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PROJECT IP-2

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

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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PROJECT IP-2: BEANS IN SUB-SAHARAN AFRICA

PROJECT DESCRIPTION

Objective: To improve in a sustainable manner the nutrition and food security of a significant part of the rural population of Eastern and Southern Africa, by deploying gene pools and sustainable production technologies developed in close collaboration with national research institutions and farmers.

Outputs:
1. Enhanced productivity, food security and nutrition, and income of farms on which beans are an important component.
2. Pilot communities become better managers of their resources.
3. Wider impact achieved across Africa through strategic alliances and the use of sustainable approaches to seed dissemination.
4. The institutional base of PABRA is consolidated, with greater responsibility being taken by the regional networks, wider partnerships, and efficient pan-African collaboration.

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:

2001	Poor people, including women, in at least four major bean-producing countries accessing new varieties rapidly thorough sustainable low-cost seed systems.
2002	At least three national research systems in important producer countries generate and distribute elite lines, derived from their own crossing programs for improved yield and multiple constraints resistance, to sustain cultivar development in PABRA networks.
2003	Farmers adopted new agronomic practices, including erosion control and use of green manure.

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, IITA, CIP, TSBF and national partners in the African Highlands Ecoregional Program (AHI). *Training in breeding and IPM:* Bean/Cowpea CRSP, IPM CRSP, NRI and ICIPE. *Diffusion of new technology:* NGOs, churches, relief and government agencies, entrepreneurs, and universities in the Netherlands, Switzerland, UK and USA.

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

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

Project Objective: **To improve in a sustainable manner and in close collaboration with national research institutions the nutrition, food security and incomes of a significant part of the rural population of Eastern and Southern Africa**				
1. Household food security and nutrition of women, children and the rural poor is improved	2. More income from beans	3. Pilot communities become better managers of their resources	4. Wider impact achieved across Africa	5. The institutional base of PABRA is consolidated
1.1 Develop acceptable bean varieties rich in protein and micro-nutrients	2.1 Improve understanding of local, regional and international bean markets	3.1 Catalyze improved organizational capacity in pilot communities	4.1 Reinforce sustainable approaches to decentralized seed systems	5.1 Support wider partnerships within ECABREN through a more integrated network approach
1.2 Exploit genetic diversity of bean to address marginal environments	2.2 Develop new bean varieties that address these market demands	3.2 Support farmers' experimentation and application of technical skills	4.2 Equip farmers for selecting among options for knowledge-intensive technologies	5.2 Enhance regional coordination and effectiveness within SABRN
1.3 Make available more options for managing soil productivity and bean pests	2.3 Implement strategies that enable women also to benefit from increased household incomes	3.3 Develop an approach to strengthen community capacity to invest their potentially higher income in alleviating poverty	4.3 Scale up proven technologies through strategic alliances	5.3 Catalyze efficient pan-African collaboration in research and information exchange
		3.4 Assist farming communities to protect their environmental resources	4.4 Assess and document impact at household and country levels	5.4. National and regional specialists take more responsibility within PABRA
		3.5 Support women's empowerment and leadership at the community level		5.5. Improve the research and dissemination capacities of scientists and institutions

Project Logframe

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To improve in a sustainable manner and in close collaboration with national research institutions the food security, nutrition and incomes of a significant part of the rural population of Eastern and Southern Africa	Family production, income distribution and nutrition in important bean growing areas.	National and regional statistics. Partners' technical reports. Annual reports.	Peace, stability and a favorable economical environment
Purpose To improve bean productivity and commercialization, and resource management in bean producing communities, through adoption of sustainable production technologies, approaches and decision tools developed in close collaboration with national research institutions, farmers and other partners	Regional networks fully devolved to local management, with CIAT participating as a research partner. Varieties resistant to multiple stresses occupying about 200,000hectares (5% 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. Bean varieties and soil / pest management practices that enhance household food security and nutrition of women, children and the rural poor.	• Improved populations/lines available to NARS and networks. • Varieties tolerant to intransigent constraints. • Low-cost soil amendment methods available.	Annual reports of PABRA, ECABREN and SABRN.	Regional bodies and national governments continue to give priority to bean.
2. Technologies and improved market opportunities that raise household incomes from beans.	• Breeding materials of market types available. • New varieties appear in local/regional markets.	Networks and national program reports.	Sources of resistance exist and adequate germplam support received from Project IP-1.
3. Pilot communities become better managers of their resources.	• Publications on decision support tools. • Participating communities organize own problem diagnoses and action plans.	Annual reports of PABRA, ECABREN and SABRN.	Networks bring in non-traditional partners.
4. Wider impact from bean technologies across Africa.	• Poor people including women in at least four countries access new varieties rapidly through sustainable low-cost seed systems by 2001.	Adoption survey reports.	
5. The institutional base of the Pan-African Bean Research Alliance (PABRA) is consolidated.	• Wider partnerships within networks. • National specialists take responsibility. • Strategic alliances with NARS and NGOs.	Annual reports of PABRA, ECABREN and SABRN.	

