ETH, KYA, MLW, RSA, SDN, TZA	Rust, CBB.	N, P	
	Black	DRC, ETH, RWA, UGA			
	Pintos	ETH, KYA, LES			
Climbers		BUR, DRC, KYA, RWA, UGA	ANT, ALS, ASC, BCMV, RR.	N, P, drought	Lack of seed; Lack of high yielding cvs outside Great Lakes; Access to stakes; Few marketable cvs.
Snap		ETH, KYA, TZA	Rust, ALS, BCMV, ANT, RR, BSM, Thrips, Nematodes	Drought, N, P,	Lack of good quality seed; Lack of information on adaptability of climbing snaps, bobby and runners.

[1] BUR: Burundi; DRC: DR Congo; ETH: Ethiopia; KYA: Kenya; LES: Lesotho; MAD: Madagascar; MLW: Malawi; RWA: Rwanda; RSA: Rep. South Africa; SWZ: Swaziland; TZA: Tanzania; UGA: Uganda; ZAM: Zambia; ZIM: Zimbabwe.

[2] ALS: angular leaf spot, ANT: anthracnose, ASC: ascocyta (phoma) blight; BCMV: bean common mosaic virus; BSM: bean stem maggot; cv: cultivar; CBB: common bacterial blight; N and P: tolerance to low soil nitrogen phosphorous, respectively; RR: root rots.

Table 6. Summary of research priorities identified by pan-African breeding working group.

Topic	Andean	Mesoamerican	Climbers	Snap beans
Future priorities[1]	ANT, ALS, CBB, Rust, ANT, N, P	ANT, ALS, CBB, RR, MCR	ANT, ALS, ASC	Rust, ALS, RR BSM, MCR. Climbing cultivars
New activities	Develop biotic constraint nurseries	Sources of biotic resistance	Develop MCR lines	Develop biotic constraint nurseries
	Backcross resistance into main seed types	Develop MCR lines	Widen the genetic base	Develop MCR lines
	Combine biotic and abiotic resistances	Pathogenic variation in ANT and rust	Develop improved cultivars	Develop climbing snap bean cultivars
			Evaluate staking options [climbers]	

[1] ALS: angular leaf spot, ANT: anthracnose, ASC: ascocyta (phoma) blight; BSM: bean stem maggot; CBB: common bacterial blight; N, P: tolerance to low soil nitrogen, phosphorous; RR: root rots.

Contributor: H. Gridley
Collaborators: Coordinators and scientists in ECABREN and SABRN; R. Buruchara; M. Blair (CIAT IP-1)

Identification of bean user groups for participatory plant breeding

Rationale: Previous participatory plant breeding activities have paid little attention to farmers' differentiated needs and interests. User groups are defined as producers/consumers with similar socio-economic and agronomic circumstances who share selection criteria and preferences for bean characteristics.

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

Results: In Awassa, Ethiopia, preliminary user groups seem to be differentiated according to soil type and degree of input use. In Nazreth, Ethiopian researchers stratified farmers by wealth and soil type. However, they concluded that bean preferences are mainly differentiated by end use—whether for direct home consumption or for sale/export. In Eastern Ethiopia researchers are testing hypotheses that wealth and gender are the main differentiating factors determining farmers' bean preferences. In Northern Tanzania bean preferences seem to differ by gender and market orientation, with three primary groups being identified: small-scale women, small-scale men and market oriented farmers. [See also Section 2.3].

Contributor: S. David
Collaborators: D.Dauro (Awassa RC); Frew Mekbib (AU); E. Nkonya and P. Xavery (DRD); Abraham Tesfaye (EARO); L. Sperling (CIAT/PRGA)

Characterization of pathogen diversity of *Phaeoisariopsis griseola* in Africa

Rationale: Angular leaf spot (ALS) caused by *Phaeoisariopsis griseola* is the most widespread and important bean disease in Africa, causing an estimated annual yield loss of 374,800 tons. Host resistance is the most effective and practical management strategy for the majority of the poor resource farmers, but deployment and usefulness of resistance can be adversely affected by occurrence of pathogen variability in *P. griseola*. Recent characterization of African isolates by virulence and molecular methods showed that, in addition to Mesoamerican and Andean pathogen groups associated with small and large-seeded cultivars, respectively, an Andean sub-group (known as Afro-Andean) also occurs. Characterization and mapping of pathogen diversity is a tool in targeting of resistance breeding.

Methods: Isolates from Madagascar were characterized for the first time using virulence methods. More isolates from Uganda, DR Congo and Malawi were also characterized. A total of 24 isolates were characterized. Virulence phenotypes of isolates were characterized based on a set of 12 bean differentials of which six belong to the Andean and six to the Mesoamerican genepool.

In collaboration with CIAT Project IP-1, some aspects of molecular characterization of *P. griseola* were initiated at Kawanda. More emphasis was given to developing and establishing DNA extraction capacity and procedures adapted to conditions and facilities in laboratories typical of national research institutions in the region.

Results and discussion: On the basis of virulence, the six isolates from Madagascar could be grouped into three races within the Mesoamerican pathogen genepool (Table 7). They infected at least four Mesoamerican differentials in addition to the Andean ones. Some of those from DR Congo and Malawi belonged to Andean (infecting Andean differentials only) and others to the Mesoamerican pathogen genepool. Some isolates from DR Congo (Z4, Z11 and Z15) and Uganda (KAB.1N, KAB.2N and KIS.1R) gave reactions associated with the Afro-Andean group. Characterization of these isolates continues using molecular methods to establish occurrence and importance of the Afro-Andean group. For the moment detection of Afro-Andean races require comparison of molecular and virulence characterization. The differential variety Mex 54 was resistant to most African isolates and shows potential as a source of resistance to most races of *P. griseola* identified so far. Work has been initiated to determine the nature of resistance in Mex 54.

DNA extraction from *P. griseola* was successful on 60 isolates using modified protocols in a typical laboratory. Molecular characterization of these isolates is reported elsewhere.

Table 7. Virulence diversity of *P. griseola* in DR Congo, Madagascar and Malawi.

			Phenotypic reaction on differential cultivars[x]											
			Andean						Mesoamerican					
Isolate Identification	Origin[y]	*Race*	A	B	C	D	E	F	G	H	I	J	K	L
M3	MLW	30-0		B	C	D	e							
Z1	DRC	61-0	a		C	D	e	f						
Z6	DRC	63-1	a	b	C	D	e	f	g					
Z15	DRC	5-4	a		C						I			
Z11	DRC	31-4	a	b	C	D	e				I			
KAB-1N	UGA	62-4		b	C	D	e	f			I			
KAB-2N	UGA	63-5	a	b	C	D	e	f	g		I			
KIS.1R	UGA	63-6	a	b	C	D	e	f	g	h				
Z4	DRC	55-35	a	b	C		e	f	g	h				l
M1	MLW	51-38	a	b			e	f		h	I			l
Z12	DRC	63-38	a	b	C	D	e	f		h	i			l
Z5	DRC	0-39							g	h	i			l
M4	MLW	25-39	a			D	e		g	h	i			l
MDR1	MDG	31-39	a	b	C	D	e		g	h	i			l
MDR2	MDG	63-39	a	b	c	D	e	f	g	h	i			l
Z2	DRC	63-39	a	b	c	D	e	f	g	h	i			l
M2	MLW	53-55	a		c		e	f	g	h	i		k	l
2M	MLW	63-55	a	b	c	D	e	f	g	h	i		k	l
KAB-2	UGA	63-55	a	b	c	D	e	f	g	h	i		k	l
KIS-1	UGA	63-55	a	b	c	D	e	f	g	h	i		k	L
MDR4	MDG	63-55	a	b	c	D	e	f	g	h	i		k	l
MDR5	MDG	63-55	a	b	c	D	e	f	g	h	i		k	l
MDR6	MDG	63-55	a	b	c	D	e	f	g	h	i		k	l
MDR7	MDG	63-55	a	b	c	D	e	f	g	h	i		k	l

[x] CIAT *P. griseola* differentials:

A = Don Timoteo; B = G 11796; C = Bolon Bayo; D = Montcalm; F = Amedoin; E = G 5686; G = PAN 72; H = G 2858; I = Flora de Mayo; J = MEX 54; K = BAT 332; L = Cornell 49-242.

[y] Origin of *P. griseola* isolates:

MDG – Madagascar; DRC = Democratic Republic of Congo; MLW = Malawi; UGA = Uganda.

Contributors: R. Buruchara; G. Mahuku (IP-1); F. Opio (NARO), G. Rakotomalala (FOFIFA) and K. Ruhebuza (PNL/INERA). (Jointly with PE1)

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

Rationale: In Latin America, VAX bean lines from CIAT Project IP-1 exhibit high levels of resistance [incorporated from tepary beans, *P. acutifolius*] against common bacterial blight (CBB) caused by *Xanthomonas campestris* pv *phaseoli*. However, VAX lines 1 and 2 were found in Malawi, Uganda and S. Africa to give intermediate to susceptible reactions. Studies were initiated in 1998 to characterize and understand reactions of these lines to *X. c.* pv *phaseoli* isolates in Africa.

Methods: Trials were designed to investigate two likely explanations: first, to ascertain if host-pathogen interaction exists between African isolates and the VAX lines and, secondly, if the method of bacterial entry (inoculation) influenced reaction of the VAX lines. Eight entries varying in reaction to CBB were inoculated with five isolates (XCP-1 to XCP-5) using the razor blade method on three-week old seedlings. Two additional inoculations were made one week apart. Evaluations were started when symptoms first appeared and were made weekly for three weeks. To assess methods of inoculation, five entries varying in reaction to CBB were inoculated with XCP-1 using razor blade, multiple needle and spraying methods under greenhouse conditions.

Results and Discussion: Reactions of 5 representative varieties four weeks after inoculation with different isolates are shown in Figure 1. Differences within varieties and isolates were significant, whereas variety-isolate interactions were not. Isolates XCP-1 and XCP-2 were more virulent on all varieties tested, while XCP-5 was the least virulent. The bean lines VAX 1 and 2 gave susceptible and intermediate reactions with XCP-1 and XCP-2 isolates, respectively, and resistant or intermediate reactions with the other isolates. The pattern of reaction was similar on the other varieties tested, implying that isolates varied in virulence.

Reaction to different methods of inoculation is shown in Figure 2. There were significant differences in varietal reaction to the XCP-1 isolate; within each variety, however, there was no significant difference between the three methods tested, indicating that facilitating entry by razor blade and multiple needle methods was no more advantageous than spraying. This also means that tolerance of VAX lines was not related to restricting entry of the bacterium into the host. On the basis of these, it is tentatively concluded that the reactions incited on VAX 1 and VAX 2 by XCP-1 and XCP-2 are due to the virulence of these isolates, which appear greater than other isolates tested, probably including those of Latin America. There is, however, a need to compare isolates from the two continents.

Contributors: R. Buruchara and B. Bosco.
Collaborators: R. Chirwa (DARTS), A. Liebenberg (ARC)

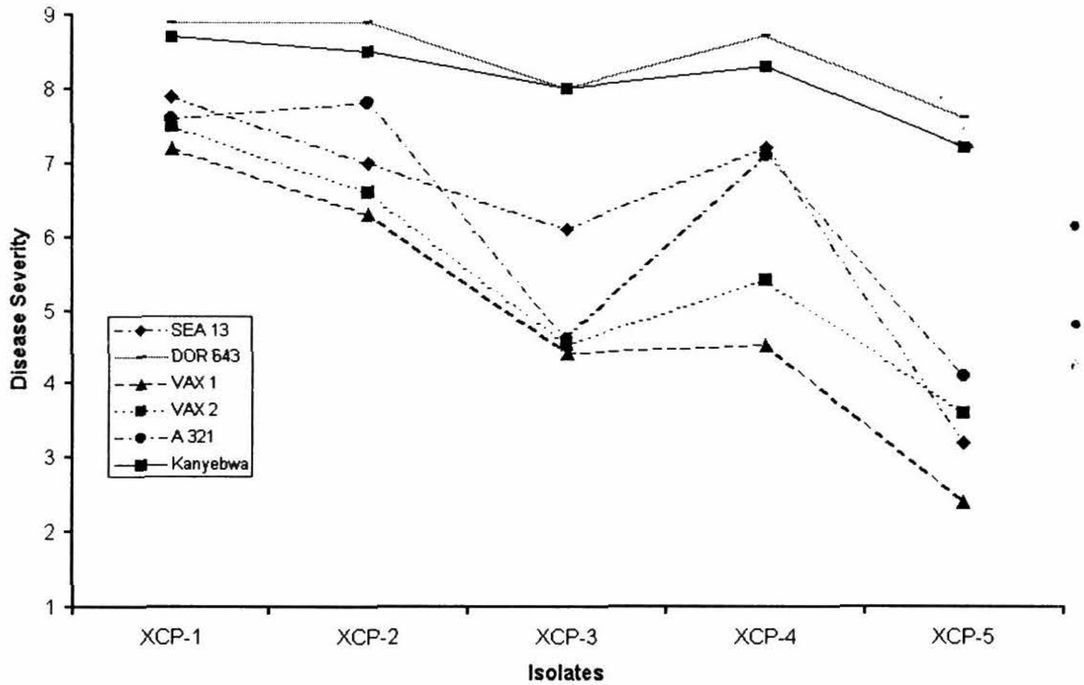

Figure 1. Reaction of selected entries to inoculation with five *Xanthomonas campestris* pv *phaseolicola* isolates, Kawanda, Uganda.

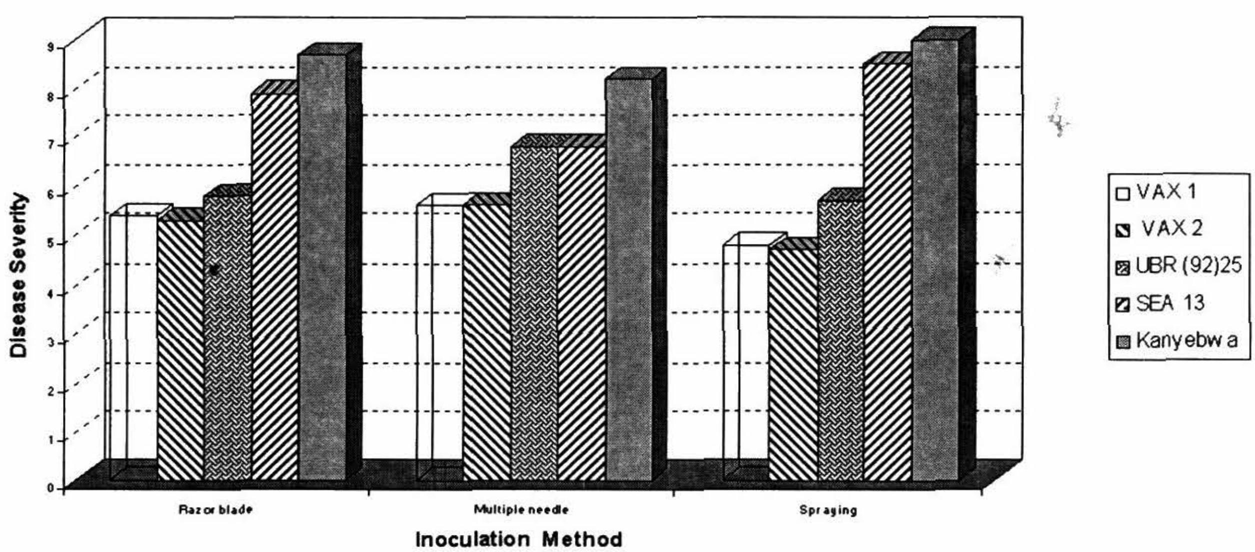

Figure 2. Effect of three inoculation methods (razor blade, multiple needle and spraying) on the reaction of selected bean entries to *X. c.* pv *phaseoli* in a screenhouse, Uganda.

Activity 2.2 Germplasm to address African production constraints

Achievements:

- Mean annual yield increase since inception of the regional virus resistance breeding program in 1991 was 8.5% in Uganda against a standard variety
- New sources of resistance to aggressive Andean and Mesoamerican strains of ALS inAfrica identified in lines from CIAT and progenies selected in Uganda.
- Severity of Pythium root rot shown to be a good measure of resistance; reduction in root and shoot weights (but not root length) being associated characteristics useful in selection
- Few additional sources useful against Pythium identified from evaluating many nurseries, but more promising results from selection among single plant progenies
- Further promising lines identified from BILFA II for tolerance to low soil N and P availability and acid soil conditions, and with generally more acceptable seed types than earlier selections
- Several new sources of resistance to stem maggot confirmed in first results from collaborators
- Excellent progress in identifying multiple constraint resistance – combining resistance to angular leaf spot with resistance to bacterial blight, tolerance to Pythium root rot or to low soil N and/or P, and often with reasonable yield potential

General rationale: Over the past two decades NARS have made intensive use of introduced lines in breeding and constraint nurseries from CIAT, Colombia (now Project IP-1), which have provided 95 (59%) of 162 cultivars released by NARS from the 1950s to 1998. The reduction in this supply jeopardizes the rate of new cultivar releases as few NARS have developed crossing programs that can compensate for this loss. Whilst NARS expand their crossing activities, we are developing and distributing well adapted lines, early generation progenies and segregating populations with resistance to single and multiple combinations of important biotic and abiotic African constraints for evaluation by NARS.

General methods: The development of single and multiple resistance has involved teamwork: the identification or confirmation of sources resistant to African pathogens or strains (led by the CIAT IP-2 pathologist) is followed by generation and evaluation with artificial inoculation in the screenhouse (led by CIAT IP-2 breeder) of:
(i) F_1-derived-F_3 progenies selected from locally generated multiple parent crosses for combinations of resistance to angular leaf spot (ALS), BCMV/BCMNV (bean common mosaic and necrosis virus), common bacterial blight (CBB), root rots, bean stem maggot (BSM) and tolerance to low soil nitrogen (N) and phosphate (P);
(ii) F_2-derived-F_7 progenies selected from segregating populations introduced from CIAT; and advanced lines bred for multiple resistance to ALS, CBB and anthracnose, introduced from CIAT-Cali.

Development of bush lines with resistance to the principal viral diseases in Africa

Rationale: Bean common mosaic virus (BCMV) is the most important virus disease in Africa. Many CIAT-Cali lines carry the dominant 'I' gene that confers resistance to all known strains. This gene, however, produces a hypersensitive reaction leading to systemic necrosis with the 'necrotic' strains NL3, NL5 and NL8 now termed bean common mosaic necrosis virus (BCMNV), which are common in eastern and central Africa. To combat this, 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.

Methods: We yield-tested 24 BCMNV resistant bush lines selected from segregating populations, at three sites in Uganda in the first season of 1999.

Results: The yield results from two sites were discarded due to high coefficients of variation (≥35.0%). At the third site of Bukalasa, eight large seeded significantly outyielded the large seeded, released cultivar, CAL 96, in the range of 32% to 69% (Figure 3), but no medium or small seeded line showed a significant yield increase over the released, small seeded cultivar, MCM 5001. These eight and a further two large seeded lines and 10 medium or small seeded lines exhibited significant yield increases over the earlier released, large seeded cultivar, K20, in the range of 45% to 106% and 48% to 97%, respectively (Figure 3). The mean yield of these 20 lines is 68% greater than K20, denoting a 8.5% mean annual yield increase over K20 since the inception of the BCMNV breeding program in 1991.

To date, 134 lines have been distributed to NARS in two pan-African BCMV nurseries and a further 53 resistant lines are now available for distribution to NARS breeding programs.

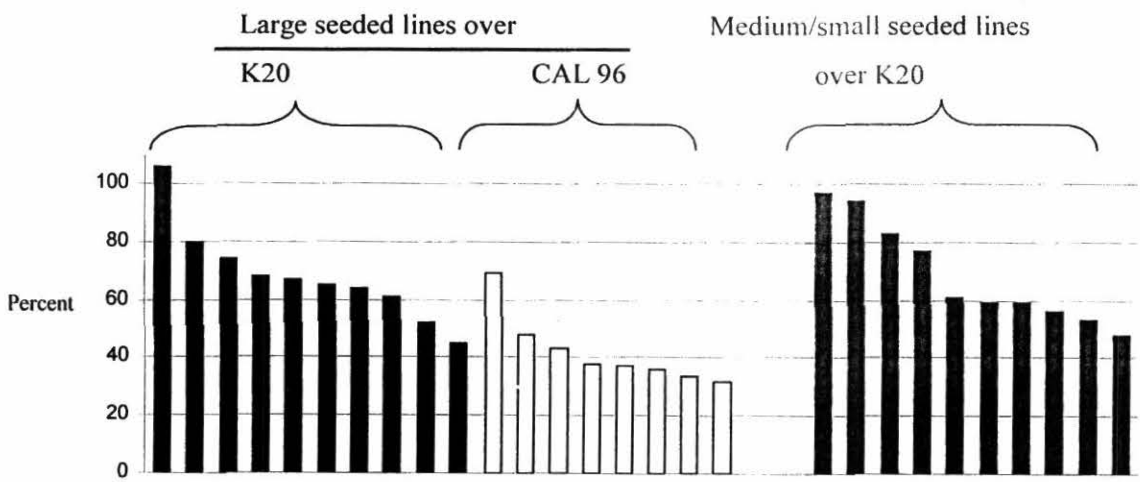

Figure 3. Significant ($P \leq 0.05$) yield increases (as a percentage) of 10 large and 10 medium or small seeded BCMNV resistant lines over the controls K20 and CAL 96 at one site in Uganda in 1999a.

Contributor: H. Gridley
Collaborator: Theresa Sengooba (NARO)

Identification of sources of resistance to angular leaf spot

Rationale: Angular leaf spot (ALS) is the second most important biotic constraint in Africa. *Phaeoisariopsis griseola*, the pathogen that causes ALS, exhibits wide pathogen diversity. Although the Mesoamerican and Andean pathogen groups have been identified both in Latin America and Africa, sub-groups (Afro-Andean) or races that seem to be unique to Africa also exist. For example, Mex 54 is resistant to most races (both Mesoamerican and Andean races in Africa) characterized so far, whereas it is susceptible to several Mesoamerican races group in Latin America. Identifying germplasm resistant to existing pathogen diversity in Africa is important to provide new varieties or as a source of resistance in improving susceptible commercial varieties.

Methods: Forty-six entries showing resistance to certain races in Latin America were artificially inoculated with separate mixtures of local Andean and Mesoamerican isolates.

Results and Discussion: Eighteen entries gave reactions of less than 5 (on a CIAT scale of 1 – 9) with Mesoamerican isolates, while 12 entries gave similar reactions with Andean mixtures of isolates. Only 9 entries gave reactions of less than 5 to both isolate groups. G 2852 had a highly resistant score of 2; BAT 332, EMP 354, G 5653, MAR #1, MAR #2 and MAR #3 had a score of 4 while G 2121 and G 3927 had a score of 5. Given the occurrence of both Mesoamerican and Andean races in several African locations, evaluating resistance sources against both race groups is necessary.

Contributors: R. Buruchara and B. Bosco
Collaborators: NARO

Identification of bush lines with resistance to angular leaf spot

Rationale: The breeding objective is to identify or develop sources resistant to strains from both pathogen diversity groups in a range of commercially useful seed types.

Methods: Each screening for resistance in the screenhouse involved 70 test genotypes plus a resistant and susceptible control, with two pots of five plants of each genotype sown in two replicates. Plants were inoculated at the first trifoliate stage with a mixture of local Andean and Mesoamerican strains and rated four weeks later on CIAT's 1-to-9 scale. Disease ratings were only considered acceptable if the susceptible check rated 7 or more.

Results and discussions: We identified as resistant 41 F_1-derived-F_3 single plant progenies, eight F_2-derived-F_7 progenies and 22 advanced breeding lines from CIAT-Cali, representing 19% of all the genotypes evaluated, with a 198 progenies and 70 lines rated intermediate (Table 8). The marked variation between single plant ratings within many progenies was indicative of considerable segregation and potential for improving resistance by further intra-progeny selection.

Table 8. ALS screening with artificial inoculation in the screenhouse in Uganda, 1998-99.

Genotypes[1]	Source	Frequency of disease ratings[2]		
		R	I	S
F_{1-3} SPP	Selections from CIAT-Uganda crosses for MCR	25	42	3
F_{1-3} SPP	Selections from CIAT crosses for MCR	16	145	18
F_{2-7} SPP	Selections from CIAT-Cali crosses for ALS	8	11	0
CIAT-MCR lines	CIAT-Cali MCR lines	22	70	14
Total	Number	71	268	35
	Percent	19	72	9

1. F_{1-3} SPP: F_1-derived-F_3 single plant progenies; F_{2-7} SPP: F_2-derived-F_7 progenies; MCR: multiple constraint resistance.
2. Disease ratings on a scale of 1-9, where 1-3 =resistant (R), 4-6=intermediate (I) and 7-9=susceeptible (S).