Highlights in 2001

This year we implemented a new project framework. Although main outputs are differently expressed and the organisation of activities is reordered, only one output is completely new. There has been a fair degree of continuity in activities and outputs, but the changes reflect gradually shifting emphases over the past two years and bring the project logframe into harmony with the various donor projects upon which IP-2 depends.

Regional breeding program (through strategic alliances, e.g. with the University of Nairobi) is making energetic progress in crosses to improve the main bean market classes. At the same time, ECABREN's decentralised approach to leadership in breeding has stimulated a great increase in the number and range of crosses being made by national programs. Regional trials of the SABRN bean network also identified further potential varieties for direct national releases of several useful grain types. These developments, and our advocacy of a multiple-release strategy by NARS, appear likely to maintain the rapid flow of new varieties that require cost-effective seed dissemination systems. In the general absence of commercial seed companies for beans, for some years we and our collaborators have placed considerable importance upon developing low-cost dissemination approaches to achieve high adoption rates.

Consequently, our milestones this year were focused around the wider use of sustainable low-cost seed systems that reach poor people, including women, in at least four major bean-producing countries. The implicit impact target has been surpassed – in that at least 7 countries are now routinely applying the methods we developed originally in pilot studies and strategic action research. With over 100 tons of seed of new bean varieties being disseminated in small packs by these countries, not less than 250,000 families were the direct new beneficiaries of these programs in 2001 – without counting [the larger number of] those benefiting from secondary multiplication by NGOs and farmers. However, economic sustainability of these efforts is still elusive. We have been following up on the smaller number of cases of farmer seed enterprises, and finding that many fail to reach a critical size to create widespread impact or to develop their markets. This suggests the need for a multi-commodity approach to commercial seed production (less dependence upon beans alone), stronger links with a set of commodity programs at a research station that offer a more regular flow of new products, and training in business skills.

Massive impact has been achieved from the introduction of root rot resistant bush and climbing bean varieties, in Western Kenya and elsewhere. Farmers in areas affected by root rots have changed to smaller-seeded and more tolerant bean varieties -- even growing new black-seeded varieties because tolerant varieties have been difficult to develop in popular grain types. Our strategic research, in collaboration with IP-1, has focussed on understanding the variation in both the pathogen and the host. This study has demonstrated the complex nature of the genus *Pythium*. Twelve *Pythium* species, including putative new species and two potential biological control agents, were identified from 50 East African isolates by sequencing the ITS and ITS2 regions of the ribosomal DNA; characterization by this method gave better results than using RFLPs. Forty-six isolates of *Fusarium solani* f. sp. *phaseoli* , the other main causal agent of root rots, were characterized into two broad groups using cultural criteria, pathogenicity and AFLPs;

two primers that can distinguish the two groups were designed, synthesized and evaluated. Of 500 red mottle and red kidney lines evaluated for resistance to *Pythium* root rots, 25% appeared promising, and 42 F_5 progenies derived from multiple disease resistance crosses also gave promising reactions against this root rot. This success rate is considerably higher than in previous years, and suggests that 5 years' sustained effort to address this increasingly important problem are paying off.

Declining soil fertility is one of Africa's greatest challenges. The problem affects production in many bean-growing areas and, in the face of low adoption of soil improving technologies developed in a traditional top-down manner, warrants the participatory research expertise that we have acquired. An Ethiopian farmer research group in one of our action research sites rapidly became enthusiastic about soil conservation once their testing of new forage species along contours led to increased production of milk and manure; farmers quickly increased the number of forage-producing contour bunds and started spontaneously testing other ways to intensify their systems so as to take advantage of the extra manure. Their still poorer neighbors, who lack livestock, observed these developments and preferred evaluating legume cover crop species for soil fertility improvement.

Formal experiments were unnecessary for evaluating some of these innovations, and the role of researchers switched into observing, understanding and documenting farmers' behavior in soil improvement and systems intensification. Out of this work has come this year a set of decision tools for integrating fertility-restoring legumes into niches within low-input highland farming systems. Introducing mixtures of early and late maize varieties created a promising new niche for incorporating legume cover crops into the less intensive and more degraded system in farmers' outfields. Developing a farmer typology also proved important in designing indicators for natural resource management that were sensitive to levels of resource endowment.

Progress Report 2001

Output 1. Bean varieties and soil / pest management practices that enhance household food security and nutrition of women, children and the rural poor.