Contributor: H. Gridley
Collaborators: R. Buruchara; NARO; IP-1

Characteristics associated with resistance to *Pythium* root rot

Rationale: Root rot caused by *Pythium* spp has become the most import soilborne disease of beans in some of the main bean growing areas of east and central Africa, and threatens production in an increasing number of areas and especially where soil fertility is low. Many popular and commercial varieties are susceptible. Though few in number, some varieties have been identified as having good levels of resistance and offer potential for genetic improvement of susceptible varieties. Understanding their characteristics could improve future selection.

Methods: In a continuation of studies started last year, characteristics associated with resistance against Pythium root rot were determined. Twenty entries selected from previous evaluations were assessed under screenhouse conditions for root and shoot parameters associated with root rot resistance – including root biomass, root length, shoot weight and disease severity on the hypocotyl and roots. These parameters were compared in non-infected and artificially infected soils, and seedling emergence, plant stand one month after germination and other characters were noted. Entries were further reduced to 8 and evaluated in detail. CAL 96 and RWR 719 were used as susceptible and resistant checks respectively.

Results and discussion: There was no difference among the entries or between the two soil environments for plant emergence. Differences in root rot severity between the susceptible cultivar CAL 96 (8.9) and the resistant entries were significant (Figure 4A) in infected soil. Differences among some resistant cultivars were also significant, and varied between 3 and 6 using the CIAT scale of 1 to 9. All entries showed virtually no symptoms in non-infected soil.

Severity of root infection was a good measure to distinguish between susceptible and resistant cultivars and also between infected and non-infected soils. Root length was significantly reduced on CAL 96 and on two other cultivars in infected soil, while there was no difference in four varieties and roots were significantly longer on AND 1064 and RWR 719 (Figure 4D). The little or no effect observed on most resistant cultivars indicated that Pythium root rot least affect this parameter. On the other hand, root weight on the susceptible variety (CAL 96) and most resistant varieties was significantly reduced in infected soil in comparison to non-infected soil (Figure 4B). Of interest were entries MLB 17 and RWR 719, in which no reduction in root weights in infected soil implied minimal damage of roots.

With the exception of MLB 17 and RWR 719, there was significant reduction in shoot weight with all entries in infected soil (Figure 4C). The percentage reduction varied with different entries, but reduction in root weight seemed to be associated with reduction in shoot weight. These results show that disease severity is a good measure of resistance. However, the percentage reduction in root weight appeared to be associated with severity. Entries with little or no reduction in root weight (MLB 17, RWR 719) had also better levels of resistance. There were, however, some exceptions.

Contributors: R. Buruchara, H. Gridley and B. Bosco. (Jointly with PE1)

Identification of new sources of resistance to *Pythium* spp.

Rationale: Evaluation of more diverse types of germplasm against Pythium root rot may identify new sources of resistance for germplasm improvement or direct use by farmers.

Methods: A total of 622 entries was evaluated in a screenhouse under artificial inoculation. Entries evaluated included germplasm from CIATs' Core Collection (213), sources of resistance of anthracnose (70), entries from BILFA- IV (72), the Rwandan germplasm collection made in 1995 under the Seed of Hope (SOH) project for Rwanda (169), components of mixtures from southwest Uganda (Kisoro) and the IBN 96 from CIAT Project IP-1 (98). These materials represented both bush and climbing beans and diverse seed characteristics.

Results and discussion: Out of 622 entries, one was resistant, 28 (4.5%) gave intermediate reactions, while 95 % were susceptible. The identity and some of the characteristics of resistant and intermediate entries are given on Table 9. Eight entries were selected for inclusion in the Regional Root Rot Nursery, which now totals 68 materials. These and previous results highlight the limitation of relying solelyon a varietal strategy in the management of Pythium root rots.

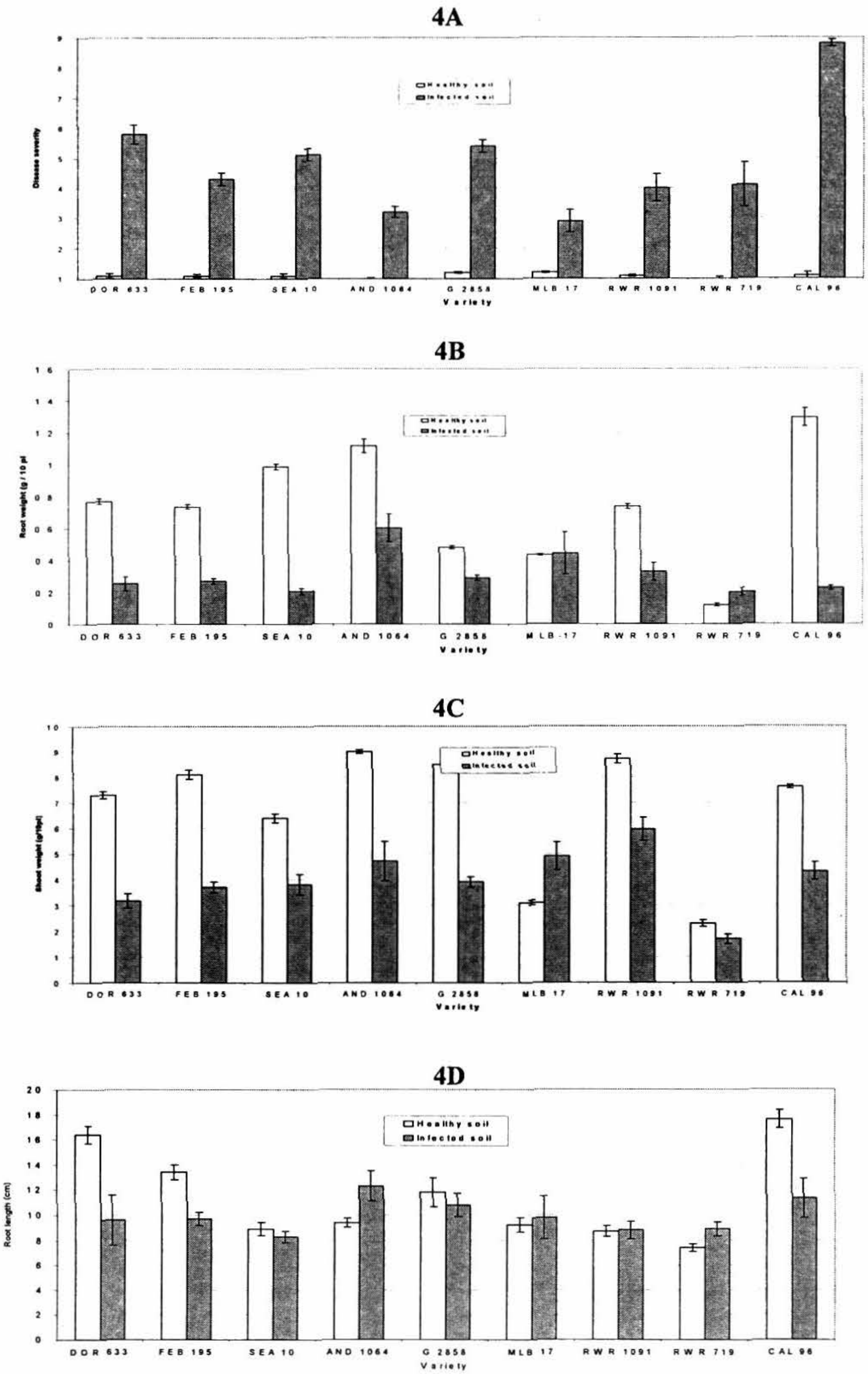

Figure 4. Effect of Pythium root rot on disease severity (3A), root weight,(B), shoot weight(3C) and root length (3D) of susceptible (CAL96) and selected tolerant entries. Bars indicate standard error of means. Greenhouse, Kawanda.

Table 9. Origin, seed types, growth habits and reaction of the best entries from the Lamb collection (ex-Rwanda) to Pythium root rots in the screenhouse, Kawanda, 1998.

Entry	Source Nursery	Seed Type	Growth Habit	Reaction
AFR 619	BILFA	M	1	4.3
CIM9313-1	BILFA	S	1	5.1
CIM9314-4	BILFA	M	1	3.9
DFA 54	BILFA	M	1	5.9
RWR 1946	BILFA	M	1	4.0
RWR 2075	BILFA	L	1	3.9
UBR(95)2	BILFA	S	1	3.7
MS1/3	SOH			6.0
199/4	SOH			5.9
G 11088	CC	M	4	5.5
G 731	CC	M	4	5.7
G 9871	CC	M	3	6.0
G 10944	CC	M	5	5.9
G 14241	CC	M	5	4.5
G 11037	CC	M	5	4.9
G 2620	CC	L	5	6.1
G 3936	CC	S	3	5.4
G 10997	CC	S	3	5.8
G 2205	CC	M	3	5.0
G 10950	CC	L	3	6.0
G 9872	CC	M	3	5.8
MX9065-3-M	IBN-96	M	Bush	5.6
LP90-15	IBN-96	M	Bush	3.7
FM-M-38-1	IBN-96	M	Bush	3.6
MX9065-3-A	IBN-96	M	Bush	4.5
ICTAJU95-19	IBN-96	S	Bush	5.2
MX8754-22T	IBN-96	G	Bush	5.5
LM93204453	IBN-96	M	Bush	3.0
CB9021806	IBN-96	S	Bush	3.6

Contributors: R. Buruchara and B. Bosco (jointly with PE1)
Collaborators: ISAR

Identification of bush bean breeding lines with resistance to root rots

Rationale: Lines resistant to root rots with a range of useful seed types are urgently needed to meet the varied demands of producers and consumers.

Methods: Fifty-one F_1-derived-F_3 single plant progenies from nine crosses for multiple resistance involving a source *Pythium* spp. resistance were screened for resistance to *Pythium* spp. Two rows of fifteen seeds of 'sets' of eight progenies and two control entries (the released large seeded cultivar, CAL 96) were sown into infected soil in a wooden tray in the screenhouse at Kawanda. Progeny and control disease rating were derived from the mean of infection ratings on the roots of all plants in a plot one month after sowing, using CIAT's 1-to-9 scale. In addition, the progeny disease ratings in a tray were expressed as a percentage of the mean of the controls in the same tray, to adjust for any discrepancy in infection levels between trays.

Results and discussion: Of the 51 F_1-derived-F_3 single plant progenies, seven (14%) rated between 3.3 and 3.9, twenty-eight (55%) between 4.0 and 4.9, eight (16%) between 5.0 and 5.9, two (4%) between 6.0 and 6.9 and six (12%) between 7.0 and 7.7. The more resistant progenies showed a greater percentage increase in resistance over CAL 96 and a higher frequency of resistant single plants (rating ≤ 3.0) (Figure 5). As for ALS, marked within-progeny variation for disease ratings and the frequency of resistant single plants indicated the potential for improving resistance by further intra-progeny selection.

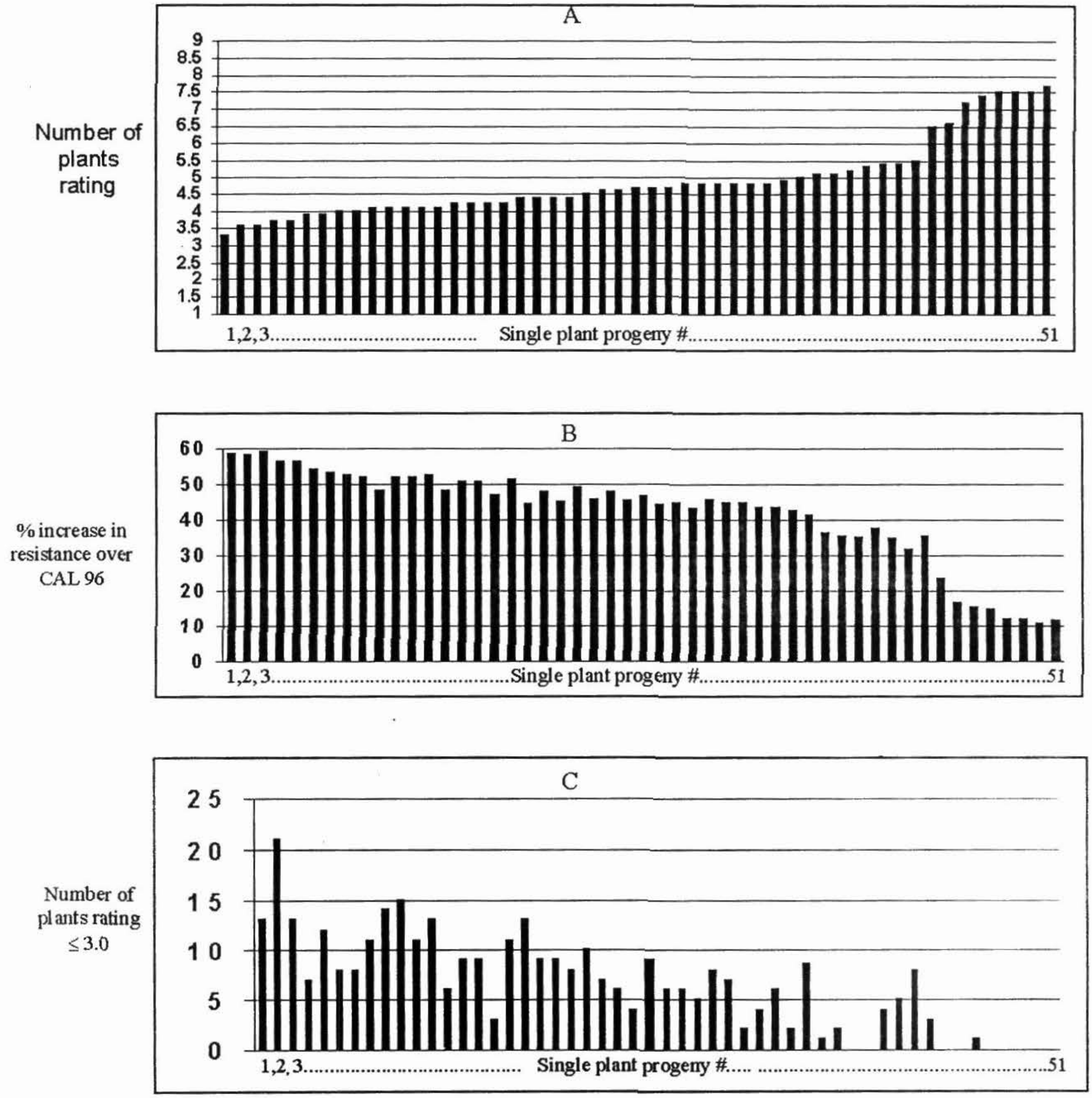

Figure 5. A: Disease ratings for *Pythium* spp. infection in 51 single plant progenies;
B: percent increase in resistance over CAL 96;
C: number of resistant plants in a progeny (rating ≤ 3.0).

Contributor: H. Gridley
Collaborators: R. Buruchara; NARO; IP-1

Identification of bush lines with multiple resistance to root rots and angular leaf spot

Methods: Screening of F_1-derived-F_3 single plant progenies for resistance to ALS and *Pythium* spp. has been described above. Due seed shortage for three progenies, resistance scores for both constraints are only currently available for 48 progenies. The ratings for ALS are provisional, as that for the susceptible control was one unit less than the acceptable level of 7 and all ratings are based on one replicate.

Results and discussion: Although there was no correlation between the ratings for the two diseases of the 48 F_1-derived-F_3 single plant progenies, 32 progenies combined resistant or intermediate ratings (≤4.9 for both constraints; Figure 6). A significant proportion of selections had popular seed types, and are being given priority for the development of multiple resistance. The intra-progeny variation noted previously for both characters indicates that reselection within such progenies for the two constraints may be expected to develop lines with dual resistance.

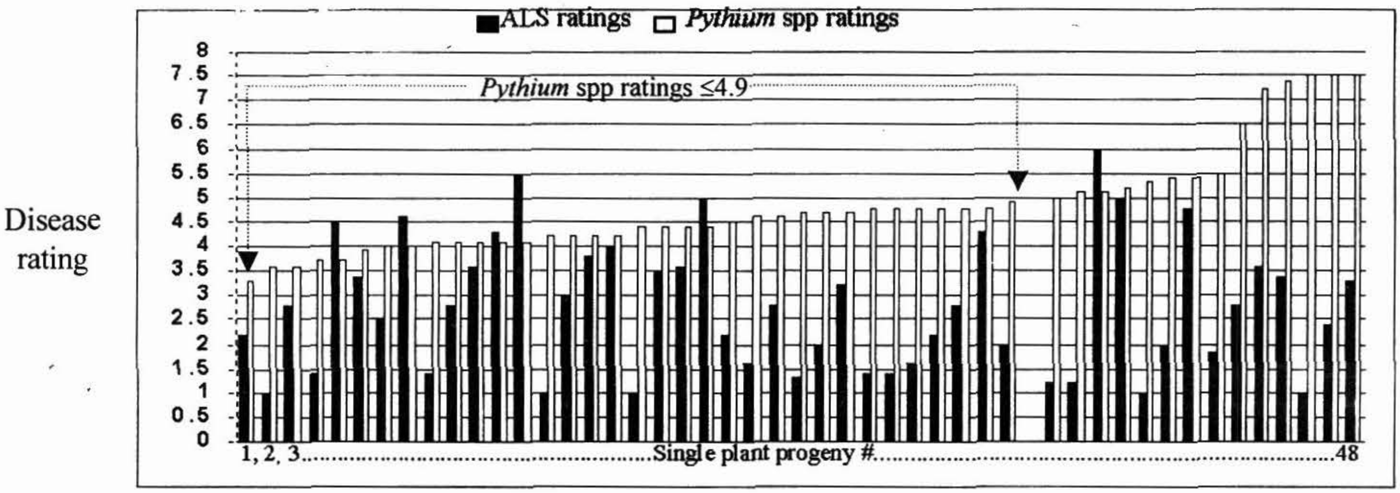

Figure 6. Disease ratings for angular leaf spot (ALS) and root rot (*Pythium* spp.) for 48 single plant progenies from nine crosses for multiple constraint resistance.

Contributor: H. Gridley
Collaborators: R. Buruchara; NARO

Segregating bush populations and lines selected for tolerance to low soil fertility

Rationale: Soil fertility related constraints are estimated to cause one million tons of bean yield loss annually in sub-Saharan Africa. Resource poor farmers are severely constrained in their ability to manage soil productivity. New varieties that allow biotic tolerance and abiotic resistances to be combined would improve small-farmers' productivity.

Methods: Forty-six segregating bush populations, introduced from CIAT-Cali, were evaluated for yield and disease reaction in a replicated trial at three sites in Uganda. Twenty-four lines introduced lines from CIAT-Cali for tolerance to low soil P and N, were yield tested in a replicated yield trial at a low N and a low P site in Uganda.

Results and discussion:

Population Yield Trial: The results from two sites were discarded due to very high (>40%) coefficients of variation for yield. At the third site of Senge (near Kawanda) no population significantly outyielded the large seeded, released cultivar, CAL 96, though thirteen had equivalent yields. Of these thirteen, one was significantly superior to CAL 96 for disease ratings in the field for angular leaf spot and common bacterial blight (Table 10).

Table 10. Yield (kg/ha) and ratings for common bacterial blight (CBB) and angular leaf spot (ALS) of 13 F_5 or F_6 large seeded populations at Senge, Uganda in 1999a.

Populations, generation and code	Yield		CBB[2]	ALS[2]
	kg/ha	% CAL 96[1]		
F_5 VTTT 910	1319	100	5	5
F_6 VXAM 20	1302	99	6.5	5
F_6 VXAT 10	1270	97	5	4.5
F_5 STTT 190	1181	90	5	5
F_5 VLLL.55	1168	89	5	4
F_5 VTTT 899	1111	85	5	5
F_5 VTTT 904	1102	84	4.5	6.5
F_5 VLLL 62	1077	82	4.5	4
F_5 VLLL 72	1073	82	5.5	4
F_5 STTT 203	1067	81	6	5.5
F_5 VTTT 902	1057	80	6	4.5
F_5 VLLL 60	1049	80	4	4.5
F_5 STTT 201	1018	77	6.5	6.5
CAL 96	1315		5.5	6.2
Mean	931		5.1	6.5
CV%	20.5		15.8	14.3
LSD (P≤0.05)	318.0		1.31	1.20

[1] Yield of the control (the large seeded release, CAL 96) taken as 100.

[2] Underlined values significantly (P≤0.05) lower than CAL 96. Disease ratings made on a scale of 1-9, where 1-3=resistant, 4-6=tolerant and 7-9=susceptible.

Low Fertility Yield Trial: The two lines, VAX 1 and VAX 2, significantly (P≤0.05) outyielded the controls (the large seeded release CAL 96, and the two small seeded releases MCM 5001 and UBR(92)25), at the low N site at Kawanda. One line ,XAN 263, outyielded CAL 96 across the two sites (Table 11). Further testing is required at Bukalasa due the high coefficient of variation recorded.

Table 11. Yield performance of three superior lines in the Low Fertility trial 99a at Kawanda (low N) and Bukalasa (low P) in Uganda in the first season of 1999.

Line code	Kawanda				Bukalasa				Mean			
	Yield (kg/ha)	% of controls[1]			Yield (kg/ha)	% of controls			Yield (kg/ha)	% of controls		
		UBR (92)25	MCM 5001	CAL 96		UBR (92)25	MCM 5001	CAL 96		UBR (92)25	MCM 5001	CAL 96
VAX 1	1222	145[2]	157	175	600	132	135	144	911	140	149	188
VAX 2	1444	171	186	206	600	132	135	144	1022	157	167	211
XAN 263	933	110	120	133	444	97	100	107	689	106	113	142
UBR(92)25[1]	845				456				650			
MCM 5001	778				445				612			
CAL 96	700				417				484			
Mean	620				263				441			
CV%	21.5				47.5				37.7			
LSD	241.8				226.3				204.1			

[1] MCM5001 and UBR(92)25, small seeded released with good tolerance to low N and low P.

[2] Control yield taken as 100; underlined values represent a significant ($P \leq 0.05$) over a control.

Contributor: H. Gridley
Collaborators: CIAT Project IP-1

Bean improvement for low fertility soils in Africa (BILFA)

Rationale: Bean varies genetically for tolerance to low soil fertility conditions and for responsiveness to variation in nutrient supply. Lines selected under low fertility conditions generally respond to improved soil fertility as well.

Methods: The second cycle of germplasm evaluations under the collaborative activity Bean Improvement for Low Fertility Soils in Africa (BILFA) originally consisted of 340 lines. After preliminary evaluation at a few sites, 40 and 50 genotypes were selected for low N and low P multi-location evaluation across countries, respectively, including at some acid soil locations. Collaborators met in June, 1999, to compile and analyze the data, and to interpret the results.

***Results*:** Twenty, 34 and 28 lines were identified as promising for low N, low P and acid soils, respectively. Tolerance to low N and P was most common in small seed types and rare in large seed types (Table 12). Acid soil tolerance, however, was found in lines of all seed sizes up to 50 g per 100 seeds.

Cream, tan and black seed lines were most likely to be selected for one or more stresses. White and pink seed types were likely to be selected for low N. Lines of yellow, purple and Calima seed type were unlikely to be selected, but Calima (e.g., AND 920 and AND 923) types were selected for tolerance to the acid soil complex. Lines with indeterminate growth habit were most likely to be selected for all stresses. A few determinate lines were selected for acid soil conditions.

Discussion: BILFA has been a success, but its impact could be much greater. Most national programs have not yet integrated BILFA into their breeding programs. That most tolerant lines were often of less preferred seed types discouraged breeders, but there are exceptions. In the BILFA III, there are more lines of preferred seed type, such as large seeded Calima types. These must be judged less critically than some other types; while they are tolerant within their class, they cannot match the tolerance of small and tan or black seeded meso-American types.

Table 12. Proportion of BILFA II lines having specific seed or growth habit characteristics selected for tolerance to low soil N, low soil P and acid soils.

Seed characteristics / growth habit	Percent of Original set	Probability for selection of a line from character sets		
		Low N	Low P	Acid soil
100 seed weight(g)				
< 30	27	22	33	19
30-50	58	0	2	6
> 50	15	0	0	0
Seed color				
White	2	18	0	0
Cream-biege	18	13	22	14
Pink	2	35	15	0
Red	41	5	5	6
Black	5	7	5	43
Other	31	0	23	3
Growth habit				
Type I	52	1	0	5
Type II & III	48	11	21	12

Contributors: C. Wortmann; Lunze Lubanga (INERA/ECABREN) and Rowland Chirwa (DARTS/SABRN)

Multilocation evaluation of stem maggot resistant lines

Rationale: Host plant resistance is becoming an easy strategy for the management of bean stem maggot (BSM). Efforts have centered on identification and distribution of BSM resistant lines to network members for utilisation in the management of the pest.