Activity 1.1 Develop acceptable bean varieties rich in protein and micro-nutrients

Assess nutrient status of African germplasm

Achievements:

- A successful start in identifying a wide range of variation among current African bean varieties in concentrations of zinc, iron and protein, and offering immediate potential for test promotions and feedback to bean breeders.

Rationale: Iron and zinc deficiency in diets is widespread in Sub-Saharan Africa, affecting mainly the poor and particularly pregnant women and children. Micronutrient rich cultivars of common bean offer a unique alternative to supplementation for alleviating these deficiencies in Africa because bean is so widely grown and consumed by medium and low income households and is cheaper than animal sources of micronutrients. This activity, developed in close consultation with related work by CIAT Headquarters (IP-1), represents our first initiative on iron and zinc concentration among bean cultivars in East and Central Africa as part of larger efforts to develop micronutrient-dense cultivars. We are also checking trends in protein content.

Methods: Bean samples were obtained from Democratic Republic of Congo (DR Congo), Ethiopia, Kenya, Rwanda, Sudan and Uganda. They included over 70 locally popular cultivars, landraces or selections from segregating populations. The samples were washed with double distilled water, dried overnight in an oven and ground in a stainless steel hammer mill. To compare mineral recovery levels, samples were prepared either by ashing followed by acid dissolution of the ash, or digestion with a mixture of perchloric and nitric acid prior to elemental analysis (Zarcinas et al, 1987; AOAC, 1981). Elemental analysis was done by atomic absorption technique (AAS). Zinc concentration was determined by wet digestion only. Nitrogen was determined by standard Kejdhal digestion.

Results and Discussion: Zinc concentration varied from 12 to 62 ppm with a mean of 31 ppm. These results are comparable to analyses of 1500 varieties in Colombia (mean of 35 ppm with a high of 52 ppm), and in both analyses Vunikingi had a concentration of 35 ppm (Table 1). The top five varieties for zinc were VNB 81010, MLB-49-98A, LIB 1 and Kiangara and A 620, which had 38 ppm and above. All others showed rather ordinary levels.

Iron concentration ranged from 147 to 68 ppm for wet digestion and 131 to 59 ppm by ashing (Table 1). Means of 96.1 and 94.1, respectively, are 55 ppm higher than reported in Colombia, where the highest value was 102 ppm. This may be due to influences of soil type and location (and perhaps other environmental influences). Effect of environment was clearly demonstrated by Beebe et al (2000), who concluded however that superior mineral content of a line selected at one experimental site would not be lost when the materials are planted at other sites. The most promising cultivars for iron content are AND 620, GLP 2, MLB-49-98A, VCB 87013, G59/1-2, Naindeky and Kiangara with more than 100 ppm. The results of wet digestion and ashing were highly correlated (r=0.8). AND 620, MLB-49-98A (the black seeded root resistant cultivar popular in western Kenya) and Kiangara combined high levels of both zinc and iron and represent three seed types consumed in the region.

Table 1. Iron and zinc concentration in selected African bean cultivars, landraces and lines.

Cultivar	Origin	Growth habit	Seed colour	Seed size [1]	Wet digestion (ppm)		Ashing (ppm)	Protein (%)
					Zinc	Iron	Iron	
MLB-49-98A	DR Congo	bush	black	S	55	124	131.1	-
Maharagi Soja	DR Congo	bush	yellow	S	23	97	107.7	20.1
VCB 87013	DR Congo	climber	white	S	25	122	109.6	19.4
Ituri Matata	DR Congo	bush	white	L	35	87	87.0	16.2
Vunikingi	Rwanda	climber	brown	S	35	88.5	76.7	20.1
MLV-6-90B	DR Congo	climber	brown	S	26	96	96.0	18.8
M'Mafutala	DR Congo	bush	brown	S	28	95	102.4	-
VNB 81010	DR Congo	climber	black	S	62	77	70.1	-
GLP 24	Kenya	bush	red	L	35	93	99.2	18.0
GLP 1127	Kenya	bush	mwezi moja	L	29	91	88.4	
GLP X 92	Kenya	bush	pinto	M	16	68	68.5	16.3
G59/1-2	DR Congo	climber	brown	L	24	106	115.5	-
Kiangara	DR Congo	climber	brown	S	44	104	117.9	20.1
M211	DR Congo	climber	pinto	S	12	94	92.5	
VCB 81012	DR Congo	climber	brown	M	32	86	74.9	26.4
Simama	DR Congo	bush	calima	L	13	78	68.1	19.4
AND 10	DR Congo	climber	sugar	L	30	80	90.0	18.9
LIB 1	DR Congo	climber	yellow	M	52	94	105.0	20.8
Naindeky /Naidekondo	DR Congo	bush	white	S	30	106	105.2	21.4
GLP 2	Kenya	bush	calima	L	28	124	115.1	16.2
AND 620	DR Congo	bush	calima	L	38	147	121.8	20.4
M'Sole	DR Congo	bush	brown	S	22	99	61.1	22.2
Nakaja	DR Congo	bush	brown	S	20	74	96.0	20.1
Kirundo	DR Congo	bush	yellow	L	31	76	59.2	17.1
Awash Melka	Ethiopia	bush	white	S	28		65.0	25.3
K 131	Uganda	bush	carioca	S	31		32.0	25.0
Awash-1	Ethiopia	bush	white	S	24		58.0	23.0
Gisenyi	Rwanda	climber	cream	L	23		57.0	22.6
Sarrag	Sudan	Semi-climber	white	M	23		36.0	22.4