Methods: A reconfirmatory nursery for BSM resistance, comprising 16 entries, was distributed from our regional base in Arusha to six countries (DR Congo, Kenya, Malawi, Rwanda, South Africa and Uganda) for evaluation using a common methodology: infestation levels, plant mortality and yield under local production systems.

Results and discussion: Results are in from Kisii, Kenya only. Most of the entries performed better than the standard checks. The best performers in terms of percent plant survival and yield were: TBF-151 and G 5625 with respect to yield compared with GLP X92, a current farmers' variety used as the check (Table 13). Several entries including G 22501 have been reported to show promise in Malawi in farmer managed trials. In Malawi, BSM tolerant lines PAD 3, Mlama 127, G 22501 and Ex-Lushoto 52 continued to perform well in on-farm trials and are planned for release.

Table 13. Performance of selected stem maggot resistant lines in Kisii, Western Kenya.

Entry	Plant Mortality (all causes, %)	s% of total mortality due to: Stem maggot	Root rots	Yield
TBF-170	17.3 i	15.9 b	1.7 de	1272.0 cdefgh
G 8047	20.3 hi	12.5 b	2.8 cde	1475.8 abcdef
G 20854	26.0 ghi	16.9 b	2.5 de	1419.0 bcdefg
G 5625	27.7 ghi	22.0 b	0.9 e	1635.3 abc
G 16157	28.0 ghi	20.9 b	3.7 bcde	1528.0 abcde
G 22501	30.8 ghi	21.6 b	2.9 cde	1267.5 cdefgh
G 23070	31.1 gh	19.6 b	4.5 abc	1457.5 abcdef
TBF-151	31.5 gh	21.2 b	3.7 bcde	1834.3 a
GLP X92	64.8 b	40.2 b	6.3 ab	1159.8 efgh
$LSD_{.05}$	13.0	50.1	3.0	401.3

Contributors: John Ogecha (KARI Kisii) and K. Ampofo

Conservation of bush and climbing material collected during Seeds of Hope (Rwanda)

Rationale: Many seed samples were collected on-farm and from markets in Rwanda to determine loss of genetic variation in the country during the period of civil unrest (see earlier Annual Reports). Rwanda has the greatest genetic diversity among beans in Africa, and these samples need to be conserved and returned to Rwanda.

Methods: Multiplication has been underway for a number of seasons to provide 250g of large and medium seeded and 150 g. of small seeded samples for low moisture storage in glass bottles. Seed characteristics have been recorded for all samples stored. Upon completion in late 1999, one sample will be sent to Rwanda and the duplicate retained in Uganda or at another site.

Results: Of the 1336 seed samples collected in Rwanda, 220 (15%) have been lost due to poor adaptation or very high levels of virus infection, 1071 (80%) duplicate samples stored under low moisture and 45 (3%) are in a final multiplication for storage at the end of 1999.

Contributor: H. Gridley
Collaborators: NARO; ISAR

Activity 2.3 Cost effective innovative methods for variety development

Achievements:

- Farmers showed great interest in participatory plant breeding at several locations in Ethiopia
- Farmers selected a large number and wide range of bean lines with characters atypical of those commonly grown, suggesting that PPB may offer Ethiopian farmers opportunity to extend their limited on-farm bean diversity

Participatory plant breeding

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

Participatory plant breeding (PPB) may be a better option especially for local breeding programs constrained by funding. This activity aims to document the cost-effectiveness of PPB from the point of view of the formal research sector in Africa, through sub-projects at three locations in Ethiopia (near Awassa in the Southern Rift Valley, near Nazreth in the Central Rift Valley and at Alemaya in the Eastern Highlands) and one in Northern Tanzania near Arusha.

Methods: The protocol envisaged that in the first year breeders and small farmers (farmer-selectors) in Ethiopia evaluate and then select lines in a diverse germplasm pool on-station. In the following two years the breeders follow a 'classical' breeding approach, whilst the farmers evaluate their selected lines *in-situ* on their own farms. In the third year the breeders' and farmers' final selections are evaluated by other small farmers (farmer evaluators) and by the breeder in multi-location trials. Detailed accounts are being kept to compare the cost effectiveness of classical and PPB methodologies in developing lines that are readily adopted by small farmers.

In Tanzania selection was planned to follow the same pattern but initiated in populations segregating for bean stem maggot, a locally important biotic constraint. Unfortunately all the single plant selections made in the first year were virtually destroyed by powdery mildew and the selection will have to be repeated in 2000; therefore results reported here are from Ethiopia only.

The farmers and breeders selected lines in 1998 at Alemaya and Nazreth and are evaluating these, respectively, on-farm and in replicated yield trials in 1999. At Awassa selection started in the first season of 1999, with farmers and the breeder evaluating their selected lines in the second season.

Results and discussion:

Awassa

Each of 22 farmers, of whom five were women, in the villages of Qoron Goge and Remada and the breeder evaluated 127 lines in a diverse germplasm pool three times on-station in the first season of 1999. Data on growth habit and seed characters has been compiled for the majority of the lines giving the following frequencies (Table 14):

(i) for growth habit - 6 climbers (CIAT type IV), 10 semi-climbers (type III), and 70 bush lines (type I and II) (41 lines not yet classified);

(ii) for seed size - 26 large, 28 medium and 66 small seeded lines (seven lines not yet classified);

(iii) for seed colour - 105 red/red-mottle, 11 cream/cream-beige 11, two yellow-striped, one brown and one purple seeded lines (seven lines not yet classified).

The breeder's decision to have a preponderance (52%) of small red-seeded bush lines in the germplasm pool reflected the almost universal cultivation in the Awassa region of the small to medium red seeded, local bush cultivar, Red Wolaita as a food bean. This cultivar and a recently released cultivar, Roba, a semi-climber with cream medium seeds, were included in the nursery.

A mean of 3.8 farmers at Qoron Goge and 1.8 at Remada selected each line, whereas the five most preferred lines, all of which are large seeded, were selected by a mean of 10 farmers at Qoron Goge and eight at Remada (Table 15). These were notably higher frequencies than those recorded for the cultivars Roba (3 and 2 respectively) and Red Wolaita (3 and zero). Seventy-nine (62%) lines were selected at both villages whilst forty-eight (38%) were rejected at one or other village (table 5), but none at both villages.

The mean frequency of farmer selection within the classes across villages indicated a strong preference for climbing (type IV) and semi-climbing (type III) over bush (type I and II) lines, and for large and medium over small seed (Table 14). For seed color the single purple seeded line was the most preferred in both villages, probably due more to its climbing habit. This was followed at Qoron Goge by cream/cream-beige and then red, and at Remada by an equal preference for cream/cream-beige and yellow striped and then red (Table 14). However, the preferences must be treated with caution as there was a marked trend for prefering classes with fewer lines.

On average Qoron Goge farmers selected twice as many lines (at 21.7, with a range from nine to 52) as Remada farmers (at 10.9, ranging from five to 21) (Figure 7). In spite of the large mean difference, concordance was generally high between the lines selected in the classes by the two groups of farmers, ranging from unanimity (100%) for growth habits III and IV and for two seed colors, to 58% to 89% for lines in other classes; an exception was small seed at 47% (Table 14).

In the second season of 1999 the Qoron Goge and Remada farmers are evaluating their selected lines on-farm in plots of two rows of 10m and two rows of 5m, respectively. The higher frequency of line selection and larger plots of the Qoron Goge farmers are considered to reflect larger land holdings, on average double those of Remada farmers, and the greater importance of bean as a cash crop. Verification of the preferences will be determined by the characteristics of the lines farmers retain for further evaluation in 2000.

The breeder selected, and is testing in a replicated yield trial in the second season of 1999, 49 small or medium seeded and 25 large seeded lines, based on yield, constraint resistance and seed color.

Table 14. Selection practices by farmers in two villages amongst lines sown in a diverse germplasm pool, classified by growth habit and two seed characters.

Character	Class	Number of lines with data for characters[1]	Mean number of farmers selecting a line in a class at villages of:			Lines selected by one or more farmers at both villages	
			Qoron Goge	Remada	Ratio: Qoron Goge/Remada	Number	Percent
Growth habit	IV	6	10.0	7.3	1.4	6	100
	III	10	7.6	4.9	1.6	10	100
	I/II	70	4.2	1.7	2.5	52	74
Seed size	Large	26	5.9	2.7	2.2	23	89
	Medium	28	4.0	2.1	1.9	20	67
	Small	66	2.9	1.1	2.6	31	47
Seed color	Red/red-mottle	105	3.8	1.8	2.1	61	58
	Cream/cream-beige	11	4.1	2.0	2.1	9	82
	Yellow striped	2	3.5	2.0	1.8	2	100
	Brown	1	1.0	0	-	0	0
	Purple	1	8.0	4.0	2.0	1	100

[1] Of 127 lines sown, 41 lines omitted for growth habit and 7 for seed size and color as data yet to be compiled.

Table 15. Farmer selections in germplasm pool at two villages[1] near Awassa (Southern Rift Valley) and two near Nazreth (Central Rift Valley), Ethiopia, 1999.

Location	Germplasm pool size	Mean number of farmers selecting:				Lines at both villages:			
		a line at		the 5 most preferred lines		selected		rejected	
						number	%	number	%
Awassa	127 lines	QG	R	QG	R				
		3.8	1.8	10.0	8.0	79	62	48	38
Nazreth	165 lines	B	W	B	W				
		1.6	1.8	5.6	11.2	59	36	106	64

1. QG: Qoron Goge, R: Remada, B: Bofa, W: Wolenchiti.

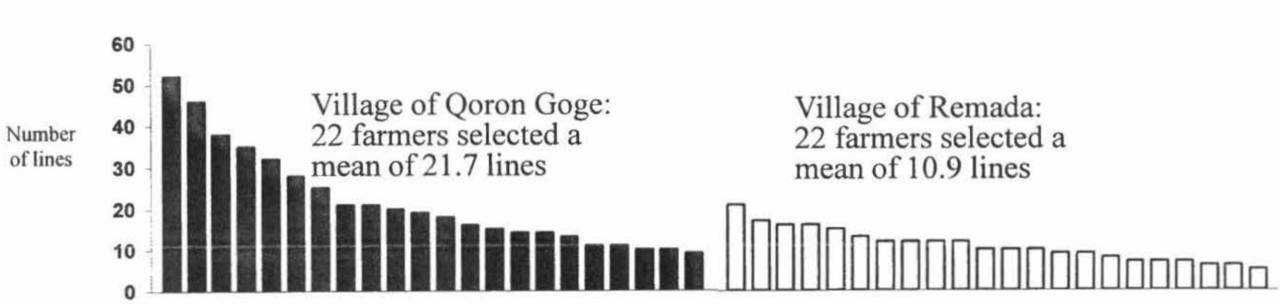

Figure 7. Number of advanced breeding lines, in a nursery of 127 lines, selected by 22 farmers in two villages in the Rift Valley near Awassa in Southern Ethiopia.

Nazreth

The breeder and 22 male farmers in the village of Bofa, and 18 male farmers in the village of Wolenchiti made three evaluations on-station of 165 lines in a diverse germplasm pool in 1998. To examine female preferences, a group of women farmers from the same villages are making selections in the same pool in 1999. Thc pool included local cultivars Brown Speckled, a large seeded sugar type, and Mexican 142, a white pea bean and the recently released Awash, a white pea bean and Roba, a medium seeded cream type.

A mean of 1.6 farmers at Bofa and 1.8 at Wolenchiti selected each line, whereas the five most preferred lines were selected by a mean of 11.2 farmers at Bofa and 16.8 at Remada (Table 15). These five included the cultivars Mexican 142 and Roba, selected by six and five farmers at Bofa and twelve and eleven at Wolenchiti. The other cultivars, Awash and Brown Speckled, were selected, respectively, by three and one farmers at Bofa and both by one at Wolenchiti. Fifty-nine (36%) lines were selected at both villages whilst 106 (64%) were rejected at one or other village Table 15) but none at both villages. This 'selection / rejection rate' stands in contrast to villages near Awassa, where 62% were selected and 38% rejected.

As data on growth habit, seed size and color have been compiled for less than half the lines, an analysis of farmer preferences at this site cannot be undertaken yet. The farmers in Bofa and Wolenchiti selected a mean of 14.6 lines, ranging from 33 to 6, and those at Wolenchiti a mean of 17.5 with a range from 26 to 11 (Figure 8). Although the means did not differ greatly, farmers preferences for individual lines varied markedly within and between villages, especially for the more preferred lines (Figure 9).

The farmers in both villages are evaluating their selected lines in plots of two rows of 10m in 1999. Compilation of outstanding data for growth habit, seed size and color and on lines retained for further evaluation in 2000 will allow farmer preferences to be determined as at Awassa.

Based on disease reaction and yield, the breeder selected 24 colored lines and 14 white pea bean lines for replicated yield testing in 1999.

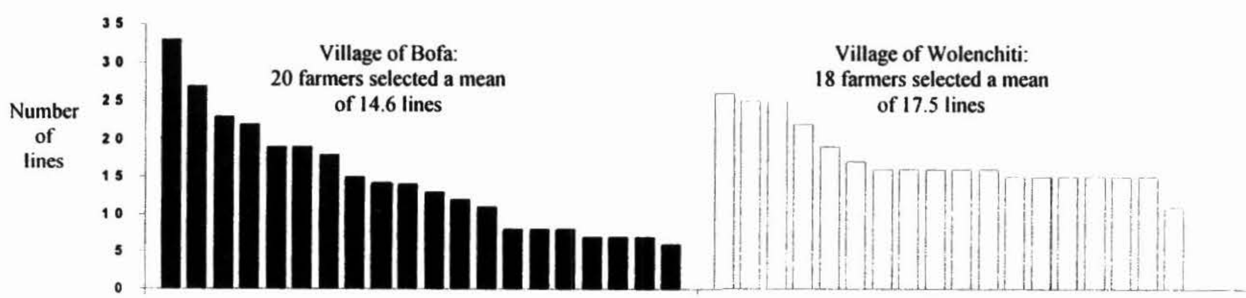

Figure 8. Number of advanced breeding lines, in a nursery of 165 lines, selected by farmers in two villages, Bofa and Wolenchiti, near Nazreth in the Rift Valley in Central Ethiopia.

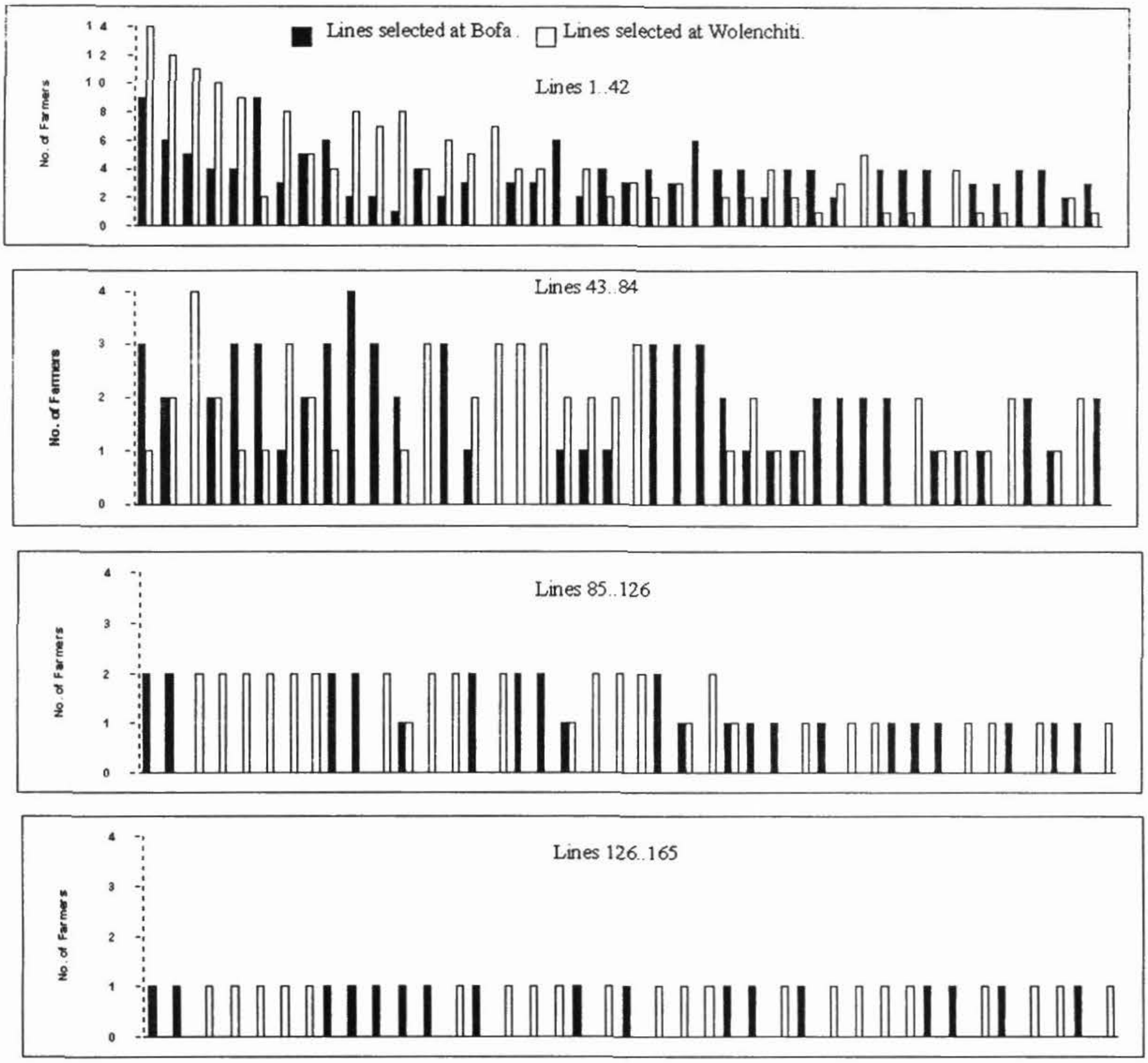

Figure 9. Number of farmers selecting a line (sorted on total for both villages) in a nursery of 165 advanced breeding lines, at Bofa and Wolenchiti, near Nazreth, Rift Valley, Ethiopia.

Alemaya

Based on farmers' selection criteria obtained from an earlier study, the breeder selected 267 genotypes from a nursery of 595 diverse bush and climbing lines. The 267 lines were divided into three nurseries, comprising, 25 climbers, 59 non-red bush lines and 180 red seeded bush lines; the local cultivars Brown Speckled (a large seeded sugar type) and Red Wolaita (a small to medium seeded red type) were included, respectively, in the non-red bush nursery and red bush nursery.

Three user groups, comprising, 10 resource rich farmers (RRF), 22 resource poor farmers (RPF) and 18 women farmers were identified to participate in the selection of lines. In 1998 each group communally evaluated the lines in each nursery on-station three times during the growth of the crop. It was decided that only those lines selected at each evaluation stage would be retained for further evaluation on-farm.

Across the groups the climbers were marginally the most preferred with 36% (nine out of 25) selected, followed by 33% (60 out of 180) of the red bush lines and 17% (10 out of 59) of the non-red bush lines. However, only eight of the red bush, two of the non-red and the climbers were common to the groups; neither of the local cultivars was selected. As at Awassa the climbers were the most preferrred. The women farmers selected a markedly higher percentage of the climbing and red lines at 32% and 62%, respectively, than the other two groups, whereas all three groups selected a similar percentage of non-red lines (Figures 10, 11, 12).

In 1999 each of the three user groups are evaluating their selected lines on a single farm for individual farmers to make selections for assessment on their own farms next season.

The breeder is testing in replicated yield trials 8 climbing lines and 24 bush lines he selected in 1999.

General discussion: Farmers' interest in PPB is clear from their active participation in selection, with the farmers in the two villages at Awassa and Nazret selecting a mean of over 14 lines. The much lower proportion of lines selected at Alemaya probably reflects the communal selection methodology employed by user groups. Additionally, the variation in the selection frequency of the lines within the sites indicates different preferences between farmers, with Awassa farmers preferring climbers and larger seed and those at Alemaya climbers and red seed. However, verification of these preferences must wait to the end of the current on-farm evaluation of lines selected by farmers.

Ethiopia has one of the lowest levels of bean agro-biodiversity on-farm in sub-Saharan Africa, with bean cultivation in the Rift Valley dominated by the small red cultivar, Red Wolaita for food and by the small white pea beans for sale. The preliminary observations on farmers' selection of a wide range of bean lines, with characters atypical of the two commonly grown and consumed cultivars, suggest that limited on-farm diversity may stem more from paucity of available options than their assumed universal preference for these cultivars. On-farm genetic diversity will be augmented as farmers continue to evaluate and retain lines adapted to own specific on-farm micro-environment and constraints, and explore new market opportunities to generate additional income.

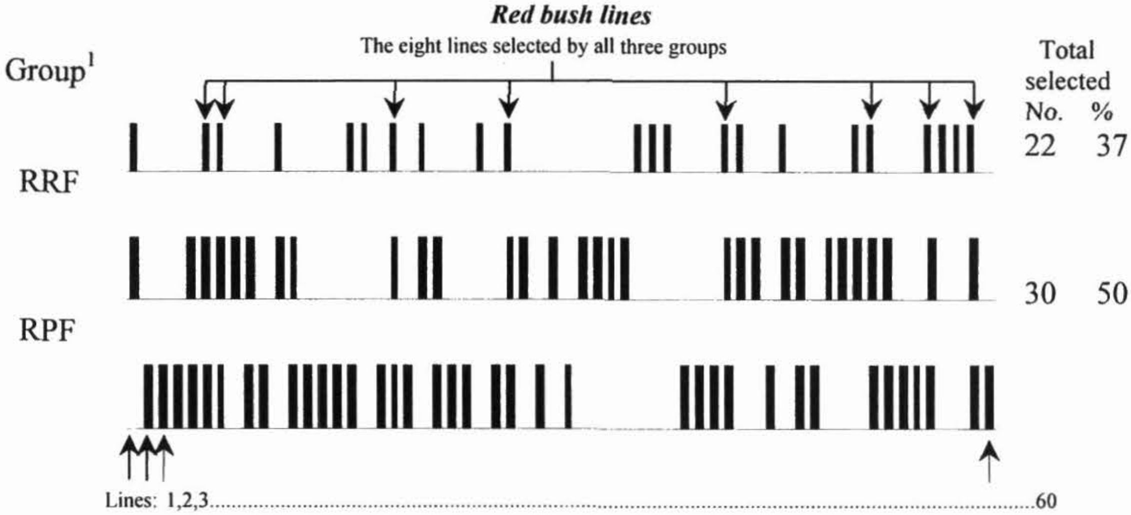

Figure 10. Lines selected by the three farming groups[1] at Alemaya in a nursery of 180 advanced red bush lines.

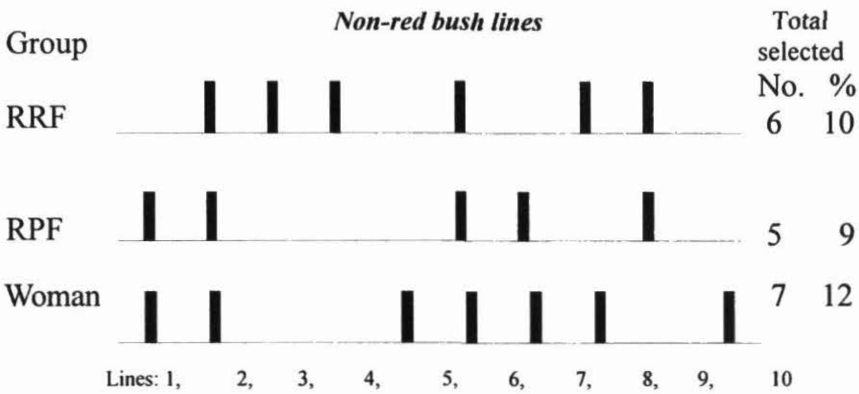

Figure 11. Lines selected by three farming groups[1] at Alemaya in a nursery of 59 advanced non-red bush lines.

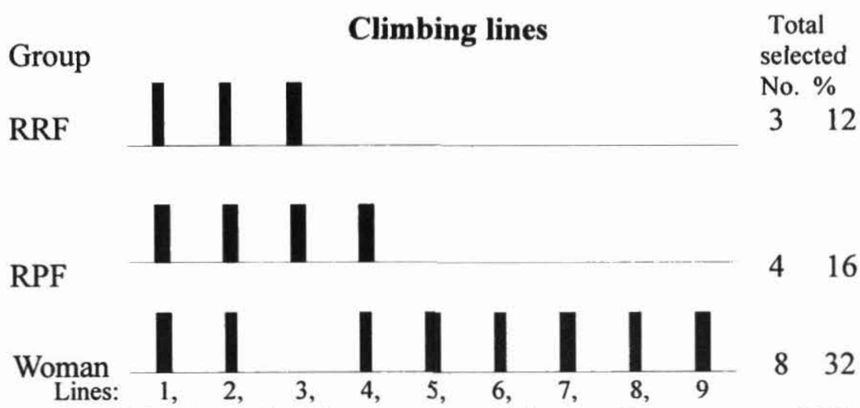

Figure 12. Lines selected by three farming groups[1] at Alemaya in a nursery of 25 advanced climbing lines.

1. RRF, RPF, Women: Resource poor and Resource rich and Women farmers, respectively.

Contributor: H. Gridley.
Collaborators: NARS breeders, pathologists and economist in Ethiopia and Tanzania; L. Sperling (CIAT/PRGA); R. Kirkby, S. David

Activity 2.4 Distribution of improved germplasm to network participants

Achievements:

- 900 advanced breeding lines, segregating populations or backcross progenies were distributed by the CIAT-Uganda breeding program to national breeding programs.

- The Malawi national program maintained its leadership in organizing germplasm exchange for Southern Africa and in predicting many of the best performing materials for the region

Distribution of germplasm from CIAT breeding programs

Rationale: With the reduced provision of breeding lines from CIAT-Cali, NARS breeding programs must urgently acquire greater self-sufficiency in cultivar development and, in particular, develop and exchange multiple constraint resistance (MCR) lines.

Methods: We multiplied and distributed materials according to specific requests, catalysed in some cases by network and pan-Africa meetings.

Results and discussion: In 1997-98 MCR lines were solicited from and supplied to five countries in the first regional MCR nursery and, in 1998-99, to three additional countries (Table 16. Other germplasm distributed in this latter period comprised:
(i) MCR germplasm from CIAT-Cali and bred in Uganda to the University of Nairobi to strengthen the MCR regional breeding program funded by ECABREN;
(ii) 73 segregating populations to Ethiopia and Rwanda and 46 to Uganda;
(iii) International Snap Bean Nursery to Kenya and selected snap bean lines to Sudan;
(iv) various constraint resistant lines and backcross resistant progenies to five countries.

A 'special' introduction to Ethiopia from CIAT-Cali in 1997 comprised 250 small to medium red seeded lines to search for a quick replacement for Red Wolaita; the most popular and widely grown cultivar in Ethiopia, that has a low yield potential due to susceptibility to most biotic constraints. Forty-one of forty-five lines selected for yield testing 1998 significantly ($P \leq 0.05$) outyielded Red Wolaita in the range of 34% to 117% over two sites. A fast-track release recommendation to replace Red Wolaita can be expected after two further seasons of testing, although all potential releases will have to be assessed for cooking and culinary qualities to ensure acceptance.

Joint publications are in draft form covering aspects of genotype x environment interaction in Ethiopia and Malawi.

Table 16. Germplasm distributed to African NARS from October 1998 to April 1999.

Country[1]	Germplasm[2]	Number	Comment
Ethiopia	Segregating populations	73	Ex CIAT-Cali..
	MCR lines.	72	Regional Nursery.
Kenya – UON	MCR lines.	30	Ex CIAT-Uganda crosses.
	MCR lines.	60	Regional Nursery.
	MCR lines.	161	Ex CIAT-Cali..
	International Snap Bean Nursery	30	
Madagascar	MCR lines.	72	Regional Nursery.
	Advanced breeding lines	8	Large seeded, calima, sugar or canadian wonder seed types.
	Large seeded white lines	31	Ex IBYAN CIAT-Cali
Rwanda	Segregating populations	73	Ex CIAT-Cali.
	Backcross progenies.	101	Incorporation of BCMNV resistance into released cultivars.
South Africa	Sugar lines.	11	BCMNV resistant bred in Uganda.
	White pea bean lines.	6	BCMNV resistant bred in Uganda.
Sudan	Snap bean lines.	6	Ex International Snap Bean Nursery.
Tanzania	MCR lines.	72	Regional Nursery.
Tanzania - (CIAT)	BSM backcross progenies.	11	Incorporation of BCMNV resistance into BSM resistant lines
Uganda	Segregating populations.	46	For yield / disease screening.
	BCMNV resistant lines.	20	Three sets of an advanced yield trial.
	CBB resistant lines.	5	Identified in Uganda.
	ALS resistant lines	10	Identified in Uganda.
	One kg of White Haricot and UBR(92)25.	2	
	Total	900	

1. UON: University of Nairobi; material sent to National Bean Program except where indicated.
2. MCR: multiple constraint resistant; IBYAN: International Bean Yield and Adaptation Nursery from CIAT-Colombia; BCMNV: bean common mosaic necrosis virus; BSM: bean stem maggot; ALS: angular leaf spot; CBB: common bacterial blight.

Contributor: H. Gridley
Collaborators: National bean breeders; IP-1

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 (SABRN). 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. Most entries were contributed by Malawi, and these were from two separated sources: introductions through CIAT and those from the CIAT-Malawi breeding programs coded CIM. 19 sets of this nursery were distributed to 9 countries. These were Angola (1), Lesotho (2), Malawi (5), Mozambique (2) South Africa (2), Swaziland (1), Tanzania (2) Zambia (2) and Zimbabwe (2).

The Southern African Regional Bean Yield Trial (SARBYT) contains varieties in the final stage of national screening. The participants included both the private sector and national bean programs of SABRN. The SARBYT comprised 16 entries contributed by various countries, and 19 trials were distributed: Angola (1), Lesotho (1), Malawi (5), Mozambique (3), South Africa (2), Swaziland (1), Tanzania (2), Zambia (2), and Zimbabwe (2). At the time of writing, data had been received from all sites in Malawi, Zambia, South Africa and Swaziland.

Results and discussion: At the time of writing this report data was available from eleven locations in Malawi, South Africa, Zambia, Lesotho and Swaziland. Yields were exceptionally good at Greytown and Delmas in South Africa. The other locations had low and highly variable yields. Data from Lesotho was abandoned because the nursery became water logging.

In SARBEN, yield for each variety across the locations led to several cultivars being selected. These include both; large and small seeded lines. Among the small seed lines there were A 752, VAX 2, MAM 38, A 247, A321 and BAT 477. In the large seeded group were CIM 9422-1, PAL 9302 A 250-2, PAL 9302 A273-2, PAL9302A A248, CIM 9427-2, CIM 9411-2, CIM 9406-2, PAL 9302 A 251 and CIM 9412-1. It is interesting to note that some large seeded lines are perform as well in yield as small seeded lines across locations in the region. Even more interesting is the number of CIAT-Malawi (CIM) lines, all of them with large seed size, that are very competitive in yield across the region. These lines have been selected for further evaluation.

In the SARBYT, the level of angular leaf spot (ALS) incidence was more severe at Bembeke and Bvumbwe than at Chitedze and Delmas. A few cultivars —XAN 76, SUG131, EXL 52, CIM 9423, AFR 699 and a released variety in Malawi, CAL 143 (Napilira) — showed very good levels of resistance. Common bacterial blight (CBB) was severe at Chitedze, Bembeke and Bvumbwe in Malawi, at Delmas in South Africa and at Misamfu in Zambia; no cultivar had a score better than 3 at any site, showing that most of the bean lines in the region do not have adequate resistance.

The grain yields in South Africa were very high compared to Malawi and Zambia (Table 17). Part of the reasons for the low yields in Malawi and Zambia were that the crops were affected by heavy rainfall, to the extent of water logging at Msekera in Zambia. Nevertheless, some cultivars seemed to have expressed their potential fairly well even under such severe stress conditions. These included FEB 196, XAN 76, RAO 55, DOR 715 and SEA 12 among the small seeded cultivars, and SUG 131, LRK 34, CIM 9419, PAD 3 and AFR 699. It is interesting to note that some of these lines are ones that are already being promoted in Malawi's multilocational and on-farm trials. This shows that such lines might have potential in other countries as well.

Table 17. Seed yield (kg/ha) of advanced cultivars in the SARBYT in southern Africa, 1998/99.

Variety	Seed yield (kg/ha)										Seed characters		
	CTZ	BBK	BVM	NCN	Bunda	G/Town	DLM	MIS	MSE	MNG	Mean	Size	Color/Class
AFR 699	428	1190	599	781	464	2095	1504	1047	271	1875	1025	43	Cafetero
CIM 9423	852	896	984	383	1281	1943	1604	837	185	1822	1079	38	Calima
CIM 9419	867	990	865	409	1526	1815	2048	688	337	1332	1088	69	Calima
SEA 12	838	930	1375	578	1063	1938	2047	763	285	1716	1153	25	Maroon
FEB 196	571	1008	1328	414	1703	2843	2839	1427	316	1664	1411	27	Mulatinho
RAO 55	882	818	1490	448	1266	2280	1839	1279	337	1165	1180	20	Mexico 80
XAN 76	1201	620	1094	398	1318	2697	2307	1230	848	1622	1333	24	Mulatinho
SUG 131	666	1083	729	760	844	2940	2329	349	82	1664	1145	48	Cranberry
LRK 34	481	982	734	391	1375	2296	1920	872	88	1568	1071	45	Light red kid
DOR 715	789	740	1135	563	927	2801	1822	1228	393	1490	1189	22	Mexico 80
DOR 814	943	794	1172	510	854	2218	1863	860	331	1467	1101	19	Mexico 80
PAD 3	668	706	578	427	1177	2150	1967	501	426	1344	994	40	Cafetero
G2201	449	951	380	630	859	720	1676	428	286	1267	765	36	Canario Gree
Mlama 127	160	917	406	688	1078	850	1198	436	184	1153	707	41	Brown m/cali
EXL 52	684	758	1250	469	1219	2100	1970	808	352	903	1051	20	Duva
CAL 143	730	1089	932	357	990	2616	1815	639	478	1172	1082	36	Calima
A 286	727	602	932	807	865	3171	2421	700	400	2115	1274	18	Carioca
OPS - RSI	663	1195	604	255	500	1660	2258	839	111	1552	964	40	Cranberry
G14369	555	799	354	284	1109	757	1652	939	309	1634	839	43	Mwezi Moja
Local check	762	602	234	128	1292	1074	2371	965	469	2249	1015		—
Mean	696	883	859	484	1085	2048	1973	842	333	1539	1076	35	
CV (%)	43	23	25	38	29	17	21	42	49	34	30		
SE ± Var	150.0	103.1	107.1	91.4	158.7	171.3	207.4	175.6	79.1	79.1	51.2		
Sig Var.	*	***	***	***	***	***	***	**	***	ns	***		
Sig LxV											***		

Key to sites: BBK: Bembeke, Bunda: Bunda College; BVM: Bvumbwe, CTZ: Chitedze, NCN: Nchenachena (all in Malawi); GT: Greytown, DLM: Delmas (South Africa); MIS: Misamfu. MSE : Msekera (Zambia); MNG: Mangcongo (Swaziland)

Contributors: Rowland Chirwa (DARTS)
Collaborators: National programs and other collaborators in the SABRN region; V. Aggarwal

Activity 2.5 Enhanced NARS capacity to use new sources of germplasm

Achievements:

- A few stronger NARS initiating or reinforcing crossing programs, and embarking on participatory breeding

Rationale: Most national programs in Africa have been dependent upon a supply of fixed breeding lines from CIAT, Colombia as the direct source of most new varieties. It is imperative that the stronger NARS quickly increase their crossing capacity for yield improvement and resistance, that others learn to handle segregating populations, and that low-cost options for participatory plant breeding are explored in a collaborative manner.

Methods: Two of the most experienced and active bean breeders in NARS (of Kenya and Malawi) are being supported to develop multiple constraints resistance breeding programs to serve Eastern and Southern African environments, respectively, and feed materials into regional nurseries. Five programs in Ethiopia, Rwanda and Tanzania are being supported to develop participatory plant breeding (PPB).

Results and discussion: Progress in PPB in Ethiopia and Tanzania is noted in more detail above (Section 2.3). Other notable developments from collaboration with CIAT IP-2 breeder included:

Ethiopia:
(i) selection strategies implemented for introduced and locally generated populations for yield improvement;
(ii) a 'fast track' selection and testing program maintained amongst red seeded introduced lines from CIAT, Colombia to identify replacement(s) for the disease susceptible but highly popular and widely grown landrace Red Wolaita (41 of these lines significantly ($P \leq 0.05$) outyielded Red Wolaita in the range of 34% to 117% over two sites in 1998).
iii) a backcross program was started to improve anthracnose resistance of released cultivars (particularly Awash 1) and landraces in Ethiopia.

Rwanda:
(i) elevation-specific breeding strategies implemented that involve farmers early in selection;
(ii) effectiveness of selection in populations segregating improved for disease resistance and yield potential by combining disease resistance (with artificial inoculation) with early generation yield testing.

Uganda:
Breeder developed a backcrossing program to introduce disease resistance into released cultivars and provided sources of resistance to angular leaf spot and common bacterial blight.

Kenya: Leader of the ECABREN sub-project on multiple constraint resistance breeding (Section 1.3) acquired materials with multiple constraint resistance derived from other NARS, CIAT IP-1 and generated by CIAT IP-2 in Uganda.

Contributor: H. Gridley
Collaborators: P. Kimani (UoN); R. Chirwa (DARTS); H. Assefa (EARO); D. Dauro (Awssa RC); F. Mekbib (AU); A. Musoni (ISAR); A. Namayanja (NARO); CIAT Project IP-1.

Output 3. Sustainable bean production systems

Activity 3.1 Sustainable crop and soil management practices

Achievements:

- Rotational benefits of the annual legume *Canavalia ensiformis* related to its high biomass production, accumulation of soil P, N fixation and effectiveness in uptake of soil N, but it also depleted soil water

- Sesbania and tephrosia effectively improve fallow, fix much N and recover deep nitrate, but care is needed as both tree legumes now shown to be good hosts of rootknot nematodes

- *Crotalaria grahamiana* and, to a lessor extent, mucuna and lablab useful in reducing root knot nematodes in badly infested fields or preceding highly susceptible crops

- Recommendations on best option and niches among legume green manures and cover crops assembled with collaborators in the region

- A decision guide developed for input use on a major soil type used for maize and bean production, with fertilizer substitution value of the abundant wild *Lantana camara*

- Decision guides drafted by NARS agronomists for their own situations, including two cases using weed flora as indicators of soil fertility status.

Rotational effects of five annual legume cover crops on maize-bean intercrop production

Rationale: Legumes have a potential role in the maintenance of soil productivity. Likely niches have been identified for *Canavalia ensiformis, Mucuna pruriens, Crotalaria ochroleuca,* and *Lablab purpureus* (Annual Report 1997), but the causes of the rotational effects have not been well understood. As rhizospheres of some vigorously growing legumes have more exudates and lower pH than for common food crops, we thought it likely that one or more of these legumes would acquire significant amounts of P from applied Busumbu rock P, a Ugandan source.

Methods: The legumes were compared to soybean in a trial of split plot arrangement over a period of five seasons, 1997a to 1999a. Main and sub-plot treatments were legume species and P treatments, respectively. P was applied at 200 kg P_2O_5 ha^{-1} as rock P, TSP or a mixture. The comparisons were for N-fixation (^{15}N atom excess with grain sorghum as the reference crop), profile soil water (monitored with neutron probe), soil nitrates and crop yield of maize-bean intercrop following the legumes in a sub-humid, bimodal rainfall system of Uganda.

Results: The legumes and the food crops did not recover significant amounts of P from the rock P. Maize-bean intercrop was most productive following canavalia and produced least after mucuna and soybean (Table 18). These effects generally persisted to the second season after producing the legumes. Canavalia produced the most biomass and accumulated the most soil P in the plant biomass. Lablab and soybean produced the least biomass. Mucuna and canavalia fixed the most atmospheric N (67 and 39% Ndfa and 155 and 133 kg N ha^{-1}, respectively; Table 19); crotalaria fixed little N. Soil nitrate following a season of maize-bean production was greatest (48 versus 32 to 40 kg ha^{-1} for other species) where canavalia had been produced previously (Figure 13). Canavalia was the most effective legume in uptake of soil N, leaving 73 compared to 120 to 148 kg ha^{-1} nitrate for the other legumes in 90 cm of soil depth, with the difference largely due to less deep nitrate following canavalia (Figure 14). Profile soil water status was highest under soybean and lowest under canavalia (Figure 15). Surface soil water was similar for all species, but differences were evident at depth. Approximately 300 mm of rain were required to replenish profile soil water during the intercrop season following crotalaria and canavalia.

Discussion: Canavalia and mucuna are promoted for use by farmers through training by NGOs, distribution of leaflets, demonstrations and farmer-experimentation mini-kits. Some NGOs link the mini-kits to farmer field school type of training. Canavalia is preferred by some for its ease of management, and it is superior for improvement of soil productivity. Mucuna is preferred by others who use it to feed dairy cows, produced in association with maize or banana, and is achieving significant adoption. Mucuna has not received much acceptance in Uganda for weed suppression; it is effective against some species, but it does not much reduce couch grass and oxalis, two noxious weeds in Central and Eastern Uganda. Mucuna may be better accepted for weed suppression in northern Uganda where it is being promoted for suppression of *Imperata cylindrica*. Lablab appears to have a niche in the Kitale area of western Kenya where it is relay intercropped with maize; it has advantages in that the grain and leaves are used as food, the leaves for fodder, and it can be incorporated with ox-drawn plows. While crotalaria is easily produced by intercropping with beans, and is effective in improving soil productivity, its niche in Uganda appears to be limited and farmers find it difficult to integrate it into their systems. *C. ochroleuca* is more promising in Nyanza Province of western Kenya where, in addition to soil improvement, it suppresses the parasitic Striga witchweed and young crotalaria plants are consumed as a vegetable.

Table 18. Grain yield for intercropped maize and bean as affected by green manure of five legume species in the subsequent and second following season.

Species	Grain yield(kg ha^{-1})			
	Subsequent season (1997B and 1998B)		Second following season (1999A)	
	Maize	Bean	Maize	Bean
Canavalia	3678	658	3747	430
Mucuna	2625	508	3465	347
Crotalaria	2970	628	3523	313
Lablab	3224	490	3192	144
Soybean	2483	613	2516	443
LSD 0.05 for legumes	493	94	465	97

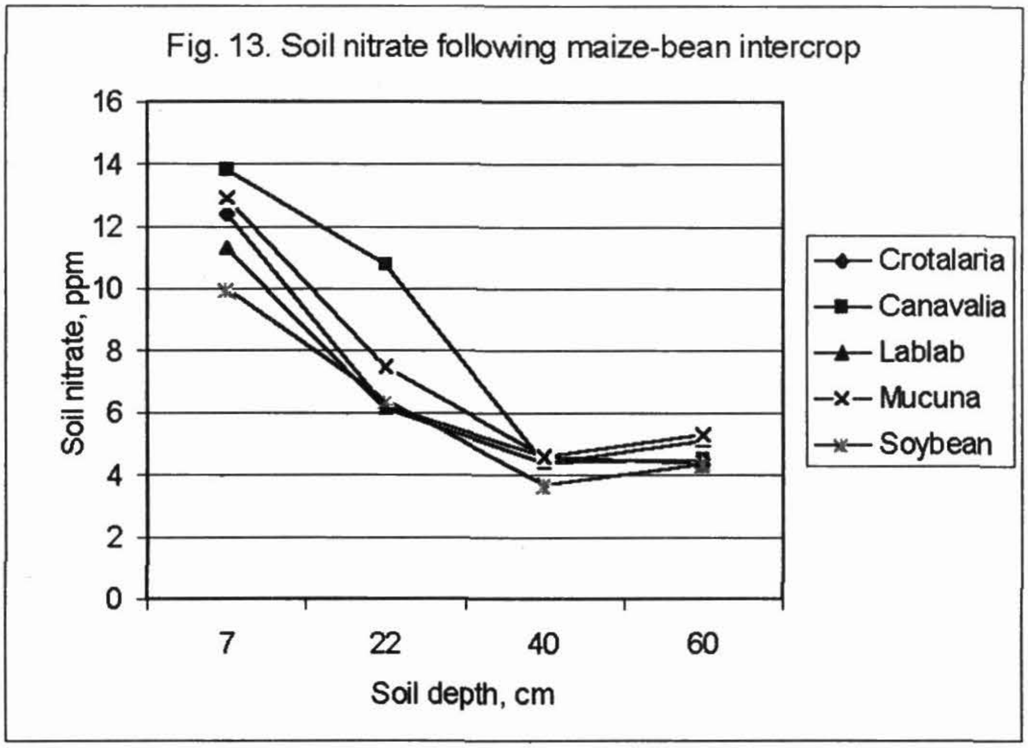

Fig. 13. Soil nitrate following maize-bean intercrop
16
14
12
10
8
6
4
2
0
Soil nitrate, ppm
7
22
40
60
Soil depth, cm
Crotalaria
Canavalia
Lablab
Mucuna
Soybean

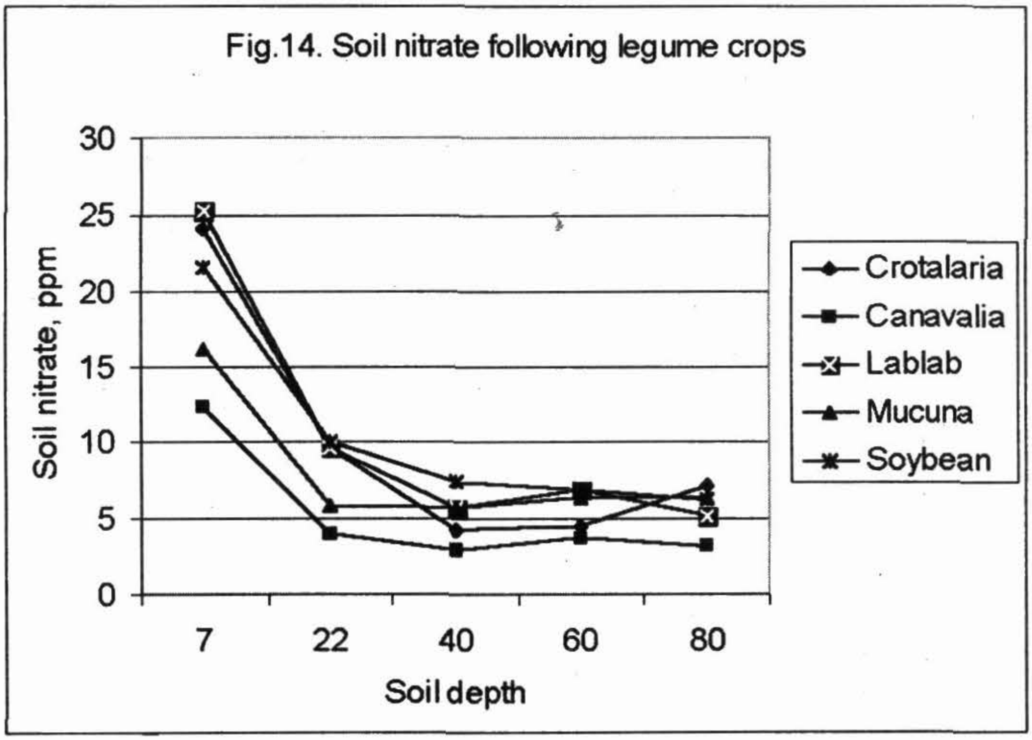

Fig.14. Soil nitrate following legume crops
30
25
20
15
10
5
0
Soil nitrate, ppm
7
22
40
60
80
Soil depth
Crotalaria
Canavalia
Lablab
Mucuna
Soybean

Fig. 15. Profile water for two legume-based rotations.

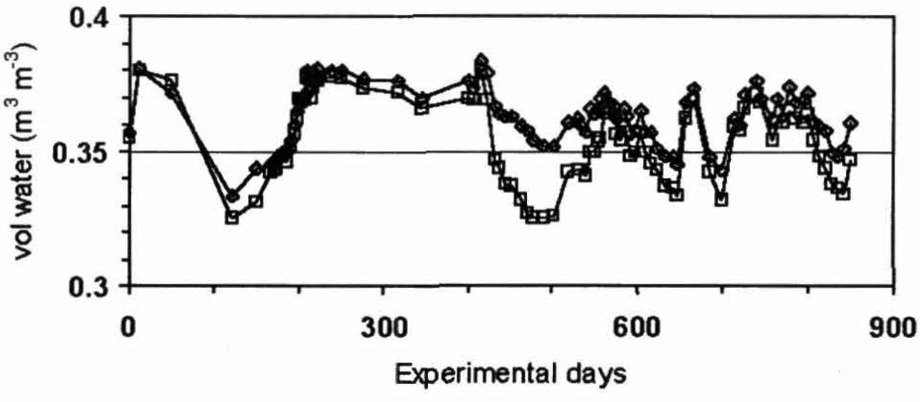

Table 19. Legume species differences for proportions of N derived from fertilizer (Ndff), soil (Ndfs) and atmosphere (Ndfa), as well as for amount of N fixed and N recovery from applied fertilizer (mean of two years).