[1] Seed size: L = Large; M = Medium; S = Small

Cultivars with high protein levels were VCB 87012, Awash Melka, K131 and Awash (Table 1). Protein concentration varied from 13 % in Roba-1 to 26.4% in VCB 87012. This indicated the potential, indeed the need, to pay more attention to protein improvement in beans for Africa. The results indicate that considerable potential exists for improving the micronutrient and protein nutrition by promoting consumption of bean cultivars rich in these nutrients, and improving popular bean cultivars that are low in these nutrients.

Contributor: P. Kimani (CIAT/ECABREN/University of Nairobi).
Collaborators: E. Karuri and S. Mwaura (Dept of Food science and Nutrition, University of Nairobi); S. Beebe.

Activity 1.2 Exploit genetic diversity of bean to address marginal environments

Achievements

- Successful collaborative research to identify lines tolerant to low soil nitrogen and phosphorus now complemented by evidence for adequate heritability of these traits.

- Twelve *Pythium* species, including putative new species and two potential biological control agents, were identified from 50 isolates from East Africa by sequencing the ITS and ITS2 regions of the ribosomal DNA; characterization by this method gave better results than using RFLPs.

- Forty-six isolates of *Fusarium solani* f. sp. *phaseoli* , the other main causal agent of root rots, were characterized in two broad groups using cultural criteria, pathogenicity and AFLPs; two primers that can distinguish the two groups were designed, synthesized and evaluated.

- Of 500 red mottle and red kidney lines evaluated for resistance to *Pythium* root rots, 25% appeared promising, and 42 F5 progenies derived from multiple disease resistance crosses also gave promising reactions against this root rot.

New lines tolerant to low soil P identified from segregating populations

Rationale: Declining soil fertility significantly contributes to farmers' low bean yields in many African countries. Factors include low availability of soil P, N and acidity with associated aluminum and manganese toxicity. Experiences during the first two cycles of the collaborative BILFA project, focused on screening germplasm separately for these three constraints, showed that tolerance was often found in less popular seed types and growth habits. With a clearer perception of preferences from market studies, BILFA-III focused on large seeded lines and segregating populations with multiple trait combinations, and BILFA-IV has emphasised low P.

Methods: BILFA-IV consisted of 300 lines and segregating populations in five main market classes. Sowing was at the low P site at KARI Kakamega (annual rainfall 1935 mm, mean temperature 20.6^0 C; P level 6-8 ppm) during long rains season of 2001. GLP 585 (Red Haricot) variety was planted in each block as a susceptible local check. No phosphatic fertilizer was applied during evaluation. Nitrogen was applied in the form of calcium ammonium nitrate (CAN 26%) in split applications before flowering. Selection was made on the basis of vigor and pod load on a scale of 1 (excellent) to 9 (very poor).

Results and Discussion: A clear distinction between tolerant and susceptible genotypes could be made because of very favourable field conditions at the test site. Selections made from each market class are shown in Table 2. Pintos appeared more susceptible to low P conditions than other seed types, with the best six progenies of pintos having a rating of 6. Most selected genotypes were of Type I (determinate) or II (erect indeterminate) growth habits. Entries were also screened for tolerance to acid soils in Mulungu (DR Congo) and at Selian (Tanzania) for tolerance to low N, for which results are pending.

Table 2. Performance of genotypes under low P soil conditions at Kakamega, Kenya, 2001A.

Market class	Very tolerant[x]	Tolerant	Susceptible	Most promising lines/populations[y]
Red kidneys	5	31	79	AND 1055-1, NR 12633-3-1, NR12634-1C-1, NM 12806-2A-1, RWR 1742-1
Red mottled	4	22	74	NR 12639-4D-4, NR 12631-3D-1, NR 12632-13A-1, NR 12806-2A, NR12631-1A
Small red	4	3	16	NR 12639-4E-4, NR12633-4H-8, NR 12632-12, NR 12632-8-1
Navy	3	18	22	AFR 676-1, FEB 187, AFR 707
Pinto	0	6	13	KS 55-1-1, KS 55-2-1, KS 84-2-1

[X] 1-3 =Very tolerant, 4-6= tolerant and 7-9=susceptible
[Y] NR, KS and NM- Codes for populations

Contributors: G. Rachier (KARI-Kakamega); P. Kimani (CIAT/ECABREN/Univ. of Nairobi).
Collaborators: All national scientists collaborating in BILFA through ECABREN/SABRN.

Inheritance of tolerance to low soil P availability and transfer to red mottled cultivars.

Rationale: Genetic variation for ability to utilize soil phosphorous in bean has often been found in germplasm of unpopular seed types, whereas the popular red mottled cultivars perform poorly under low soil P conditions. An understanding of the mode of inheritance of this trait can facilitate its transfer in breeding programs. In Eastern Africa, the BILFA working group identified lines tolerant to low soil P in 1999, and we studied inheritance in three of these lines.

Methods: Eight parents were crossed in diallel, producing 28 F_1 progenies. Three of the parents (CAL 143, CIM 9314-36 and AFR 708) had confirmed tolerance to low phosphorous and low soil pH. The other five were susceptible but well adapted cultivars. These included advanced breeding lines selected for multiple disease resistance - a large seeded sugar (E5) and a large red mottled line (E8). GLP-2 is a popular old cultivar; SCAM 80-CM/15 is a medium, red mottled cultivar resistant to bean stem maggot and root rots released in Kenya (as KK8); and CAL 96 is a large red mottled cultivar released in Uganda as K132. The 36-diallel progenies were planted out at Kabete (1860 masl) and Thika (1500 masl) under no stress and high-P stress conditions, achieved by application 100 and 0 kg P ha-^{1}, respectively, in soils considered deficient in P. The GCA: SCA ratio was calculated as suggested by Baker (1978). Wortmann et al. (1999) concluded that the best selection criterion for bean performance under P limiting conditions was grain yield.

Results and Discussion: Differences in grain yield among the genotypes were highly significant. Mean yield was 1154 and 1458 kg ha-^{1} for P stressed and non-stressed plots at Kabete, and 1015 and 1325 kg ha-^{1} respectively at Kabete. This indicated that P level was a yield limiting factor at both sites but that stress level was moderate. Combining analysis showed that the both general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant.

GCA: SCA ratios of 0.78 and 0.77 under low P, and 0.73 and 0.72 under high P levels, are a strong indication that the low P tolerance is to a great extent controlled by additive genes, and breeding for this trait should be possible when parents with known tolerance are included. As general combing ability effects for SCAM 80-CM/15, CIM 9314-36 and CAL 143 were positive and significant under low P fertility at the two locations, these genotypes would be expected to transmit low P tolerance to their progenies. Positive GCA effects for AFR 708, CIM 9314-36 and CAL 143 in high P fertility conditions at Thika indicate that these lines would transmit genes for increased P utilization and would be expected to respond to increasing soil P levels. Tolerance to low P was associated primarily with basal root length and also with root dry weight.

Seed subsequently obtained from the 28 F_2 populations in season 2001A was used to constitute the BILFA V nursery which is being evaluated and selected for P tolerance at Kakamega (Kenya), for soil acidity, Al and Mn toxicity at Mulungu (DR Congo) and low N at Selian (Arusha, Tanzania) in 2001B.

Contributors: P. Kimani (CIAT/ECABREN/Univ. of Nairobi); J. M. Kimani (Univ. of Nairobi).
Collaborators: L. Lubanga (INERA Mulungu) and BILFA working group.

Inheritance of tolerance to low soil N stress

Rationale: Inadequate soil nitrogen availability is estimated to cause annual bean crop loss of 679,000 tons, and resource poor farmers do not normally apply fertilizers to bean crops. One strategy to improve the genetic adaptation of beans to low N soils is to develop genotypes capable of making more efficient uptake and use of N. The nature of genetic control for the low soil N tolerance lines identified by the BILFA working group has not been studied until now.

Methods: Elite lines known to be tolerant to low N soils were crossed with well-adapted popular cultivars susceptible to low N, in an 8 x 8 diallel scheme. AFR 708, CIM9314-36 and CAL 143 were selected for low soil N tolerance while E5, E8, GLP-2, SCAM 80cm/15 (KK8) and CAL 96 (K132) were the well-adapted varieties. The 28 F_1 progenies and their parents were planted out in two experimental locations (Kabete and Thika) in a split plot design with three replicates. N levels were the main plots and genotypes, the subplots. Levels of applied N were 0 and 120 kg

N ha^{1}. Soil N, at 0.19% for Kabete and 0.34% ($N-NO_3$, trace for NH_4-N) for Thika, were deficient. P deficiency at both sites was corrected by applying 100 kg P ha-^{1} to all plots. Grain yield was used as an indicator for tolerance to low N stress.