	%N	%Ndff	%Ndfs	%Ndfa	Biomass dry wt. ($g\ m^{-2}$)	Ndfa ($g\ m^{-2}$)
Sorghum (reference crop)		25.9	74.1	0.0		753
Canavalia	3.29	4.0	57.0	39.0	1037	13.3
Mucuna	2.78	2.1	30.4	67.5	825	15.5
Crotalaria	3.27	6.3	90.9	2.7	877	0.8
Lablab	2.92	3.5	50.2	46.2	615	8.3
LSD 0.05 (legumes)	0.24	1.4	20.1	21.56	223	9.51

Contributors: C. Wortmann; Beverly Mclntyre (Rockefeller Foundation); and Kayuki Kaizzi (NARO).

Fallow effects of herbaceous and shrub-type legumes on maize-bean intercrop production

Rationale: Shrub and tree legumes have potential roles in the maintenance of soil productivity. Promising species including *Tephrosia vogellii, Sesbania sesban, Cajanus cajan* and *Mucuna purpureus.* The causes of the fallow effects have not been well understood. As the rhizosphere of some vigorously growing legumes is more active than for common food crops, we thought it likely that one or more of these legumes would acquire significant amounts of P from applied Busumbu rock P.

Methods: These legumes and their effects were compared in a trial of split plot arrangement over a period of four seasons, 1997a to 1999a. Main and sub-plot treatments were legume species and P treatments, respectively. P was applied at 200 kg P_2O_5 ha^{-1} as rock P, TSP or a mixture. Species effects were determined for N-fixation (^{15}N atom excess with grain sorghum as the reference crop), soil nitrates and yield of a maize-bean intercrop following the fallow period in a sub-humid, bimodal rainfall system of Uganda.

Results: The legumes and the food crops did not recover significant amounts of P from the rock P. The sesbania and tephrosia fallows produced the most biomass on a dry weight basis. Maize-bean intercrop was most productive following sesbania and tephrosia fallows, and least following the pigeonpea-weedy fallow (Table 20). The effects persisted to the second season after fallow. Sesbania and tephrosia had more soil nitrate than mucuna in the surface soil, but less deep nitrate, indicating efficiency in recovery (Table 21). Tephrosia and sesbania derived more N from the atmosphere than pigeon pea, and had fixed 170-190 kg ha^{-1} (Table 22).

***Discussion*:** Sesbania and tephrosia effectively improve fallow, fix much N and recover deep nitrate. Tephrosia is popular with farmers in Uganda as it is effective in control of mole rats (Annual Report 1998); significant adoption has occurred for this purpose. There is a need for caution, however, as both tephrosia and sesbania are good hosts of rootknot nematodes and we have observed higher infection levels with bean following these legumes and in close proximity to them.

Table 20. Biomass yields of improved fallows and mean grain yield for seasons following fallow.

	Biomass harvested at end of second fallow season (kg ha^{-1})		Grain yield (kg ha^{-1}), mean of two subsequent seasons	
	Whole plant	Wood	Maize	Bean
Mucuna	4,600		2,938	318
P/pea-weedy fallow	4,890		2,095	289
Sesbania	31,150	21,790	3,196	410
Tephrosia	27,800	16,690	3,416	362
LSD 0.05	4,047	3,745	292	55.3

Table 21. Nitrate levels in the soil after cutting and surface-applying the top growth of three legumes, and prior to establishment of the subsequent maize-bean intercrop.

	Nitrate levels at 0-15 cm		Nitrate levels at 60-90 cm	
Legume species	mg kg^{-1}	Kg ha^{-1}	mg kg^{-1}	kg ha^{-1}
Tephrosia	43.0	83.8	5.0	21.0
Sesbania	31.0	60.4	5.2	21.8
Mucuna	23.6	46.0	14.8	62.2
LSD 0.05	9.21	18.0	2.69	11.3

Table 22. Nitrogen derived from the soil (Ndfs), fertilizer (Ndff), and atmosphere (Ndfa), and N fixed (kg ha^{-1}) by 128 days after sowing, and N recovery from 20 kg ha^{-1} of applied N.

Treatment	Ndfs	Ndff	Ndfa	N fixed (kg ha^{-1})
Pigeon pea	85.0	4.2	10.8	9.2
Sesbania	49.7	2.0	48.3	168.0
Tephrosia	50.4	2.0	47.6	190.8
LSD 0.05	18.5	1.0	19.4	92.1
	**	***	**	**
Sorghum	82.2	17.8	NA	NA

Note: Species effect not significant for N recovery because of significant species by P interaction effect. Pigeon pea had more N recovery from fertilizer with TSP, while recovery by tephrosia and sesbania was not affect by P application.

Contributors: C. Wortmann; and Kayuki Kaizzi (NARO).

The effects of some legumes on infection of subsequent crops by rootknot nematode

Rationale: Legumes have a potential role in the maintenance of soil productivity, fodder production, weed suppression and pest management. Tephrosia has become popular with farmers in parts of Uganda for control of mole rats. However, tephrosia, sesbania and some other legumes are known to host *Meloidogyne* nematodes, which can be a serious pest of bean, tobacco, tomato and other important crops. Other species, however, are noted for suppression of nematodes. Better understanding of the legume-nematode relationship is needed for better integration of alternative legumes in farming systems.

Methods: Three trials were conducted where soil was sampled from trial and demonstration sites, allowing a comparison of legume effects on nematodes. Tomato seedlings, which had been established in sterile soil, were transplanted into pots containing these soil samples. At approximately seven weeks after transplanting, nematode infection was assessed by counting the number of galls per 50 cm of root length.

Results: *Crotalaria grahamiana* appears to suppress *Meloidogyne* very effectively. Results for mucuna were inconsistent, having low levels of nematode infection in two trials but high infection in another where the soil for mucuna was taken from a weedy fallow. Infection rates following sesbania and tephrosia were very high. Soybean and *Crotalaria ochroleuca* also were associated with high infection rates. Subsequent observations on farmers' fields confirmed that bean had more rootknots when in close proximity to tephrosia and sesbania (Tables 23, 24, 25).

Discussion: *Crotalaria grahamiana* and, to a lessor extent, mucuna and lablab should be useful in reducing meloidogyne numbers in badly infested fields, or preceding highly susceptible crops. The effects on other nematode species need to be determined, with a view to using these fallows to precede the establishment of bananas for improving soil productivity and reducing nematodes. Sesbania and tephrosia must be used with caution; non-susceptible crops should follow these species. Mixtures of *C. grahamiana* with sesbania or tephrosia may prevent subsequent problems with nematodes while gaining the benefits associated with sesbania and tephrosia. Our extension literature for tephrosia has been modified in consideration of this information.

Table 23. The effects of five annual legumes on infection of tomato roots by rootknot nematodes.

Legume species	Galls 50 cm^{-1} of roots	Galls g^{-1} of fresh roots
Canavalia ensiformis	7.5	10.2
Mucuna pruriens	0.7	4.7
Crotalaria ochroleuca	17.2	26.7
Dolichos lablab	0.5	6.5
Soybean	10.5	12.7
LSD 0.05	ns	Ns

Table 24. Effects of sesbania and tephrosia on infection of tomato roots by rootknot nematodes.

Legume species	Galls 50 cm^{-1} of roots
Tephrosia vogellii	20.7
Sesbania sesban	26.4
Mucuna pruriens	1.5
Weedy fallow	1.9
LSD 0.05	9.3

Table 25. The effects of three perennial legumes and mucuna on infection of tomato roots by rootknot nematodes, at two sites near Kawanda, Uganda.

Legume species	Galls 50 cm^{-1} of roots	Galls g^{-1} of fresh roots
Tephrosia vogellii, Kawanda	107	80
Tephrosia vogellii, Senge	193	93
Sesbania sesban, Senge	104	73
Mucuna pruriens, Senge (weedy)	77	54
Crotalaria grahamiana, Kawanda	0	0
LSD 0.05	44.7[1]	28.4[1]

[1] Error term is based on sampling error as soil was collected from single plots of legumes; plot effects are confounded with species effects.

Contributors: C. Wortmann; Imelda Kashiija (NARO). Linked to PE5.

Synthesis and recommendations on legume green manure/cover crops in Eastern Africa

Rationale: There is a long history of research and development efforts on the use of GMCC legumes. The information is not sufficiently available to many workers for it to be well used. Needless false starts and duplication of efforts occur because of inadequate consideration of the work of others. A synthesis and interpretation of available information is expected to enable those working with GMCC legumes to achieve greater success.

Methods: Dr. C. Gachene did an initial synthesis and interpretation of available information. We contributed to a subsequent working group meeting, convened by TSBF on behalf of the African Highlands Ecoregional Program (AHI), which added to the synthesis and interpretation and identified 'best bet options' and their niches, and recommend future activities.

Results: The 'best bet' species included *Mucuna pruriens* (Velvetbean), *Canavalia ensiformis* (Jackbean), *Crotalaria (ochroleuca and juncea)*, *Lablab purpureus, Desmodium* (*intortum* and *uncinatum*), *Vicia (dasycarpa,* and *benghalensis)*, and *Tephrosia vogelii.* A document is in preparation.

Collaborators: C. Gachene (U. of Nairobi); C. Palm (TSBF); J. Mureithi (Rockefeller Foundation); and C. Wortmann. Linked to PE 5 and the AHI.

Crop response to application of alternative plant materials for soil fertility management

Rationale: Resource poor farmers often have diverse but scarce resources which might be used in the management of soil fertility. Some naturally occurring herbaceous and shrub species produce abundant biomass of moderate nutrient levels. When these plants are near a cultivated field, the biomass can be transferred to supply the crop with nutrients. In an earlier resource assessment with farmers, they expressed willingness to use such materials if proven effective in improving productivity.

Methods: The effects on crop productivity of application of immature plant materials of *Tithonia diversifolia, Lantana camara, Cassia hirsuta* and *Aspilia kostchyi* were evaluated on-station at Senge (Kawanda), Uganda, over six seasons. The organic materials, applied at 4 t ha^{-1} dry weight, were compared to inorganic fertilizers. Surface application was compared to incorporation of the materials. Farmer-managed trials were conducted on ten farms in eastern Uganda over four seasons with two reps per farm. The test crop was maize.

Results: Tithonia and aspilia had the highest and lowest N content, respectively (Table 26). Lantana had the highest lignin (16%) and polyphenol (3.4%) contents. The organic materials, except for aspilia, supplied more N and K than the fertilizer but more P was supplied in the fertilizer treatment.

Maize yields were highest with the full fertilizer rate but bean yields with cassia and tithonia were similar to the full rate of fertilizer (Table 27). Response to the organic materials appeared to be regulated by plant N and polyphenol content, with less response to aspilia and lantana. The effects of the organic materials increased with time. Method of application did not affect crop yield.

Crop response to application of lantana was less than with fertilizer (Table 28). The effectiveness of lantana increased with continued application, indicating residual effects of the organic material. Applying half-rates of fertilizer and lantana in combination gave inconsistent results and less yield than the full fertilizer rate in two seasons, and similar yield in the other seasons. Yield response to lantana application may have been constrained by low P availability, as the median P level (Olsen method) is 3.5 ppm in this community for annual crop fields.

Discussion: The impact is not yet predictable. There has been much farmer involvement in this work since its initiation. Response of farmers, however, has been less enthusiastic than anticipated, and they have not experimented much on their own. Higher quality materials such as tithonia, where abundant, might be more attractive to farmers.

Table 26. Nutrients supplied in 4 t of dry matter by immature plant material of four species.

	N	P	K	Ca	Mg
Cassis hirsuta	119.2	7.2	182.4	51.2	16.0
Lantana camara	107.6	6.4	107.2	34.8	22.4
Aspilia kostchyi	53.2	4.4	160.8	67.2	10.8
Tithonia diversifolia	140.0	11.2	190.0	52.0	20.0
Fertilizer, full	100.0	21.3	104.3	0.0	0.0

Table 27. Maize and bean grain yield (kg/ha) as affected by application of parts of various plant species and inorganic fertilizers.

Species	Maize yield (kg ha^{-1}), mean of 4 seasons	Bean yield (kg ha^{-1}), mean of 2 seasons
Cassia	3351[bc]	984[a]
Aspilia	2558[d]	707[c]
Lantana	3006[c]	743[bc]
Tithonia	3407[b]	855[ab]
Fertilizer (recommended rate)	3890[a]	878[a]
Fertilizer (1/2 recommended)	3488[b]	788[abc]
Control	2033[e]	500[d]

Mean separation by DMRT at $p < 5\%$

Table 28. Maize grain yield (kg/ha) as affected by application of *Lantana* residues and inorganic fertilizers (results from 6-10 on-farm trials in Iganga District, Uganda).

	1997A	1997B	1998A	1998B	1999A	Mean
Control	1952	1011	2756	1186	2207	1822
Lantana, 4 t/ha	2433	1189	3815	1867	3472	2555
Lantana + Fertilizer (50% rates)	2819	1985	4630	2315	4136	3177
Fertilizer (recommended)	2967	2407	4704	3133	4676	3577
$LSD_{5\%}$	710	556	856	780	295	

***Collaborators*:** Kayuki Kaizzi (NARO); and C. Wortmann. Linked to PE5; ECABREN funded this work. Technical input of Cheryl Palm (TSBF) is acknowledged.

Adaptive research for integrated nutrient management for deep, upland, sandy loam (*myufu*) soils of the Lake Victoria Crescent

Rationale: Conceptual frameworks, in the format of decision guides, are a valuable tool in reviewing research priorities and, in revised form, as a research output. One was developed for input use on a major soil type used for maize and bean production. Priority activities identified included verification of fertilizer rates for farmers of different wealth status for the economically important sole and intercrops of maize and beans, as well as the fertilizer substitution value of *Lantana camara* which occurs in abundance in parts of this agro-ecological zone.

Methods: Following development of a conceptual framework for INM (Table 29) and identification of priority information needs, a series of on-farm trials was conducted in Iganga District, Uganda. The results were subjected to economic analysis assuming the following:
Prices at farm-gate for maize and beans: Uganda Shillings (UGS) 125 and 270 per kg, respectively.
Prices for 50 kg urea, TSP and DAP: UGS 28,000, 35,000 and 37000, respectively.
Farmgate crop prices were reduced by 10% to cover the costs of harvest, processing and marketing of additional produce to give field value of the crops.
Fertilizer costs were increased by 10% to cover transport and application costs.
Opportunity cost and risk allowance was assumed to add 25, 50, 75% to the cost of the fertilizer for moderately wealthy, poor and very poor farmers.
Plot yields were assumed to be high relative to yields which small-scale farmers can achieve at a farm level. Therefore, plot yields were reduced by 10% in the economic analysis.

Results and discussion: In all cases, there was a statistically significant response to applied nutrients, but the responses often were not sufficient to justify the cost of supplying the nutrients.

For the maize sole crop, 100 kg urea and 50 kg TSP is economical for the poorest as well as wealthier farmers, but the highest rates of return are with 100 kg of urea (Table 30). Fertilizer use on the bean sole crop was not economical (Table 31); even if similar yield increases were achieved by applying 50% of the amounts applied, fertilizer use would be sufficiently profitable only to wealthier farmers or those who can get credit at favorable rates to justify use. For the maize-bean intercrop, bean performance was generally poor, and the most economical rates are similar to those for the maize sole crop (Tables 32 and 33).

Table 29. Tentative guide as a conceptual framework to integrated nutrient use for maize and bean, in sole or intercrop, on deep sandy clay loams in Lake Victoria Crescent AEZ.

Conditions	Maize, sole crop	Bean, sole crop	Maize-bean intercrop
Adequate money or credit available	Apply 50 kg ha^{-1} TSP and 25 kg ha^{-1} urea at sowing; Apply 50 kg ha^{-1} urea-TP.	Apply 100 kg ha^{-1} TSP and 20 kg ha^{-1} urea at sowing.	Apply 100 kg ha^{-1} TSP and 20 kg ha^{-1} urea at sowing; apply 50 kg ha^{-1} urea-TP.
Money or credit is inadequate	Apply 50 kg ha^{-1} urea at first weeding.	Apply 50 kg ha^{-1} TSP and 20 kg ha^{-1} urea at sowing.	Apply 50 kg ha^{-1} TSP and 20 kg ha^{-1} urea at sowing; apply 50 kg ha^{-1} urea-TP.
Green manure produced the previous season	Do not apply inorganic fertilizer	Do not apply inorganic fertilizer	Do not apply inorganic fertilizer
Lantana, etc., available	Reduce urea-TP by 30% for each ton of fresh leafy material applied.	Do not apply	Reduce urea-TP by 30% for each ton of fresh leafy material applied.
Sowing delayed until after 15 March or 15 September	Reduce fertilizer rate by 50%	Do not reduce fertilizer rate	Reduce fertilizer rate by 50%
Sowing delayed until after 30 March or 30 September	Do not use fertilizer at sowing. Apply urea-TP at 50% rate if crop is promising	Do not reduce fertilizer rate	Apply 50% of TSP at sowing. Apply urea-TP at 50% rate if crop is promising
Farmyard manure available	Reduce fertilizer by 25% for each ton/ha of dry FYM applied.	Reduce fertilizer by 40% for each ton/ha of dry FYM applied.	Reduce fertilizer by 20% for each ton/ha of dry FYM applied.
Farmyard manure was applied last season	Reduce fertilizer by 15% for each ton/ha of dry FYM applied.	Reduce fertilizer by 30% for each ton/ha of dry FYM applied.	Reduce fertilizer by 10% for each ton/ha of dry FYM applied.
Rotated from banana or fallow within last one year	Apply urea-TP if maize is yellowish.	Do not apply fertilizer	Apply urea-TP if maize is yellowish.

Urea-TP = urea applied at time of 2nd weeding.

The labor requirements for applying lantana have not been costed. However, assuming the material will be transferred from neighboring fields and for a mean distance of 30 m, lantana alone may be economical. More economical would be 2 ton lantana applied with 25 kg TSP and 50 kg urea.

The framework in Table29 could then be modified. The estimates for maize sole crop were accurate except that the rate for urea should be increased to 100 kg/ha for farmers with less easy access to money. The estimates for the maize-bean intercrop should be changed to be as for maize sole crop. Fertilizer would more profitably be used on maize than on bean sole crop. Both N and P fertilizers can be reduced by 30% of the rate recommended for wealthier farmers, but the rate of application should not exceed 2 t/ha for most efficient use of available lantana plant material.

Agronomists at ECABREN, SABRN and AHI sites across several countries drafted decision guides for their own situations, and are to base some of their activities on refining them (see Section 1.3.

Table 30. Costs of fertilizer use and field value of added production for the maize sole crop.

Fertilizer treatment	Total cost of fertilizer application (UGS/ha at 3 opportunity costs)			Field value of the increased production (UGS/ha)	
	25%	50%	75%	1997-8 Seasons	1999A season
23 kg/ha N	38,500	46,200	53,900	49,410	87,480
46 kg/ha N	77,000	92,400	107,800	107,527	159,367
46 N + 23 kg/ha P_2O_5	125,100	150,150	175,050	120,994	234,394

Table 31. Costs of fertilizer use and field value of added production for the bean sole crop.

	Total cost of fertilizer application (UGS/ha at 3 opportunity costs)			Field value of increased production
Fertilizer treatment	25%	50%	75%	
45 kg/ha P_2O_5	94,109	112,989	131,576	48,551
45 kg/ha P_2O_5 + Inoculation	106,109	124,989	143,576	55,768
45 kg/ha P_2O_5 + 10 kg/ha N	110,849	133,076	155,011	49,426
45 kg/ha P_2O_5+ Inoculation + 10 N	122,849	145,076	167,011	62,767

Table 32. Costs of fertilizer use and field value of added production for the maize bean intercrop.

Fertilizer treatment	Total cost of fertilizer application (UGS/ha at 3 opportunity costs)			Field value of the increased production	
	25%	50%	75%	1997-8 seasons	1999A season
23 kg/ha P_2O_5	48,100	57,750	67,250	65,407	52,950
46 kg/ha P_2O_5	96,200	115,500	134,500	79,404	109,451
23 N + 23 kg/ha P_2O_5	86,600	103,950	121,150	99,618	156,330

Table 33. Costs of fertilizer use and field value of added production for the maize sole crop.[1]

Fertilizer treatment	Total cost of fertilizer use (UGS/ha at 3 opportunity costs) 25%	50%	75%	Field value of the increased production 1997-9 seasons
Lantana, 4 t/ha	Labor	Labor	Labor	74,216
Lantana + Fertilizer (50% rates)	Labor + 133,882	Labor + 160,695	Labor + 187,348	137,194
Fertilizer	267,774	321,391	374,696	177,694
[2]Lantana + fertilizer (reduced rate)	Labor + 62,550	Labor + 75,075	Labor + 87,525	?
[2]46 N + 23 kg/ha P_2O_5	125,100	150,150	175,050	?

[1] Fertilizer was applied at 100 kg N and 48 kg phosphate and 100 kg potash per ha (potash was excluded from the cost estimates below). Labor for application of lantana has not been costed.

[2] Maize sole crop trial results indicate that with this level of fertilizer use, maize yields approach those achieved with the higher rates used in these trials.

Contributors: Kayuki Kaizzi (NARO); and C. Wortmann

Acid soil amendment with lime and Busumbu rock phosphate

Rationale: Uganda has two large rock phosphate deposits that potentially could serve a regional market. Sukulu RP is of low reactivity, while the mineral composition of Busumbu rock phosphate (BRP) is more favorable for direct application. Under conditions of moderately acid soil (pH 5.3), crops failed to acquire significant P from Busumbu RP. Increased soil acidity and composting of the BRP were hypothesized to improve reactivity of BRP sufficiently to make its use profitable.

Methods: The trial was conducted on an acid soil site of ISAR's Rubona station in Rwanda. Treatments included: the control; lime at 1.5 t ha^{-1}; TSP at 370 kg ha^{-1}; BRP at 1 t ha^{-1}; BRP composted with farmyard manure (50:50) at 2 t ha^{-1}; and composted BRP + farmyard manure at 2 + 5 t ha^{-1}.

Results: Exchangeable Al was most reduced and Ca increased by lime, but also by application of TSP, BRP and BRP + compost (Table 34). The amendments increased P availability to a similar extent and increased availability of P, Ca and Mg. BRP + compost had a greater effect on soil properties than BRP alone, but the effect could not be attributed to improved reactivity of the BRP. Yield was most improved by application of farmyard manure. Yield increase with BRP was similar to TSP and BRP + compost, but less than with lime.

Discussion: While composting BRP did not have an immediate effect on yield, it made the BRP easier and cleaner to apply. Although costs of transporting the RP from eastern Uganda to southern Rwanda would make the use of BRP uneconomical, the information is applicable for acid soil sites nearer to Busumbu. It is also worthy of note that P recovery from BRP was similar to that from TSP.

Table 34. Effect of Busumbu rock P and other soil amendments on an acid soil and its productivity at Rubona.

Treatments	pH	Exch. Al	P Bray I	Exch. Ca	Exch. Mg	Bean yield
Control	4.8 b	2.6 d	7.2 d	0.4 e	0.14 a	508 d
TSP	4.8 b	2.4 c	16.3 ab	2.7 b	0.25 c	665 c
Lime	5.5 a	0.5 a	15.7 b	3.6 a	0.13 a	810 b
Busumbu RP	5.0 b	2.5 cd	13.3 c	1.9 d	0.18 b	680 c
Busumbu RP + compost	5.0 b	2.2 b	15.9 ab	2.0 c	0.24 c	690 c
BRP + compost + manure	5.1 b	2.3 bc	17.1 a	2.0 c	0.26 c	1935 a

Collaborators: Leon Nabuhunga (ISAR); C. Zaongo (ICRAF); S.Ntizo and A. Mukuralinda (ISAR). This research was funded by ECABREN.

Weed species as indicators of soil characteristics

Rationale: Farmers and their advisors need quick and inexpensive ways of assessing the soil fertility levels of arable land. Knowing the relationship between the densities of certain weed species and soil properties is useful in the characterization and diagnosis of soil fertility status. Soil management strategies can be devised accordingly.

Methods: Observations were made on 39 fields with annual crops over four locations in eastern and central Uganda. Densities of weed species relative to the total weed population were determined. The species included *Ageratum conzoides, Amaranthus* spp., *Commelina benghalensis, Bidens pilosa, Digitaria abyssinica, Eleusine indica, Euphorbia hirta, Galinsoga parviflora, Oxalis latifolia, Sorghum* spp., *Panicum maximum* and nutsedge. Surface soil samples were collected and analyzed for texture, soil pH and C, and available and total nutrients.

Results: Soil carbon level is indicated by the presence and density of ageratum, oxalis and sorghum (Table 35). Oxalis and sorghum were unlikely to be present when percent C was less than 2.3. The density of ageratum and oxalis increased as soil C increased.

Sorghum was generally absent when pH was less than 5.8. Oxalis and euphorbia increased and decreased in importance, respectively, when soil pH increased. Eleusine was not likely to occur when soil P availability was less than 13 ppm. Both eleusine and oxalis increased with increased P availability, and variation in the relative densities of these two species accounted for 40% of the variation in Olsen P. Total P was positively and negatively correlated with eleusine and euphoria densities, respectively.