Results and Discussion: Genotypic differences for grain yield were highly significant. Mean yields were 1120 kg ha-^{1} (-N) against 1346 kg ha-^{1} (+N) at Kabete, and 1036 kg ha-^{1} (-N) against 1344 kg ha-^{1} (+N). SCAM 80-CM/15, CAL 143 and AFR 708 were the best yielding parents under low N stress at Kabete but not at Thika. General combining ability (GCA) was highly significant for all treatments, except at Thika under no N stress. Specific combining abilities were important except for Thika under no N stress conditions. The GCA: SCA ratio was greater than 0.75 except, at Thika for no N stress plots where it was 0.54. This indicated that tolerance to low stress was largely due to additive gene effects. CAL 143, CIM 9314-36, SCAM 80-CM/15, and CAL 96 were the best general combiners at both locations under low N stress. GCA effects for CAL 143, CIM 9314-36 were significant.

The high GCA: SCA ratio implies that the additive genetic component was predominant in controlling tolerance to low N stress, and the medium to large seeded materials CAL 143, CIM 9314 and SCAM 80-CM/15 can be useful parents in breeding for tolerance to low soil N. Our earlier efforts to use small seeded parents from BILFA II were frustrated by high incidence of hybrid dwarfism in crosses between small seeded fertility tolerant and the susceptible but popular large seeded parents, a problem that requires use of bridging parents.

Contributors: P. Kimani (CIAT/ECABREN/Univ. of Nairobi); J. M. Kimani (Univ. of Nairobi).
Collaborators: BILFA working group.

Epidemiology of bean root rots: Characterization of Pythium and Fusarium spp associated with bean roots in Uganda

Rationale: In East and Central Africa, where bean root rots are a serious problem, soil inoculum is one of the key factors thought to influence incidence and severity. Some management technologies under consideration are intended to reduce soil inoculum to below economic threshold levels. But evaluation of such technologies, usually based on disease severity alone, is not always a good indicator of soil pathogen population because it can be influenced by environmental or host characteristics. Tools and procedures are needed for quantifying pathogen populations to enable assessment of root rot management options. However, characterization of the main root rots (Pythium and Fusarium spp.) pathogenic to beans is an important prerequisite for these epidemiological studies.

a) *Pythium* root rots

Methods: Sixty-six *Pythium* isolates from Uganda characterized last year by morphological methods were characterized using restriction analysis and sequencing. Methods were developed with CIAT Headquarters (Project IP-1).

Restriction Fragment Length Polymorphism Analysis: Genetic variability of among the *Pythium* isolates was determined by digesting extracted DNA using *Cfo* I, *Hinf* I and *Mbo* I endonucleases and separating fragments on 2% agarose.

Sequencing of Amplified rDNA: DNA was extracted from 38 isolates representing different RFLP groups and amplification of the ITS 1 region of the ribosomal gene was done using the ITS1primer (White et al., 1990). Nucleotides sequences were obtained using automated sequencer and were edited using SeqWeb Version 1.2. Multiple alignments of the reverse complement of the sequences were compared to Pythium species database sequences publicly available.

Results: ITS1/4 products of 66 isolates (plus 14 isolates from culture collection) grouped 63 isolates into seven RFLP groups; 17 isolates were not grouped. There was some relationship between morphological groupings and RFLP. In some instances RFLP groups contained isolates from more than one morphological group.

Although there was some consistency between RFLP and sequence analysis, results from the latter were better and the 38 isolates were grouped into nine species namely P. vexans, P. tolorosum, P. spinosum, P. salpingophorum, P. ultimum, P. nodosum, P. echinulatum P. aphanidemetum and P. pachycaule. Pathogenicity studies are in progress to assess variability in virulence between and within species.

Contributors: J. Mukalazi and R. Buruchara; G. Mahuku (CIAT-IP1); F. Opio (NARO); J. Carder and N. Spence (HRI).

b) Fusarium solani f. sp. phaseoli

Methods: Forty Fusarium solani f. sp. phaseoli isolates from Uganda were characterized using pathogenicity and molecular methods. Five isolates from international culture collection centers and other formae speciales of F. solani were included for comparison.

Amplified fragment length polymorphism (AFLP) analysis of F. s. f.sp. phaseoli isolates: Isolates were subjected to AFLP analysis using 15 primers and the products separated by agarose gel electrophoresis, visualized under UV light and captured by photography. Presence or absence of bands was scored and analyzed and a dendogram showing relative similarity was generated using NTSYS-pc (Ver. 2.01i)

Virulence characterization of F. s. f.sp. phaseoli isolates: Pathogenicity of isolates was determined by planting seed of bean cultivar, K20 on artificially infested soil (3000 – 4000 conidia per gram of soil) in plastic pots in the screenhouse. Four weeks later, plants were assessed for root rot severity using a CIAT scale of 1-9.