Sorghum occurred only when exchangeable Ca was above 6 $cmol_c\ kg^{-1}$. Eleusine and euphorbia increased and decreased, respectively, as exchangeable Ca increased.

Exchangeable Mg was best indicated by weed species. Eleusine occurred only with. more than 1.6 $cmol_c\ kg^{-1}$ of Mg; eleusine increased as exchangeable Mg increased. Relative densities of digitaria, euphorbia and nutsedge were negatively related to exchangeable Mg. Variation in these four species accounted for 62% of the variation in exchangeable Mg.

Sorghum occurred infrequently when exchangeable K was less than 0.6 $cmol_c\ kg^{-1}$. Eleusine and oxalis increased as exchangeable K increased; eleusine and bidens tended to increase as total K increased.

Discussion: The results offer an opportunity to better diagnose and characterize the soil fertility status of a field through field observations. This information needs integration into rule-of-thumb guides for use by farmers in the management of their land.

Table 35. Positive (+) and negative (-) relationships of the relative densities of weed species with soil properties which may be useful in diagnosis of soil fertility status.

Species	OC	PH	P	K	Ca	Mg	N total	P total	K total
Eleusine			+	+	+	+		+	+
Euphorbia			-		-	-		-	
Sorghum	+	+		+	+		+		
Oxalis	+	+	+	+					
Nutsedge	-					-			

Collaborators: Michael Ugen (NARO); Chris Wien (Cornell University); C. Wortmann.

Use of weed flora to predict bean response to applied compost

Rationale: Weed flora composition varies according to soil properties and is potentially useful in predicting responses to applied compost. Relevant information has the potential to enable farmers to use their scarce organic resources more efficiently.

Methods: Fields were identified in Walungu and Kabare, in eastern DR Congo, with one of the five weed species (*Gallinsoga parviflora, Bidens pilosa, Cynodon dactylon, Pennisetum polystachia* and *Conyza sumatrensis*) as the dominant species. Soil samples were collected from each field and analyzed for pH, carbon, N, C/N and available P. Two treatments, with and without applied compost, were applied to each field. The numerous fields, generally on different farms, consisted of main plots giving a split plot arrangement in a completely randomized design. Compost was applied at 20 $t\ ha^{-1}$, and bean was the test crop.

Results: *Gallinsoga parviflora* was most frequently dominant on less acid and higher P soils. Otherwise, measured soil properties were not consistently related to species prevalence.

Bean yield was high and moderately high, and did not respond to compost, where galinsoga and *Bidens pilosa* where the dominant species (Table 36). Bean yield was moderately high and responsive where the dominant species was *Cynodon dactylon.* Where *Pennisetum polystachia* and *Conyza sumatrensis* dominated, bean yield was low and responsive to compost application. The greatest response to applied compost occurred where pennisetum was the dominant species.

Discussion: The results are potentially useful to soil fertility management. Simple decision guides for use by farmers and extension need to be developed, enabling them to use weed flora in deciding how to use scarce resources for soil fertility management most efficiently.

Table 36. Bean response to applied compost as affected by site differences as indicated by prevalent weed species.

Dominant weed species	No compost	Compost applied
Gallinsoga	1,350 a	1,354 a
Pennisetum	105 f	562 de
Conyza	528 de	753 d
Bidens	918 bcd	968 bc
Cynodon	854 cd	1,113 b

Collaborators: M. Ngongo and L. Lunze (INERA-Mulungu). This research was funded by ECABREN.

Activity 3.2 Development of IPM components

Achievements:

- Participatory research in pilot sites identified soil fertility options (e.g. combining half rates of farmyard manure and DAP) that enhance crop vigor, tolerance to stem maggot . and yield enhanced plant vigour and tolerance to BSM attack, without unacceptable labor costs.

- Farmer field schools improve farmers' understanding of their pest problems, information base and abilities to design and evaluate potential solutions

Participatory development of IPM for bean stem maggot in Western Kenya

Rationale: IPM approaches are essential for bean stem maggot management as tolerance alone is insufficient to combat the pest and its damage. However, adoption of IPM strategies requires better understanding of the problem by farmers and complex decisions on their resource allocation. Participatory research approaches are needed to evaluate options.

Methods: Cultural strategies for BSM management were tested with farming communities in Kisii, western Kenya. Strategies included: seed dressing with agro-chemicals: earthing up, mulch, farm yard manure and di-ammonium phosphate (DAP) at half the recommended rates. These are strategies already reported to reduce BSM infestations or enhance the tolerance of susceptible plants against the pest. Farmers were encouraged to suggest other technologies, which were discussed and selections made among them. Farmer technologies selected for testing were: rotation with sweet potatoes (a common practice in the area) and farmers' common practice (i.e.

without any of the above treatments). Two bean varieties, Red Haricot and GLP 2, were used to check varietal interaction with the treatments. The trial was farmer managed.

Results and discussion: Apart from seed treatment with Murtano (lindane and thiram), none of the other treatments reduced BSM infestation significantly below that of the control or farmers' practice (Table 37). For reasons that are not currently well understood, rotation with sweet potatoes reduced BSM infestation significantly below several of the other treatments; this will be investigated in future trials. Red Haricot suffered less mortality than GLP 2. All management treatments enhanced plant tolerance; combining half rates of farmyard manure and DAP enhanced plant vigour and tolerance to BSM attack and increased yield significantly above the control. Mulch and earthing up required extra labour but did not increase yields, and were less preferred by the farmers.

Table 37. Effect of cultural practices on BSM infestation and plant performance in Kisii, Kenya.

Treatment	BSM infestation per plant	Plant mortality due to BSM (%)	Yield/plot
Chemical seed dressing	2.6 ab	7.9 ab	573.9 ab
1/2 DAP + 1/2 FYM	2.2 ab	4.6 bc	840.0 a
Earthing up	2.0 ab	12.7 a	341.6 b
Mulch	2.3 ab	7.8 ab	323.6 b
Rotation with sweet potato	1.8 b	5.8 bc	500.1 b
Control	4.0 a	11.8 a	490 5 b
$LSD_{(0.05)}$	2.1	5.6	272.8

Contributor: John Ogecha (KARI Kisii)

Participatory development of management strategies for bean pests in Tanzania

Rationale: In addition to bean stem maggot, several other pests also require IPM approaches. The Northern Tanzania offers a valuable case study for our strategic research and training.

Method: Activities this season centered on creation of farmer awareness and participatory technology generation in Lushoto District, Tanzania. Farmer groups were trained in pest identification and assessment, to enable them set action thresholds. Pictorial illustrations of the expected constraints (pest and the damage they cause) were prepared to enable farmers to identify and estimate pest intensity and damage. At harvest farmers analysed their yields for losses caused by the pests.

***Results and discussion*:** Collaborating farmer research groups already trained in integrated crop production practices are now able to produce a surplus from their fields. The next step was to create links with markets. This year farmers were contracted by businessmen to produce grain and seed for them. This development was used as an opportunity to enable farmers to better understand their economic losses.

Aphids, bean stem maggots, bruchids and foliage beetles were identified by collaborating farmers as the key pests that constrain their bean productivity. They were able to identify their importance in relation to season, as well as their sequence within seasons. They observed that early planted beans are more attacked by bean foliage beetles than late planted crops. Bean stem maggot was more important in the second season than in the first; aphids attacked in both seasons but usually appeared late in the season. Once the problem and its development were understood, farmers came up with possible solutions. Experiences from elsewhere were used to boost farmer knowledge and expand options for management. During the early part of the season, an army worm outbreak enabled farmers to test some of their concoctions on this pest. The combination of neem leaves, ash and pepper protected maize against armyworm attack. Both the neem leaf infusion and leaves of *Vernonia* sp. protected beans from foliage beetle damage, but cow urine was ineffective against this pest. Improved bean varieties were distributed to the farmer research groups.

In the separate study of farmers' assessment of economic losses, the main field pests occurring were pod borers (*Maruca vitrata)* and pod sucking bugs (*Clavigralla tomentosicollis, C. elongata and Nezara viridula*). Together they caused moderate damage to the crop. Grain yield loss caused by the pests ranged from 14 % to 27 % in different fields. This was translated into monetary terms as Tanzania Shs 38,000 to 70,000 per ha, equivalent to US$48 to 89 per ha.[1] The farmers considered these losses high, especially as the businessmen insisted on clean grain. Farmers now appreciate the need for scouting for pests and protection measures to avert high losses. Similar exercises on awareness creation among farmers are under way through network scientists.

Contributor: K. Ampofo

3.3 Design efficient methods for systems improvement

Achievements:

- Farmer research groups empowered to maintain records on own initiative, prepare posters explaining trial results, and make well-focused technical demands on the extension system
- Indicators of improving attitudes towards participatory research include financial support to PRIAM from ECABREN, and NARI managements directing donor teams to PRIAM sites
- Social linkages and dynamics in collaborating communities are key factors in farmer acquisition of technical knowledge, and in their effectiveness at passing it on to others

Test and evaluate participatory research methods within PRIAM sub-projects

Rationale**: Methods for collegial participatory research are poorly developed and understood by NARS in the region, tend to be expensive and static, and are often confused with demonstrations.**

[1] **Based on estimated yield of 1000 kg/ha, a price of TAS 350 per kg and exchange rate of US$1 = TAS 790.**

Methods: The Participatory Research for Improved Agro-Ecosystem Management (PRIAM) project catalyzed and supports community-based participatory research through NARIs with extension and NGO involvement in six countries. The objectives are to refine and develop methods, and to encourage the institutionalization of participatory research approaches. Our technical support continued this year but at a reduced level, partly because of a shift in emphasis to supporting the startup of similar community-based participatory research within AHI sites (see Section 3.4), where the larger number of partners and higher profile increase prospects for institutionalization.

Results and discussion: Communities generally chose to start experimenting, two or three years ago, with crop varieties because they could envisage immediate benefits even if the researchers never came back (which most said had been an initial fear based on experience). Gradually confidence has grown, with their research partners and in their own research abilities. Farmers have become interested in a broader range of innovations, including forage crops, implements, soil fertility management and seed enterprises; and researchers have started examining apparent examples of indigenous technical knowledge, especially pest management using local remedies.

Levels of commitment by researchers to PRIAM activities this year have varied. Some have continued to grow strongly, with notable benefits for the partnerships and their effectiveness; the best cases appear to be associated with interest and support from local NARI leadership. Sometimes, a focus on process by the few has not received adequate technical support from other programs capable of contributing to innovations. And in some cases, the logistics required to serve communities distant from research stations have proven too much.

However, in most if not all cases the farmers already seem to be feeling a difference. In one relatively remote and neglected PRIAM community that this year lacked significant formal support, farmers implemented a number of self-designed agronomic trials/activities. In addition to adaptive variety trials on several crops, these included multiplication plots to produce seed of a new bean variety for local dissemination and intercropping trials on maize and beans, and maize and Irish potato. These farmers also impressed visitors with their generosity and willingness to distribute seed from their recently selected varieties (beans and other crops) to neighboring farmers, and their record keeping practices, revealing notebooks where they continued to accurately record past PRIAM activities and the designs/layouts for this season's trials.

Evidence of a degree of empowerment comes from two directions. This same isolated community group revealed that they have been making demands on the extension system, and achieving their desired results. They reported having publicly rejected the "standard" maize variety promoted in district-wide extension packages, requesting instead a variety that they had tested and believed to be better adapted to their environment. Initial resistance by extension led to a farmer walkout and, subsequently, to the return of the extension department now offering their preferred maize variety as part of the extension package. A second example comes from one of the best supported farmer research groups (FRGs), which now prepares their own posters explaining trial purposes and results to visitors, a role normally carried out only by research or extension officials.

Two indicators of the gradually changing attitudes towards participatory research should be noted. Upon the completion of the RF grant that catalyzed the startup of PRIAM, much of the site costs for PRIAM activities have been provided as a result of support from the steering committee of ECABREN, which also appointed an experienced participatory researcher as its PRIAM coordinator (a demanding but unpaid assignment). Secondly, the senior NARI management in at least two countries this year have been directing visiting donor teams to PRIAM sites as evidence of their institutions' collaboration with farmers. It is also fair to state, however, that these examples are probably still the exception within NARS, which have considerably less exposure to these ideas than do the staff of NGOs.

Contributors: R. Kirkby and C. Farley
Collaborators: B. Rabary (FOFIFA/ECABREN coordinator for PRIAM); among NARIs: AU, EARO, FOFIFA, INERA, KARI and NARO; among NGOs, especially CARE and FARM-Africa.

An assessment of farmer experiences with PRIAM in Ethiopia

Rationale: Before the PRIAM approach can be effectively promoted and accepted widely in Eastern Africa, the experiences of participating communities and research institutions need to be assessed in more detail than most resident site teams have the time, or in most cases the skills, to do. For example, information is needed on farmers' evaluations of the functioning of farmer research groups (FRGs), and their ability to catalyze participation, experimentation and technology dissemination both within participating communities and to neighboring villages.

Methods: During the 1998 PRIAM regional workshop, sites in Ethiopia appeared to have rich experiences. Support from IDRC enabled more intensive interaction with two participating communities around Nazreth and others elsewhere in Ethiopia in this, their third year of involvement. A range of qualitative research methods were employed to examine the experiences of farmers and researchers. Group discussions are continuing over the course of a complete year with FRGs and with both participating and non-participating farmers to explore issues of village organization and local social and gender relations at household and community levels. Semi-structured interviews were carried out with 15 participating and 15 non-participating farmers in each PRIAM community to assess participation in on-farm experimentation, their access to, control over, and use of new technologies, and the distribution of the benefits of research and experimentation. On-farm observation, and interviews with researchers and extensionists, complement the farmer discussions.

Results and discussion: The impact of the PRIAM project for farmers and the national agricultural research and extension systems is far-reaching. In participating communities, PRIAM farmers report that access to new technologies such as improved agricultural implements and crop varieties have greatly improved their yields of teff, maize, sorghum, wheat, and barley, and hence their ability to generate an income and provide for the dietary and material needs of their families. Participating and non-participating farmers alike have expressed significant interest in, and acceptance of, the new technologies. On-farm experimentation of new agricultural implements designed to assist farmers in ox-drawn plowing and in changing from broadcast to row planting, for example, has met with remarkable success in participating communities, largely because the implements have been developed as attachments or modifications to the traditional *maresha* wooden plough used by farmers throughout Ethiopia for centuries. Farmers and researchers alike have reported that new implements derived from traditional implements and practices simplify the training required by farmers to operate and test them and make possible the dissemination of new information, skills, and technologies from farmer to farmer. The *maresha*-based implements are more readily accepted and adopted by farmers both because they are familiar (farmers already have considerable experience with and knowledge of the operation, maintenance, and performance of the *maresha*) and because they are relatively low cost.

Information and new technologies have been disseminated within and across participating communities through both formal (researcher-to-farmer) and informal (farmer-to-farmer) channels. The initial introduction of new technologies, including the information and training which accompany them, was accomplished through formal researcher-to-farmer linkages. Farmers were nominated by others in their community and by district level development/ extension agents to receive training with, and access to, improved technologies for on-farm experimentation. Participating farmers in each community were organized into FRGs who, among other things, are responsible for facilitating the dissemination of information, skills, and technologies throughout their community. Although the functioning and effectiveness of the FRGs varies from site to site, they have enabled the diffusion of information and technologies from farmer to farmer. The dissemination of technical information and skills has taken place through a variety of formal and informal channels. In all participating communities, farmer field days have been organized at least annually to provide the opportunity for community members to visit and observe the on-farm trials of PRIAM farmers, to learn about new technologies and experimentation methods, and to discuss the results of on-farm experimentation with PRIAM farmers.

A small number of PRIAM farmers also organized special events to enable them to share their experiences from on-farm experimentation with a wider audience. One PRIAM farmer, for example, organized a demonstration of the improved implements he was testing during an annual celebration in a town near to his community. The same farmer has visited local schools to speak with children, as future farmers, about the benefits of experimentation. Information has also been transmitted through local social networks such as *Idir* funeral groups and women's *Baltina* social groups, as well as though labor groups known as *Jiggi*, and other informal social relationships. As farmers have learned about new technologies and experimentation methods they have sought opportunities to gain access to these technologies to test in their own fields. During the experimentation stage, agricultural implements were shared between participating and non-participating farmers to allow those outside the formal research project to gain access to these technologies for experimentation. As crop varieties were tested and selected by farmers, they were distributed by participating farmers to interested neighbors, friends and family within and across communities. Once these technologies have been popularized, however, they need to be multiplied and made available at local markets to ensure that all farmers are able to secure access to them.

Beyond the economic and material benefits derived from the FPR process, PRIAM farmers report having benefited in many other equally important ways. Locating experiments on-farm and handing over ownership and control of such experiments to farmers has placed farmers at the center of research, making them partners in, rather than recipients of, technology development. As a result, farmers now claim to have new levels of confidence in their own experimentation skills and a stronger voice, both individually and collectively, within the district level and even national level agricultural research and extension systems.

Contributor: A. Adamo
Collaborators: Melesse Temesgen and Habtu Assefa (EARO); Daniel Dauro and Shiferaw Tesfaye (Awassa Research Center); Frew Mekbib (AU)

Activity 3.4 Inter-center and ecoregional linkages

Achievements:

- Broadbased stakeholder meetings defined outputs and activity plans for a new participatory project to improve integrated nutrient management in benchmark sites in three countries

- Communities and research teams at AHI sites are identifying ways of intensifying production systems in highly populated target areas

Improving integrated nutrient management (INM) practices on small-scale farms in Africa

Rationale: Intensification of agriculture in the high-density sub-humid areas of Africa, generally without addition of plant nutrients, has resulted in 'nutrient mining' and subsequent land degradation. Nutrient depletion is a reversible constraint and high agricultural production can be realized with proper soil nutrient management. Management of soils by integrated use of organic and inorganic sources of nutrients will lead to increased agricultural productivity. However, improvement in INM strategies requires their identification and adaptation using systematic learning with stakeholders, and that farmers perceive economic incentives for changing practices to be adequate. However, skills in using participatory approaches to improving soil nutrient management are still uncommon in Africa.

Methods: A new project under the Soil, Water and Nutrient Management (SWNM) system wide program started this year. Funded by BMZ, the project is managed by CIAT with TSBF (for Eastern Africa) and IFDC (for West Africa). The project aims to enable small-scale farmers to profitably reverse nutrient depletion of their soils by increasing their capacity to develop, adapt and use INM strategies, and to improve the participatory approaches, skills and tools of research and extension personnel to support that process. The project held an initial stakeholders' meeting in March, when the proposal was revised through a facilitated participatory process, and a general three-year workplan was agreed.

Results and discussion: Participating countries in Eastern Africa were agreed to be Kenya, Tanzania and Uganda, with CIAT IP-2 providing initial leadership with local institutions at sites in Tanzania and Uganda, while participating under TSBF leadership in Kenya. Three site stakeholders meetings were held, one for each country, during the course of the next few months, with participation being drawn from the NARI, NGOs and extension service, and community and farmer groups, in addition to TSBF and CIAT. Stakeholders reviewed the niche for this project and revised the outputs and corresponding activities as outlined below.

Output 1(Research): INM strategies identified and adapted to various circumstances using systematic learning with stakeholders. The main activities will be to characterize INM problems and opportunities, develop an inventory of current farmer and researcher strategies in INM, develop and test with farmers several decision support tools from research results and strengthen farmers' knowledge base and capacity for INM research. Lessons learned will be synthesed across sites annually.

Output 2 (Dissemination): Strategies, methods and information on INM disseminated to stakeholders. Activities will include developing and evaluating dissemination strategies based on farmers' learning systems and farmer/extension tools, and disseminating INM materials to stakeholders within pilot areas through schools, churches, farmer groups etc. Monitoring impact of INM messages developed through highly participatory approaches will be important, since stakeholders' initial diagnosis had been that failures of adoption were related more to failures in the processes of developing and disseminating practices appropriate to local circumstances, rather than to a lack of adequate on-station INM research.

Output 3 (Capacity Building): Capacities of researchers and extension workers to facilitate farmer innovation are developed. Activities will include strengthening the acceptance of new ideas by researchers and extension workers through sensitization and training in participatory methods. Frontline personnel throughout the pilot sites are expected to need training in principles of INM and participatory methods.

The pilot area for each country was determined by a common set of criteria that included the existence of previous dissemination attempts of INM practices (so that the introduction of more participatory approaches would have a base from which to learn local experience), current INM research, and the local presence of research and development partners. In two of the countries, working through the AHI readily provide these opportunities without a coordinated multi-institutional setting (Table 38).

Contributor: A. Esilaba (PE2/IP2)
Collaborators: TSBF, IFDC, NARO, KARI, DRD, AHI and several NGOs.

Table 38. Site selection criteria and project site characteristics.

	Kenya	Tanzania	Uganda
Site characteristics	Emuhaya Division Vihiga District Western Kenya	Soni Division Lushoto District Northern Tanzania	Imanyiro Sub-County Iganga District Eastern Uganda
Altitude (masl)	1350 – 1800	800 – 2200	1070 – 1161
Rainfall (mm)	1800 – 2000	500 – 1700	1250 – 2200
Population	600,000	471,240	945,783
Selection criteria			
Agroecological zone	Western Kenya Highlands	Northern Tanzania Highlands	Eastern Uganda Highlands
Availability of partners			
NARS	KARI, KEFRI	SARI, ARI Mlingano	NARO, Makerere Univ.
IARCS	TSBF, ICRAF	AHI / ICRAF, CIAT	CIAT
Extension	MoALD	MOA	MAAIF
NGOs	None	None	AF2000, SG2000, IDEA
Socioeconomic potential	Wide representation	Wide representation	Wide representation
Nutrient depletion	N and P deficiencies	N and P deficiencies	N and P deficiencies
Farming/landuse system	Maize, beans, Coffee and tea	Maize, bananas, beans, coffee and tea	Banana, maize, beans, cassava, coffee, fruit trees. Intensive banana/ coffee system in lake region
Prior INM research by:	AHI, ICRAF, KEFRI, and KARI	AHI, CIAT, SARI, ARI, Mlingano	CIAT, NARO, NGOs, Makerere University
Promising INM technologies	Tithonia biomass transfer, improved fallows	Biomasss transfer, improved fallows	Vetiver (soil erosion), improved fallows, green manure / cover crops
Current INM research activities	Farming systems, soil fertility, soil erosion livestock management, striga and pest control	Farming systems, soil fertility, soil erosion, agroforestry	Farming systems, soil fertility, soil erosion, pest control

Participatory improvement of production systems in the African Highlands Ecoregional Program (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 upon solving soil degradation and other natural resource management problems at 8 benchmark sites across five countries within the highly populated Eastern Africa highlands. Partners agreed that CIAT take responsibility for catalysing community-level participatory research by local inter-institutional site teams.

Methods: The series of site start-up training workshops in participatory research methods was completed in December 1998 with workshops held for the benchmark sites in Embu (Kenya) and Madagascar. This series was modeled on workshops successfully used in starting up PRIAM sites through development of a research action plan with which farmers identify. Under AHI auspices, CIAT has continued to provide much of the support for participatory research by the inter-institutional site teams, with our main focus being Areka (Ethiopia), Kabale (Uganda), Lushoto (Tanzania) and the sites in Madagascar. This year we also led a training workshop for key professionals from all sites in facilitation skills, team building and for capacity building in participatory NRM research in general.

Results and discussion: The capacity building workshop emphasized, on the technical side, skills for identifying farmers' knowledge of NRM, analyzing resource flows, identifying agroecological niches for research, and understanding social differentiation. In the workshop evaluation, participants ranked highest their new skills for communicating with farmers and within a diverse team. Institutionally, this year completed the transition from a commodity-oriented small-grants approach to organizing site research to an integrated, participatory agroecosystem approach to research planning, in response to last year's series of CIAT-led site workshops. However, the transition has had its difficulties, as research planning and implementation by other programs and projects (even in the same locations) tends to emphasize the interests of individual scientists.

CIAT also leads IARCs support to AHI in the areas of seeds systems [see 4.1 below] and IPM. This year, our IPM specialist and the bean pathologist visited AHI sites in western Kenya, southern Ethiopia and Tanzania for technical support to on-going research on IPM of beans (root rots, root knot nematodes, stem maggots) and sweet potato (butterfly). CIAT staff also convened AHI's working group on IPM and participated in two AHI Technical Support Group meetings.

Contributors: R. Kirkby, K. Ampofo and C. Farley
Collaborators: R. Buruchara; A. Stroud (ICRAF/AHI); AHI site teams in Ethiopia, Kenya, Madagascar, Tanzania, Uganda

Participatory improvement of production systems in the Areka site within AHI

Rationale:

Areka is a benchmark site for focusing AHI partnership activities in southern Ethiopia, where population density exceeds 400 people/km2, farm sizes are with very small (averaging 0.25ha) and only about 10% of people own livestock. Nutritional status and income generating possibilities are the poorest of all eight AHI sites, and improving both are specific objectives of AHI in this area.