Development of molecular detection techniques for F. s. f. sp. phaseoli: The aim of this study was to develop specific primers that would be used to detect pathogenic isolates of F. s. f. sp. phaseoli. Eleven isolates were used; five pathogenic and four non-pathogenic but isolated from beans with fusarium root rot symptoms. F. s. f. sp. fabae (IMI 172300) and F. s. f. sp. pisi

(MUCL 906), which cause fusarium root rots of broad bean (Vicia faba) and peas (Pisum sativum), respectively, were included. AFLPs were used to determine unique bands within the genome of the pathogenic isolates. Six bands were recovered, purified, quantified, and sequenced. The three longest sequences were visually inspected for suitable sequences for primer design. Four pairs of primers were designed, synthesized (by Sigma-Genosys Ltd. (UK)) and tested for specificity on a limited number of pathogenic and non-pathogenic F. s. f. sp. phaseoli. The most promising pairs were then tested on more F. solani isolates and other Fusarium species.

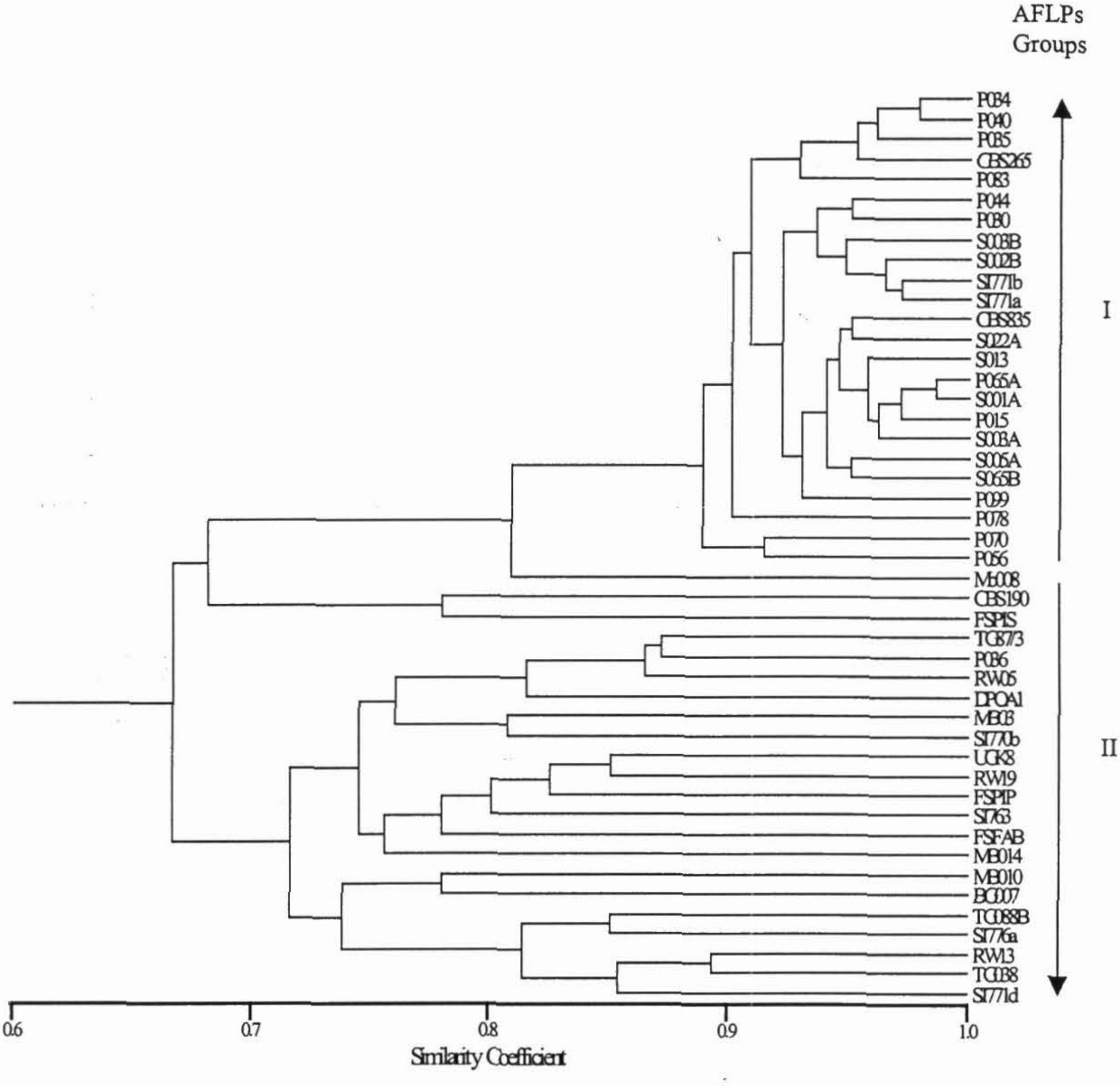

Figure 1. Dendogram of *F. solani* isolates based on UPGMA methods using SAHN and tree program in NTSYS showing relative similarity based on AFLPs data. Isolates in group I and II also gave pathogenic and non-pathogenic reaction, respectively, on *Phaseolus* bean cv K20.