Methods: We hired a research fellow from the region in mid-year, for stationing at Areka Research Center, Ethiopia, to intensify research and site support in systems agronomy at this and other selected AHI sites. A workplan was developed from participatory diagnosis and a stakeholders' workshop in 1998, initially to serve the pilot area of Gununo.

Results and discussion: A wealth ranking exercise had indicated that farmers themselves consider health, including malnutrition and frequent ill-health, to be among the most important indicators of poverty in Areka. A better understanding of traditional resource sharing (e.g. for oxen) will be necessary, as a prelude to examining options for improving access to credit in this isolated area. Options that might make credit more sustainable (e.g. introduction or dissemination of other livestock) also need examining. Gender aspects are important.

The following activities were started this year and are considered as entry points to address farmers' multiple goals in a holistic manner:

1) Characterization of erosion risk and factors, and introduction and evaluation of contour planting (with banana, enset (false banana) and Grevillia trees), soil/fodder grass bunds, and remodeling of farm contours and furrow systems.

2) Introduction and farmer evaluation of higher yielding varieties of bean, teff, wheat and sweet potato – since previous non-participatory introductions have led to little adoption.

3) Evaluation of indigenous and IPM measures against sweet potato butterfly, using interplanting with Desmodium fodder and application of Eucalyptus or pepper extract, in comparison with insecticide.

4) Introduction and evaluation of high value fruit trees (avocado and banana) as soil and water conservation measures, accompanied by assessments of current and potential markets.

5) Evaluation of multipurpose trees (Calliandra, Sesbania and Leucaena) and fodder grasses on contours, boundaries and in niches identified together with farmers.

6) Integrated soil nutrient management in fields planted to sweet potato through organic, inorganic and combined sources, including biomass transfer.

Contributor: Tilahun Amede (CIAT/AHI)
Collaborators: EARO, staff of Areka and Awassa Research Centers; Southern Ethiopia Bureau of Agriculture; FARM Africa

Output 4. Technology adopted

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

Achievements:

- Two Kampala communities introduced to climbing beans as an intensive production system for urban landscapes, and seed of five modern bush bean varieties sold to 165 urban farmers through local authorities

- Bean seed dissemination activities growing immensely throughout the region

- Case studies conducted of NGO-initiated farmer seed enterprises with the goal of developing sustainability guidelines

Promotion and dissemination of bush and climbing beans among urban farmers in Kampala, Uganda

Rationale: Given the shortage of land available to urban African farmers and their motive to improve household food supply, new bean varieties, and especially climbing beans, potentially offer an important advantage by producing higher yields. However, different approaches may be necessary for successful promotion and seed distribution efforts in an urban setting. Moreover, climbing bean production may face specific constraints in towns due to land tenure issues (insecurity), theft and shortage of staking materials. Lessons learned in Kampala are likely to be widely applicable in other East African cities.

Methods: Community meetings were held to decide on sales outlets. In March and April, 210 kg of five new bush bean varieties (K132, K131, MCM 2001, MCM 1015, UBR 9225) packed in 250g packets with labels in local languages were delivered to local authorities in two communities for sale. Seed distributors were compensated with 30% of sale earnings. Posters promoting the new varieties were also distributed to sale outlets. Seed sellers were requested to keep records of sales and to limit sales to 500g of each variety per household. Two demonstrations per community were agreed to introduce climbing beans (Vunikingi and Umubano varieties introduced from Rwanda and now released by Uganda), a new technology to most Kampala farmers.

Results: Farmers rejected seed sales through several channels that have proven effective in rural settings (e.g. clinics, shops). Shops were rejected because of shopkeepers' tendency to mix in seed of dubious quality, the desire to limit sales to community members for purposes of the study and the need to account for sale proceeds. Because clinics were under-staffed and the study required record keeping, it was difficult to find clinic staff willing to take responsibility for selling the seed; lack of space to store the seed in clinics was also problematic. Seed was sold through the offices and homes of local authorities, at local meetings and through door-to-door sales. Over a six-week period, 136 kg of seed were sold to 165 farmers. K132, a Calima type preferred in Uganda, was the most popular variety, followed by K131 (a Pinto seed type) and UBR 9225 (white haricot types) (Table 39). Women buyers outnumbered men (121 compared to 44) in both communities.

Discussion: Major problems encountered with selling through local authorities included: limited effort to widely promote and popularize the varieties due to other commitments, the frequent absence of local authorities, and the centralized nature of selling from homes and offices which limited farmers' access to the seed. One conclusion of the study is to avoid using local leaders to distribute seed. Because issues of mistrust may be more prevalent in urban areas, distribution through non-commercial channels may be more appropriate in towns. These may include agricultural supply shops, roadside kiosks, market vendors and churches.

Table 39. Bush bean seed sales among urban farmers in two Kampala communities, 1999.

Varieties	Quantity sold (kg)		Number and sex of buyer			
	Nakawa	Makindye	Nakawa		Makindye	
			Male (N=32)	Female (N=81)	Male (N=12)	Female (N=40)
K132	40	17	31	66	12	36
K131	25	12	25	45	6	28
MCM 2001	13	2	13	26	0	2
MCM 1015	12	2	11	27	2	4
UBR 9225	9	4	8	7	3	8

Note: Records were incomplete in both locations

Contributors: S. Kasozi; M. Ugen (NARO); S. David; F. Opio (NARO)

National and local dissemination activities for bean seed

Rationale: Numerous bean varieties have been released in eastern and southern Africa, including this year eight in Uganda (so clearing a backlog in applications) and several in Ethiopia. Much promotion, including seed multiplication, dissemination and marketing, is needed for these and other varieties to reach the millions of bean producers. There is a role for a range of approaches to serve this important need.

Methods: Countries vary greatly in the extent to which seed dissemination is centrally organized. The bean networks encourage national bean coordinators to catalyse initial multiplication and dissemination of new varieties, and to track and report seed activities nationally. Strategic research by CIAT has had a significant effect in promoting the concepts that small farmers can become seed producers, and *en masse* are willing and able to buy seed of new varieties if packaged in small quantities and labelled appropriately; our publications continue to be in demand with GO and NGO sectors. continue to be in demand

Results: Numerous activities are currently being undertaken by and among various partners, and at an increasing pace. Below are listed some of the activities for which feedback was available.

In Madagascar, FOFIFA researchers have linked with NGOs and farmer associations to multiply and disseminate/market seed of new varieties.

In Kenya, a snap bean variety, bred by CIAT at KARI's request by crossing a locally used variety with sources of rust resistance from dry beans, was registered and licensed to a private company, with 5% royalties returning to KARI .

In Uganda, the Uganda Seed Project (USP), the primary producer of certified seed, sold to NGOs and farmers approximately 200 and 540 t of seed of improved bean varieties for the second season of 1998 and the first season of 1999, respectively.

Masaka-Rakai farmer associations produced and wholesale marketed 200 and 320 t of the popular K132 variety in 1998B and 1999A seasons, respectively – main buyers were USP, CIE (a private company retail marketing bean seed in 5 kg bags) and NGOs and relief organizations. They also provided significant amounts to their neighbors. The associations hope to meet the requirements for providing certified seed next year.

AT (Uganda), an NGO which aims to improve food security, farm incomes and rural institutions, last season supported the management of on-farm trials of bean varieties from NARO/CIAT sources undertaken by 214 farmer groups in 7 districts (mostly in semi-arid northern areas of Uganda including camps for farmers displaced by the Sudan war). Trials directly involved 2,883 farmers, 45% being women, and the number of farmer groups had almost doubled from 115 groups in the previous season. This NGO also trained local seed stockists, who reported selling over 20 tons of improved bean seed to farmers. SG 2000 initiated a farmer-to-farmer seed multiplication scheme in 7 districts, and trained stockists to market the commercially attractive bush bean variety, K132. AfriCare, an NGO oriented more specifically to poorer farmers, has contracted small-scale farmers to multiply seed of climbing bean varieties.

The Uganda Bean Program introduced seed of newly released climbing bean varieties to local seed systems in mid-altitude areas through on-farm demonstrations. CIAT distributed seed and information in farmer experimentation mini-kits for legumes, as part of a strategic research activity (see also 4.2 below).

In Tanzania, a rural development project has contracted small-scale farmers in communities of five districts in the Northwest to multiply seed of Lyamungu 90; it is envisioned that this initiative will link with a component for strengthening of stockists in input supply.

Discussion: Bean seed dissemination activities are growing immensely throughout the region, and especially in Uganda and Tanzania, where amounts probably exceed total quantities produced and marketed for all other countries combined if we exclude diffusion between individual farmers and RSA.

Contributors: C. Wortmann, R. Kirkby
Collaborators: National bean coordinators

Developing sustainable farmer seed enterprises in Africa

Rationale: We promote community-based seed production initiatives as a sustainable approach to disseminating seed of modern crop varieties. Pilot work conducted by CIAT in Eastern Africa showed that small-scale farmers are capable and willing to produce good quality bean seed on a commercial basis. However, there is little evidence from Eastern and Southern Africa that this approach is replicable on a modest-to-large scale and sustainable. To verify the relevance of community-based seed production in the African context, existing NGO seed production projects in Rwanda and Kenya are to be evaluated.

Method: Aspects to be evaluated include organizational aspects of the project, a financial assessment of a sample of individual producers and the impact of the project on producers and the community. Project staff were interviewed, and informal discussions held with producers. Formal surveys of producers and buyers will be conducted.

Results: Not yet available

Contributor: S. David
Collaborators: A. Kariuki, R. Ng'ethe (ASAL-Laikipia); S. Kantengwa (World Vision-Rwanda)

Activity 4.2 Promotion of crop and pest management options

Achievements:

- Fifty-three extension staff and 23 representatives of farmer associations trained in root rot management in a scaling up of bean IDM in Rwanda

- Demand for bean IPM information was met by production of posters and compact discs for translation by NARS to local languages

- Understanding how farmers learn about management-intensive innovations appears to need a combination of methods

- Experimental distribution of 3,000 minikits including seed of leguminous green manure species and a decision guide generated much interest from NGOs and demand from farmers

Scaling up bean root rot management in Rwanda

Rationale: Increasing population pressure associated with acute shortage of land in Rwanda and other highland areas has led to continuous bean production, reduced soil fertility and the appearance of bean root rots as a major yield-limiting factor. Improved climbing beans offer opportunities for yield intensification, and root rot management practices have been developed between CIAT and ISAR. These technologies need to be more widely available.

Methods: Under a sub-project supported by ASARECA/CIP Technology Transfer Project, ISAR with CIAT technical support is disseminating climbing bean systems and scaling up root rot management technologies in Rwanda. Our main joint activity this year was a training course for extension staff and key farmers representing associations from different prefectures of Rwanda.

Results and Discussion: Fifty-three extension staff drawn from the Extension Service (DRSA) of the Ministry of Agriculture (MINAGRI), NGOs and ISAR's regional stations were trained in two groups. NGOs, including World Vision International-Rwanda, CARE-Rwanda, Catholic Relief Services and a local NGO, represented all the prefectures of Rwanda. Aspects emphasized were improved climbing bean varieties, staking options, farmer seed production, soil improvement, diseases and root rot management technologies. The trainees are expected to train their colleagues and farmers in their areas of work.

Twenty-three farmers representing farmer associations were also trained in a one-day course in which farmers were encouraged to share their experiences on climbing beans and root rots. During and after the discussion, proposed management technologies were introduced. It is expected that further training will be conducted in areas represented by trainees, and complemented by demonstrations.

Contributors: A. Musoni (ISAR); R. Buruchara and S. Kasozi

Information dissemination to NARS on integrated pest management (IPM)

Rationale: Lack of appropriate information limits the extent of adoption of technologies developed for bean pest management. 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.

Method: IPM posters on management strategies for bean stem maggots, bean foliage beetles and storage pests were developed. As an experimental approach for northern Tanzania, Rural Information Centers (depositories for extension information) were created with support of rural schools and farmer groups to provide farmer access to information.

Results and discussion: As the demand for IPM information increased among bean network members, posters were reproduced on CDs and distributed to NARS. The materials are designed in Microsoft Word and are set up for easy translation into local languages without distorting the illustrative materials. In northern Tanzania the extension service has translated some of the information into Kiswahili, and farmers in Lushoto district, Tanzania are translating the materials into the local vernacular (Kisambaa) for ease of understanding within that community. The Bean Program in Malawi is also in the process of translating the IPM information into the local language for greater dissemination. Dissemination strategies through the individual national extension systems were discussed at the Working Group meeting and networks steering committee meetings (Sections 1.3 and 1.1).

Approaches for improved dissemination: sources of change and dissemination channels

Rationale: Research generally has been more effective in producing technologies in response to smallholder farmers' problems than in achieving an impact with a significant farming population. Disseminating agricultural technologies is more likely to be effective if based on farmers' ways of learning about new ideas and how they pass on innovations to other farmers.

Methods: The first phase of this SDC-sponsored research was an exploratory study on dissemination of a wide range of technologies. Participatory Reflection and Action (PRA) methods were used with farmers from 6 villages in three agroecological zones of Arumeru District, Northern Tanzania. The project follows an action-research framework in which, beside the main line of investigation, farmers' priority problems are addressed or farmers are linked with other organizations to help them.

Results and discussion: The first phase was carried out in the past six months, with PRA exercises in the six villages identifying sources of change and dissemination channels. Innovations introduced included: simple bean variety trials (5 plots with 3 or 4 varieties), started by 20 farmers from two villages being invited to the research station to learn about climbing beans and their management. Ten farmers from a third village visited a research station field day and learned about beans and other crops. It is too early to say if those had any positive effect for the farmers. Contacts were made with other organizations: colleagues from SARI's wheat program are considering collaboration with farmers from one village, and all villages started storage trials for beans and maize using locally available botanicals with TPRI collaboration.

Action-research proved useful in obtaining close relationships with farmers in the six villages. Farmers often mentioned several sources for the same technology (Table 40). Not all the technologies, however, were mentioned or used in all six villages. Important dissemination channels mentioned by farmers were: observation on their own trials or on other farmers' fields; discussions during/before/after meetings or communal labor; visitors to the village; visiting people in other villages; going to workshops or seminars within or outside the village; observation during field days and agricultural shows; demonstrations by outsiders in the village; and advice by industry (often with leaflets or posters).

Some of the PRA sessions were difficult: it was not always easy to go into a subject in depth with a group, as a few farmers do most of the talking and others get bored easily. This first phase needs supplementing by a second phase with individual interviews in depth.

Contributor: U. Hollenweger
Collaborators: D. Mohamed; staff of SARI; Juma A. Saidi and Mariam Njama (TPRI)

Table 40. Frequency of change agents for different technologies mentioned by farmers.

Technologies / **Sources of change**	GOs (extension, MoA,...)	NGOs, projects	Industry	Cooperatives, shows	Large-scale farmers	Other villages	Farmers' adaptation/invention	Tradition, knowledge
New varieties of known crops	4		1	3	2			
New crops (coffee, wheat, sunflower...)	1	2	1			3		
General, new crop management	2	1						
Inorganic fertilizer	1			1				
Manufactured pesticides (field, storage)	1					1	1	
Natural pesticides (field, storage)	1	1		1				3
Organic fertilizer (manure, compost...)	3		1			2		2
Grade milk cows				1	1	1		
Animal traction (oxen, donkeys)					5			
Tractors					3			
Soil conservation (incl. fodder, trees...)	2	2			2			1
Total:	**15**	**6**	**3**	**6**	**13**	**7**	**1**	**6**

Farmer-experimentation mini-kits as a tool for promotion of legume technology

Rationale: Mini-kits were distributed to farmers to enable learning experiences about green manure / cover crops. Cover crop technology is difficult to promote because: benefits are generally slow to be observed; adjustments of cropping systems are generally needed; technical options are environment specific and identification of appropriate niches takes time; farmers have little understanding of the potential of cover crops in soil management; and the extension services generally lack the capacity to promote such technology.

Methods: For the 1999A season, 2,000 kits were prepared in collaboration with Uganda's IDEA project for distribution to farmers in six districts. Another 1,000 kits were prepared for the second season of 1999 and distributed through various NGOs for use in eight districts. The kits contained seed of canavalia, mucuna and sometimes tephrosia and/or climbing beans. They also contained leaflets on canavalia, mucuna, tephrosia for mole rat control, a listing of best-bet options for mid-altitude areas of Uganda, a decision guide to the use of four legume species and, later, a leaflet on control of bean stem maggot.

***Results*:** The effectiveness of this approach has not yet been evaluated. However, the NGOs are using the minikits in various ways; at least one linking them to 'farmer field school' type of training. They also report considerable unsatisfied demand from farmers in the selected districts.

Contributor: Charles Wortmann
Collaborators: Mark Wood (IDEA), Africa 2000, SNV with Talent Calls Club and WEP, Buganda Development Foundation, SAFA, FARMESA, FOSEM and other NGOs.

Activity 4.3 Develop improved methods for documenting social and environmental impacts

Contributions to impact assessment methods in the ASARECA region

While no new methods were developed, we have contributed this year to regional thinking about impact assessment. Generally in the ASARECA region, assessments are based on standard economic approaches and limited to valuing increased income. In an ASARECA workshop on impact assessment, we drew attention to the value of social indicators and sociological methods reported below in documenting impacts on household food security in the dry season and on women's labor and time (*Section 4.4, Assessing the impact of bush bean varieties in Uganda*).

Contributors: R. Kirkby and S. David

Activity 4.4 Adoption and impact of bean research

Achievements:

- Former trial farmers in Malawi adopted six new bean varieties, and some report seed sales
- Just four years after introduction, two bush bean varieties accounted for 74% of bean area among a sample of adopters in Uganda
- One of these varieties now accounts for 90% of bean earnings, and some farmers report improved food security during the dry season due to increased production
- Value of the 40% of bean production marketed in sub-Saharan Africa estimated as US$226 million at farm gate and $452M retail, with 6 countries each exceeding US$ 50M retail

Adoption of modern bean varieties by Malawian trial farmers

Rationale: Preliminary information on acceptance of new bean varieties can be obtained in a cost-effective way from former trial farmers.

Method: Farmers who hosted on-farm bean varietal trials of the Malawi Bean Improvement Program (BIP) in Bembeke and Kalira from 1995 to 1997 were interviewed during the 1997-98 summer season. The trial varieties were: A 197 (Nagaga), CAL 113 (Maluwa), CAL 143 (Napilira) DRK 57 (Sapatsika) A 286 (Kambidzi) and A 344 (Mkhalira). In October 1997, just prior to the start of the 1997-98 planting season, 49 trial farmers were interviewed to assess adoption by investigating seed retention and intention to sow that season. The intention was to reinterview the same farmers after planting, but in January 1998 only 28 could be located, and results presented here focus on these farmers. The majority of farmers interviewed for both surveys were women from households of average wealth.

Results: Just over half (57%) of the 49 farmers had retained seed of one or more varieties in the season after trials ended. Nine out of 28 farmers sowed three or more varieties in summer 1997-98, one sowed two varieties and 9 sowed one variety. DRK 57 was the most widely adopted variety, followed by CAL 143, CAL 113 and A 286 (Table 41). The small numbers of farmers in the sample who conducted trials with A 344 make it difficult to assess its popularity. A 197 was least likely to be retained. Nearly all farmers interviewed (N=28) were willing to buy seed of the new varieties for a price ranging from MWK 5 to 10 per 500g. Sales outlets preferred by farmers included: agricultural offices (EPA office), the parastatal marketing organisation (ADMARC) and shops.

Farmers stopped growing a variety due to agro-environmental factors, notably wind damage (CAL 113, CAL 143 and A 197 in particular), and rotting during heavy rains (CAL 113, CAL 143, A 197 and A 286). Socio-economic factors, particularly selling seed, were next in importance. The reasons given for disliking a variety included dull color, poor marketability and small seed size. A significant number of farmers had shared seed with other farmers and sold seed, mainly to traders.

Discussion: Although the sample size was too small to allow us to draw strong conclusions about adoption trends, the study provides evidence of acceptability of all six introduced varieties. The most important reasons for disadoption were related to agro-environmental factors which do not reflect farmers' preferences. Catalysing a seed supply system which meets the needs of small-scale farmers for accessibility, price and other factors should be a principal concern of researchers. Research on seed storage methods might also boost adoption by improving farmers' ability to retain seed during the long dry season. By documenting farmers' willingness to purchase seed, this study confirms the appropriateness of the BIP's seed selling strategy.

Table 41. Adoption of six bush bean varieties by Malawian trial farmers in Summer 1997-98 (N=28).

	CAL 113 (n=28)	CAL 143 (n=27)	A 197 (n=27)	DRK 57 (n=27)	A 286 (n=27)	A 344 (n=6)
Sowed in 1997-98	9	9	6	12	8	3
Plans to sow in Winter 1998	15	11	11	17	9	3

Contributors: M. Maideni (DARTS); S. David and S. Kasozi
Collaborator: R. Chirwa (DARTS)

Assessing the impact of bush bean varieties in Uganda

Rationale: Assessing the impact of new crop varieties is complex, and requires going beyond documenting change in yield and production. Few studies examine the impact of new technologies on household income, food security and consumption patterns and gender relations.

Methods: To achieve quick adoption, nearly 400 kg of seed of the new Ugandan bush varieties K132 and K131 were sold to farmers in three communities between 1995 and 1997. Their impact was assessed through a longitudinal study using a combination of quantitative and qualitative data collection methods including a baseline survey, a food security survey and impact and adoption surveys covering 200 households.

Results: Households in both the impact and food security surveys preferred K132: 98% and 100% of the households sampled in the impact and food security samples sowed that variety in 1998 compared to 47% and 43% for K131 (Table 42). Only seven seasons after introduction, the two varieties accounted for 74% of total bean area sown on household plots by surveyed households (Table 43). Mean yields (Table 44) were high for intercropping. The yield advantage of the two modern varieties over the dominant local varieties indicated that K132 and K131 brought about significant productivity increases on farms where they were adopted.

Better-off households were more likely to grow both varieties and sowed a larger proportion of total bean area to K131. Households in the average and poor wealth categories were less likely to cultivate K131 or sowed small amounts. While impact of the new varieties was wealth neutral, the evidence nevertheless suggests that the greatest benefits went to households of average wealth. Probably due to lack of land, labor and other resources, the poorest households were unable to increase production significantly. Women farmers were as likely as men to adopt the varieties and, overall, both appear to have bettered women's lives by improving household welfare, increasing both household and personal income and reducing their labor, despite negative implications of expanded bean area and increased marital conflict reported by some households.

K132 was quickly accepted by traders, and by 1997 had captured the market held by the old Calima type K20, commanding a premium price of Ush150 to 500 per kg (US$0.12 to $0.40) in 1998, Ush 50 to 100 (US$0.04 to 0.08) above the price of K20. On average in the first season of 1998, adopters sold 92 kg of K132 at a farm-gate value of Ush 26,169 (US$21) compared with 48 kg for all other bean varieties combined, valued at Ush 17,400 (US$14). K132 provided 90% of bean earnings in the major season of 1998.

Improved food security and health were important benefits mentioned by adopters of both varieties. More farmers reported a positive impact on food security during the dry season compared with the rainy season for both varieties (Table 45). At 214 g, the median value for per capita bean consumption in September 1998, a period of moderate bean insecurity, was significantly higher than the 166g recorded among non-adopters in September 1996 for all wealth groups. On average, households growing the new bush varieties ate beans at 5 meals a week during the dry season compared to only two meals for non-adopters, and more often prepared mixture dishes (consisting of beans mixed with staple foods which require a larger quantity of beans). The impact of climbing varieties is expected to be higher than for this bush bean case.

Table 42. Adoption of bush varieties K132 and K131 in Nabongo, Uganda by 1998.

	% of impact sample (N=100)	% of food security sample (N=21)
Both varieties	45	43
K132 only	53	57
K131 only	2	0

Table 43. Area sown to specific bean varieties on household plots in Nabongo Parish, Uganda 1998 and 1994.

	Season 1998a		Season 1994a	
Variety	Area (ha)	Total (%)	Area (ha)	Total (%)
K132	19.3	62	-	-
K131	3.8	12	-	-
All modern varieties	23.1	74	-	-
Kanyebwa	5.4	17	5.2	13
K20	2.3	7	30	74
All local varieties	8.2	26	-	-
Total	31.3	100	40	100

Table 44. Comparison of mean yields of K132 and K131 with local cultivars, first season 1998, Nabongo Parish, Uganda.

Variety	Mean yield (kg/ha)	Percent increase over local cultivars	
		K20	Kanyebwa
K132	680	38 (n=14)	35 (n=48)
K131	724	79 (n=5)	69 (n=14)

Table 45. Impact of K132 and K131 on bean availability and food security by season in Nabongo Parish, Uganda (percent).

	K132 (n=98)		K131 (n=49)	
	Dry season	Rainy season	Dry season	Rainy season
Have beans in store, before had none	24	1	57	0
Eat more beans per meal	26	62	55	51
Eat beans more often	48	36	71	35
Use earnings to buy food	45	35	0	0

Contributors: S. David and S. Kasozi

Bean as a cash earner in Sub-saharan Africa

Rationale: The commercial importance of bean in Africa is generally underestimated, and the importance of bean as a cash earner is occasionally down-played by policy makers and donors.

Methods: Using information from the African bean database, and typical farmgate and retail prices for beans, country-level estimates of the quantities of beans marketed and their value were determined.

***Results*:** Common (dry) bean is the most important grain legume in Africa. It is produced primarily by small-scale farmers in sub-Saharan Africa, largely for home consumption. The market importance of beans, its importance as a source of income for many peasant farmers, and its contribution to national economies is often not recognized and underestimated. Data on crop production and marketing for 90 bean production areas in sub-Saharan Africa were used to estimate the amount and value of marketed beans Table 46).

Bean marketing is primarily in response to domestic demand especially from urban centers. Regional export markets are less important, but significant, contributors to the economies of some countries, while there is some export out of Africa, e.g. navy bean from Ethiopia and seed bean from Tanzania to Europe.

Currently, approximately 40% of bean production in sub-Saharan Africa is estimated to be marketed for a total farm-gate value of US$226 million and a retail market value of $452 million. A small proportion of bean produced is marketed (<20%) in some countries such as Rwanda and Burundi, while only a small proportion is consumed by the producing households in Ethiopia and South Africa. Kenya and Tanzania are estimated to market the most beans, with market values of greater than $30 million at the farm-gate level ($300 t^{-1}), and greater than $60 million at the retail value ($600 t^{-1}). DR Congo, Ethiopia, and Uganda sales are estimated to be between $20-30 million at farm-gate value. A greater proportion of annual bean production is marketed in Southern Africa than elsewhere.

Trends in bean marketing cannot be determined precisely due to lack of earlier baseline data. Marketing is probably increasing in importance due to the increasing urban demand for beans. The current value of marketed beans, and the probable trend towards increased marketing, raises challenges for research and development efforts to improve marketing efficiency, and to respond to the needs of consumer as well as producers.

Consumers in Africa generally have specific preferences for grain types, which vary with location, ethnic group and use. Bean grain types marketed in Kagera Region of Tanzania, for example, differ from those that producers prefer to consume. Better identification of market niches (grain types and timing of supply) is needed. Elasticity of demand for beans, and for specific grain types, is not well understood. However, consumers in Africa appear to be more open than their Latin American counterparts to trying new grain types, which generally enter the market at a low price.

The margin between the price received by the farmer and that paid by the consumer is typically 100% or more, even though beans undergo little or no processing before retail sale. The constraints to efficient marketing need to be accessed. Poor roads and long distances, delays in obtaining transport, losses due to pests and weathering, costs for prevention of losses, storage costs, inefficient farm-level buying, inefficient retail selling, and long storage time all may contribute to market inefficiency. Information on such constraints is needed to enable good *ex ante* analyses of the potential of possible interventions.

Table 46. Estimated amounts and values of bean marketed in countries of sub-Saharan Africa[1].

	Annual Production	Amount marketed	Percent marketed	Farm-gate market value	Retail market value
	'000 t yr^{-1}			*'000,000 US$ yr^{-1}*	
Angola	58.2	23.3	40	6.99	13.97
Burundi	228.1	29.8	13	8.95	17.91
Cameroon	42.6	17.0	40	5.11	10.21
Congo, D.R	221.5	88.6	40	26.58	53.16
Ethiopia	130.9	95.1	73	28.52	57.04
Guinea	17.0	6.8	40	2.04	4.09
Kenya	280.4	108.5	39	32.55	65.09
Lesotho	5.7	2.3	40	0.68	1.36
Madagascar	59.7	27.6	46	8.27	16.54
Malawi	87.5	17.2	20	5.15	10.31
Mauritius	1.6	1.5	95	0.46	0.92
Mozambique	65.3	26.1	40	7.84	15.67
Nigeria	8.1	4.6	57	1.39	2.79
Rwanda	164.1	16.4	10	4.92	9.84
South Africa	67.8	64.4	95	19.33	38.65
Sudan	37.5	14.2	38	4.27	8.55
Swaziland	1.3	0.5	40	0.16	0.32
Tanzania	207.2	102.4	49	30.73	61.46
Uganda	226.0	83.0	37	24.91	49.81
Zambia	17.4	12.6	72	3.77	7.55
Zimbabwe	17.9	11.4	64	3.42	6.85
Eastern Africa	1,297.5	452.2	35	135.7	271.3
Southern Africa	564.5	260.7	46	78.22	156.43
Sub-Saharan Africa	1,945.8	753.5	39	226.04	452.09

[1] Assumptions were made to determine these estimates as yield and market data is of poor quality for most bean production areas. Sole crop and intercrop bean yield were assumed to be 950 and 450 kg ha^{-1}, respectively. Farm-gate and retail prices were assumed to be US$300 and 600 t^{-1}, respectively.

Contributors: C. Wortmann, C. Eledu and S. David

Activity 4.5 Propose policy reforms that facilitate technology adoption

Contributions to development of harmonized seed policies in Eastern Africa

Rationale: Seed policies are set by individual countries, where they have been developed independently and in response to varying concerns at different times; some are deterrents to innovation, others appear outdated and/or do not foster regional collaboration.

Method: We are contributing experiences and evidence to a study aimed at regionally harmonizing a logical and streamlined set of national seed policies and coordinated by the Eastern and Central Africa Policy and Planning Network (ECAPAPA) of ASARECA.

Results and discussion: The study is still in progress. Suggestions raised by us and our collaborators include:

1) national varietal release procedures that encourage more rapid and flexible evaluation, more open farmer access to a wider range of materials, respond to farmer and consumer criteria rather than those perceived by researchers, enable local access to seed for niche situations, and permit farmer access to the intermediate products of participatory plant breeding;
2) a fast-track procedure for release of a variety already accepted in a neighboring country, and subsequently for unrestricted commercialization of seed across countries within the region;
3) seed sale and dissemination policies that do not discriminate against local-level farmer or community seed producers in favor of the interests of seed companies (which are generally uninterested in legume seed);
4) easier intra-regional transfer of experimental seed, including quarantine procedures that differentiate between the pathogen risks involved in intra- and extra-regional transfers;
5) a more transparent and improved system for updating crop disease risk information for quarantine purposes.

Contributors: R. Kirkby, S. David, H. Gridley, R. Buruchara
Collaborators: ECAPAPA, ASARECA, ECABREN

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 five-year strategy which started last year (see Section 1.1).

PUBLICATIONS

Refereed publications

Ampofo, J.K.O. and S.M.S. Massomo. 1998. Some cultural strategies for management of bean stem maggots (Diptera: Agromyzidae) on beans in Tanzania. African Crop Science Journal 6: 351-356.

Buruchara R. A., Pastor-Corrales, M. A and Scheidegger, U. 1999. Fusarium wilt disease caused by *Fusarium oxysporum* f. sp. *phaseoli* on a common bean cultivar, G 2333, in Rwanda and the Democratic Republic of Congo. Plant Disease 83:397.

Buruchara, R. A. and L. Camacho. 1999. Common bean reaction to *Fusarium oxysporum* f. sp. *phaseoli*, the cause of severe vascular wilt in Central Africa. Accepted in J. Phytopathology

Fischler, M. and C.S. Wortmann. 1999. Green manure research in eastern Uganda -- a participatory approach. Agroforestry Systems (in press)

Fischler, M., C.S. Wortmann, and B. Feil. 1999. Crotalaria (*C. ochroleuca* G. Don) as a green manure in maize-bean cropping systems in Uganda. Field Crops Research 61/2:97-107.

Songa, J.M. and J.K.O. Ampofo. 1999. Ecology of bean stem maggot attacking dry bean (*Phaseolus vulgaris* L.) in semi-arid areas of eastern Kenya. Int'l. J. Pest Management 45: 35-40.

Wortmann, C.S. and C.K. Kaizzi. 1998. Nutrient balances and expected effects of alternative practices in farming systems of Uganda. In: E.M.A Smaling (ed), Nutrient Balances as Indicators of Productivity and Sustainability in sub-Saharan African Agriculture. Agricultural Ecosystems and Environment 71(1/2/3):115-130.

Papers under review for refereed journals

Abate, T., A. van Huis and J.K.O. Ampofo. Pest management strategies in traditional agriculture: an African perspective. Ann. Rev. of Entomology.

Fischler, M. and C.S. Wortmann. Green manures for mid-altitudes zones in Uganda: a comparison of four leguminous species. Field Crops Research.

Kaizzi, C.K. and C.S. Wortmann. Alternative plant materials for soil fertility management: I. rates of mineralization and nutrient release. African Crop Science Journal.

Kaizzi, C.K. and C.S. Wortmann. Alternative plant materials for soil fertility management: II. crop response. African Crop Science Journal.

Pyndji, M.M., G.S. Abawi and R.A. Buruchara. Root rot pathogens of beans in the highlands of southern Uganda and evaluation of bean germplasm for resistance to root rot diseases. Plant Disease.

Pyndji, M.M., G.S. Abawi and R.A. Buruchara. Suppressing the severity and damage of root rots of dry beans in the highlands of southwestern Uganda by using locally available organic amendments. Plant Disease.

Rachier, G. O., C.S. Wortmann, J.S. Tenywa and D.S.O. Osiru. Efficiency of phosphorus acquisition by common bean (*Phaseolus vulgaris* L.) and root characteristics. African Crop Science Journal.

Ugen, M.A., C. Wein and C.S. Wortmann. Competition between dry bean (*Phaseolus vulgaris* L.) and annual weed as affected by soil nutrient availability: I. Effect on nutrient uptake. J. of Weed Science.

Ugen, M.A., C. Wein and C.S. Wortmann. Competition between dry bean (*Phaseolus vulgaris* L.) and annual weed as affected by soil nutrient availability: II. Effect on growth, bean yield and yield components. J. of Weed Science.

Book chapter

Stroud, A. and R. Kirkby. 1999. The application of FSR to technology development. In: M.P. Collinson (ed.), History and Achievements of Farming Systems Research. In press.

Other publications

Ampofo, J.K.O. 1999. IPM in traditional African Agriculture. Presented at 13th Meeting and Scientific Conference of the African Association of Insect Scientists, Ouagadogou, Burkina Faso, 19-23 July 1999.

Ampofo, JKO and S.M.S. Massomo. Participatory approaches to bean foliage beetle (*Ootheca* spp.) management in northern Tanzania. Presented at 13th Meeting and Scientific Conference of the African Association of Insect Scientists. Ouagadogou, Burkina Faso, 19-23 July 1999.

Buruchara, R.A. Effects of some organic amendments on root rots of beans. Paper presented at the International Workshop on Tropical Soil Biology: Opportunities and Challenges for African Agriculture, 16-19 March 1999. Nairobi, Kenya.

Buruchara, R.A. Seed health: a perspective from small-scale common bean (*Phaseolus vulgaris* L.) production in Eastern and Central Africa. Paper at the International Workshop to develop 10 year strategy for the Danish Institute for Seed Pathology, Denmark

David, S., R. Kirkby and S. Kasozi. 1999. Assessing the impact of bush bean varieties on poverty reduction in sub-Saharan Africa: evidence from Uganda. Paper at International Workshop on Assessing the Impact of Agricultural Research on Poverty Alleviation, San Jose, Costa Rica, 14-16 September, 1999; published as CIAT Occasional Publications Series. Kampala, Uganda.

Mahuku G and R.A. Buruchara. 1999 Manual on simple molecular methods to characterize pathogen diversity of bean pathogens. CIAT.

Mukandala, L.G. and C.S. Wortmann, 1999. Beans: a crop for food and income for Kagera farmers. In: Planning for the future: past, present and future perspectives of land use in the Kagera Region. Folmer, E.C.R., C. Schouteen and F.P. Baijukua (Eds.). Maruku ARI, Bukoba, Tanzania. Pp 98-107.

Wortmann, C.S., 1999. Nutrient budgets: understanding the problems, causes and trends of soil resource degradation. Presented at the Soil Fertility Management Workshop of the Soil and Water Conservation Society of Uganda, 5-6 May, 1999.

Wortmann, C.S. and C.A. Eledu, 1999. Uganda's Agroecological Zones: A Guide for Planners and Policy Makers. CIAT Publication.

Wortmann, C.S. and C.A. Eledu, 1999. An Agroecological Zonation For Uganda: Methodology and Spatial Information. Occasional Publication Series, No. , CIAT, Kampala, Uganda.

Wortmann, Charles S., Charles A. Eledu and Soniia David, 1999. Bean as a cash earner in sub-Saharan Africa. Bean Improvement Cooperative 42:103-104.

Wortmann, C.S., C.K. Kayuki and B.D. McIntyre, 1999. Green manure, nitrogen, soil water and yield of subsequent crops. Agronomy Abstracts.

Wortmann, C.S., L. Lubanga and C. K. Kaizzi, 1999. Integrated nutrient management for bean production in eastern Africa. Presented at the 17th Soil Science Society for East Africa Conference, 6-10 Sep., 1999.

Wortmann C.S., L. Lubanga and C. K. Kaizzi, 1999. Integrated bean plant nutrition in Africa: genetic improvement and soil fertility research. Presented at the Bean Improvement Cooperative Meeting, 8-12 Nov. 1999.

WORKSHOPS AND CONFERENCES

African Highlands Ecoregional Programme (AHI) Steering Committee, 11-15 January 1999

Five-year planning and priority setting workshop for the Ugandan National Bean Programme. Kampala, Uganda, 25 – 28 January 1999.

What works in development? IDRC stakeholders workshop for Eastern and Southern Africa, Nairobi, Kenya, 2-5 February 1999.

ASARECA-Donors-Networks Meeting, Entebbe, Uganda, 8-12 February 1999.

Stakeholder meeting of the Agricultural Technology Development and Transfer Project. ISAR/IITA, Butare, Rwanda, 2-5 March 1999.

Annual Plenary Session of Special Program for African Agricultural Research (SPAAR) and the Forum for Agricultural Research in Africa. Gaborone, Botswana, 8-12 March 1999.

International workshop on tropical soil biology: opportunities and challenges for African agriculture. TSBF Nairobi, Kenya, 16-19 March 1999.

Improving integrated nutrient management practices on small-scale farms in Africa: General Stakeholders' Planning Workshop, CIAT/TSBF/IFDC, Kampala, Uganda, 23-26 March 1999.

African Highlands Ecoregional Programme (AHI) working group on participatory research and systems intensification, CIAT/ILRI/ICRAF, Kampala, Uganda, 30-31 March 1999.

African Highlands Ecoregional Programme (AHI) Technical Support Group Meetings, Kabale (Uganda) 26-28 April and Lushoto (Tanzania) 20-23 September 1999

Pan-African bean entomology working group and monitoring tour, 1-14 May 1999.

Meeting of Minds: CGIAR consultative meetings for Africa, ILRI (Nairobi) 10-12 May and WARDA (Abidjan) 1-3 September 1999.

Improving integrated nutrient management practices on small-scale farms in Africa: Kenya Stakeholders' Workshop, TSBF/KARI, Kakamega, Kenya, 8-9 June 1999.

PABRA BILFA working group meeting, Arusha, Tanzania, 6-8 June 1999.

PABRA soil fertility working group meeting, Arusha, Tanzania, 9-12 June 1999.

First PABRA pan-African breeders' working group meeting, University of Nairobi, Kenya, 14 17 June 1999.

PABRA scientific writing retreat (for agronomists), CIAT Arusha, 14-22 June 1999.

Participatory Research for Agro-Ecosystems Management (PRIAM) monitoring tour, western Kenya, 5-9 July 1999.

13th Meeting and Scientific Conference of the African Association of Insect Scientists, Ouagadogou, Burkina Faso, 19-23 July 1999.

Improving integrated nutrient management practices on small-scale farms in Africa: Uganda Stakeholders' Workshop (NARO/CIAT), Mukono, Uganda, 19-20 August 1999.

DARTS national annual grain legumes programme planning meeting, Lilongwe, Malawi, 9-10 September 1999.

Improving integrated nutrient management practices on small-scale farms in Africa: Tanzania Stakeholders' Workshop (DRD/CIAT), Lushoto, Tanzania, 27-28 September 1999.

International Workshop on Assessing the Impact of Agricultural Research on Poverty Alleviation, San Jose, Costa Rica, 14-16 September, 1999

African Highlands Ecoregional Programme (AHI) Working Group on IPM, Kampala, Uganda, 4-5 October 1999

African Highlands Ecoregional Programme (AHI) workshop on monitoring and evaluation. ICRAF, Nairobi, 11-13 October 1999.

African Crop Science Society conference, Casablanca, Morocco, 11-14 October 1999.

African Highlands Ecoregional Programme (AHI) working group on participatory research and intensification of production systems, ICRAF, Nairobi, Kenya, 1 November, 1999.

African Highlands Ecoregional Programme (AHI) stakeholders' seed workshops, Lushoto (Tanzania) 26-27 October and Kabale (Uganda) 10-11 November 1999.

ASARECA/ECART regional workshop on impact assessment. Entebbe, Uganda, 16-19 November 1999.

MANAGEMENT COMMITTEE MEETINGS FOR BEAN NETWORKS

Eastern and Central Africa Bean Research Network (ECABREN), Annual Meeting of Steering Committee, Arusha, Tanzania, 22-26 February, 1999.

Pan-Africa Bean Research Alliance (PABRA), Annual Meeting of Steering Committee, Kisumu, Kenya, 20-22 April 1999.

Entomological research methods. Training Attachment, CIAT Arusha, June 1999.

ASARECA Committee of Directors, Annual Meeting with Networks, 7-9 September 1999.

SADC Bean Research Network, Annual Meeting of Steering Committee, Potchefstroom, South Africa, 20-21 October 1999.

SACCAR Technical Committee, Lusaka, Zambia, 15-16 November 1999.

TRAINING EVENTS

Multiple constraints resistance breeding for new NARS bean breeders. PABRA/University of Nairobi, Kenya, 24 May to 12 June 1999.

Practical training of young entomologists, CIAT, Arusha, May-June 1999.

Simple molecular methods to characterize bean pathogen diversity. CIAT, Kawanda, Uganda, 8-11 June 1999.

Experimenting with farmers. ICRAF/CIAT/AHI, Nairobi, 28 June to 2 July 1999.

Dissemination of climbing bean technologies in Rwanda: training workshop for extension and farmers, ISAR, Butare, Rwanda, 20-25 September 1999.

Agricultural Research Management for NARS Program Leaders in Sub-Saharan Africa (French and English courses). Ouagadougou (Burkina Faso), 8-21 August and Mhlume, Swaziland, 18-31 October 1999. ISNAR.

DONORS

Donor	Project	Duration of current funding
ICRAF (donor consortium to AHI)	Ecoregional research on IPM, seed systems and systems intensification	1995-98; 1998-99
CIDA (Canada)	Pan-Africa Bean Research Alliance	1996-2000
DFID (UK)	Participatory Plant Breeding	1998-2001
ICRISAT (from USAID)	Seeds of Freedom (Angola)	1997-99
SDC (Switzerland)	Pan-Africa Bean Research Alliance	1998-2001
	Associate Expert in Agronomy (Tanzania)	1998-2000
The Rockefeller Foundation (USA)	Publication of Bean Atlas	1996-98
	Social Science Research Fellowship	1996-99
USAID (USA)	Eastern and Central Africa Bean Research Network	1997-98; 1998-2002
	Study of Seed Relief in Kenya	1997-99

Notes:

ECABREN: activities reported here are supported financially by the member Governments of ASARECA, and by CIDA, SDC and USAID as the donors to PABRA.

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

**Adamo, Abra, MA, Sociologist (stationed in Nazreth, Ethiopia)
*Aggarwal, Vas Dev, PhD, Plant Breeder (stationed in Canada)
**Amede, Tilahun, PhD, Systems Agronomist (AHI) (stationed in Areka, Ethiopia)
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)
**Esilaba, Anthony, PhD, Participatory Management of Soil Fertility (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)
Hollenweger, Ursula, MSc, Agronomist (stationed in Arusha, Tanzania)
Kirkby, Roger, PhD, Agronomist, Project Manager (stationed in Kampala, Uganda)
Mukishi, Pyndji, PhD, Plant Pathologist, ECABREN Coordinator (stationed in Arusha, Tanzania)
**Sanginga, Pascal, PhD, Sociologist (AHI) (stationed in Kabale, Uganda)
*Wortmann, Charles, PhD, Crop/Soil Productivity Specialist, Site Coordinator (stationed in Kampala, Uganda)

Research assistants

Bashieja, Henry, Laboratory Technician (Pathology) (stationed in Kampala, Uganda)
Eledu, Charles, MSc, Research Associate, GIS (stationed in Kampala, Uganda)
Kasozi, Sarah, BSc, Research Assistant, Sociology (stationed in Kampala, Uganda)
Lyimo, Jackson, Field Assistant (stationed in Arusha, Tanzania)
Massomo, S.M.S, BSc. Research Assistant (on unpaid study leave from Arusha, Tanzania)
**Mohamed, Daima, Field Assistant (IPM) (stationed in Arusha, Tanzania)
Nalukenge, Grace, Dip., Field Assistant (Systems) (stationed in Kampala, Uganda)
Suleiman, Sebuliba, Field Assistant (Breeding) (stationed in Kampala, Uganda)

Administrative staff

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

* Left CIAT during 1998
** Joined during 1998

INSTITUTIONAL ABBREVIATIONS

Africa2000	Africa2000 Network (of the United Nations)
AHI	African Highlands Ecoregional Programme (led by ICRAF)
ARC	Agricultural Research Corporation, Sudan
ARC/GCRI	Agricultural Research Council, Grain Crops Research Institute, South Africa
ASAL	Arid and Semi-Arid Lands Program, Kenya
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AT (Uganda)	Appropriate Technology Uganda
AU	Alemaya University, Ethiopia
BMZ	German Federal Ministry for Economic Cooperation and Development
CARE	(International NGO in Ethiopia, Rwanda, Uganda)
CIDA	Canadian International Development Agency
CIE	(private company marketing seed in Uganda)
CIP	International Potato Center
CMRT	Crop Management Research Training Course, Egerton University, Kenya
CRS	Catholic Relief Services
CRSP	Collaborative Research Support Project (of USAID)
DARTS	Department of Agricultural Research and Technical Services, MoA, Malawi
DFID	Department for International Development (UK)
DR Congo	Democratic Republic of Congo
DRD	Department of Research and Development, Ministry of Agriculture, Tanzania
DRSA	Extension Service, Ministry of Agriculture, Rwanda
EARO	Ethiopian Agricultural Research Organization
ECABREN	Eastern and Central Africa Bean Research Network
ECAPAPA	Eastern and Central Africa Policy and Planning Network of ASARECA
FARM Africa	Food and Agricultural Research Management (an international NGO)
FARMESA	An FAO Project in Eastern and Southern Africa
FHI-Congo	Food for Hunger International, DR Congo
FOFIFA	Centre National de la Recherche Appliqué au Développement Rural, Madagascar
FOSEM	Food Security and Marketing for small holder farmers
GO	Governmental organization
GoM	Government of Malawi
ICRAF	International Centre for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
IDEA	Investment for the Development of Export Agriculture, a Ugandan project
IITA	International Institute of Tropical Agriculture
IFDC	International Fertilizer Development Center, Africa Regional Program, Togo
ILRI	International Livestock Research Institute
INERA	Institut National des Etudes sur la Recherche Agronomique, DR Congo
INIA	Instituto Nacional de Investigacao Agricola, Mozambique
ISAR	Institut des Sciences Agronomiques du Rwanda
KARI	Kenya Agricultural Research Institute
MoA	Ministry of Agriculture
MU	Makerere University, Uganda
NARI	National agricultural research institute

NARO	National Agricultural Research Organisation, Uganda
NARS	National agricultural research system
NGO	Non-governmental organization
PABRA	Pan-Africa Bean Research Alliance
PNL	Programme National Légumineuses, DR Congo
REDSO	Regional Economic Development Services Office, 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
SAFA	Sustainable Agriculture Farmers Association, NGO operating in Uganda
SARI	Selian Agricultural Research Institute, DRD, Tanzania
SENASEM	National seed company, DR Congo
SNV	National extension service, DR Congo
SPAAR	Special Program for African Agricultural Research
SDC	Swiss Agency for Development and Cooperation
SWNM	Soil, Water and Nutrient Management, a system-wide program of the CGIAR
TPRI	Tropical Pesticides Research Institute, DRD, Tanzania
TSBF	Tropical Soil Biology and Fertility Program
UNIBU	Université National du Burundi
UoN	University of Nairobi
USAID	United States Agency for International Development
USP	The Uganda Seeds Project, Ministry of Agriculture
WEP	Women Empowerment Program
WVI	World Vision International