Results:

Molecular and cultural variation: On the basis of AFLP analysis, the isolates could be divided into two broad groups with little intra-group variation (Figure 1). One group consisted of isolates with light-yellowish mycelia, with relatively fast growth (at least 6mm per day) on PDA at 22^{0}C and produced numerous micro- and macro-conidia. The second group was made of isolates that grew relatively very slowly (not exceeding 1.8mm per day), produced less mycelia that was initially whitish but later turned bluish with production of conidia, and produced macro-conidia only.

Variation in virulence: All slow growing isolates caused lots of root symptoms (severity above 6.5) and hypocotyls 4 weeks after inoculation, while little (severity of less than 2.5) or no apparent symptoms were observed with the fast-growing isolates.

Molecular detection technique: The four primers designed were tested for specificity in a PCR on pathogenic and non-pathogenic *F. solani,* other *Fusaria* and *non-Fusaria* fungi. Two primer pairs (FSP1F-BEAT/FSP1R-BEAT and FSP4F-DETT/FSP4R-DETT) were specific and amplified expected fragment sizes of 180 and 287 bp, respectively from pathogenic isolates only, while the other two pairs, (FSP2F-CETT/FSP2R-CETT and FSP3F-DETT/FSP3R-DETT) were non-specific and amplified fragments from pathogenic and non-pathogenic *F. solani*, other *Fusarium* spp. and also from other fungal species used in the study.

Our studies resulted in the recovery of two groups (pathogenic and non-pathogenic) of *F. solani* isolated from bean plants and distinguished by pathogenicity and molecular methods. On the basis of fungal isolates tested so far, two of the primers developed show promise in developing molecular diagnostic techniques for *F. solani* f. sp. *phaseoli*. Their specificity and capacity to detect pathogenic forms in the soil should complement cultural methods in facilitating subsequent epidemiological studies.

Contributors: G. Tusiime and J. R. Buruchara; F. Opio (NARO); J. Carder and N. Spence (HRI, UK).

Adaptation of specific PCR based markers to characterize and differentiate *Pythium* spp.

Rationale: Pythium root rot is the most destructive soilborne disease of beans in East, and Central Africa and development of effective management strategies against the disease requires accurate, reliable, and rapid detection assays. A diagnostic test has been developed for the detection of most known (particularly temperate) species of Pythium using Reverse Dot Blot Hybridization (RDBH) (Levesque, 1998). It is based on species-specific oligonucleotides that have been designed and blotted onto a membrane array. There are approximately 100 species in the genus *Pythium*; some are highly pathogenic, some are almost exclusively saprophytes and others are biological control agents. Given this wide genetic variation, it is almost certain that some strains (pathogenic or beneficial) particularly in the tropics could be novel. This study was initiated using the reverse dot blot hybridization technique to rapidly identify the species commonly associated with bean root rots in East and Central Africa. Because the sequences used to develop the probes were obtained exclusively from *Pythium* spp found in temperate zones, the first step was to test the suitable of this assay for tropical zones and populations.

***Methods*:** This work was done in Canada. DNA from 100 *Pythium* isolates from Uganda, Kenya and Rwanda was carried to Canada for analysis. All isolates were amplified with primers targeting the ITS regions of the ribosomal genes and specific to *Pythium* spp. This first step allowed the differentiation of *Pythium* and non-*Pythium* species. Direct sequencing of the PCR fragment by primers that annealed inside the first fragment; the sequencing products were run on an ABI prism automated sequencer. After editing, the sequences were compared to sequences of known species from the *Pythium* database managed by Dr A. Levesque.

***Results and Discussion*:** Amplification with *Pythium* specific primers identified 17 isolates as *Mortierella* spp. (Figure 2); the rest of the isolates were identified as *Pythium* spp. *Mortierella* is a common saprophyte that can be isolated on *Pythium* specific media; morphologically, it cannot be differentiated from *Pythium*. This molecular method (using Pythium-specific primers) is a very useful tool that can be used to eliminate *Mortierella spp* from the collection of *Pythium*. Sequence analysis of the isolates identified 12 species. Of the four species reported to infect beans, only *Pythium ultimum* and *P. irregulare* were identified; *P. ultimum* var *ultimum* had the highest incidence (25) and is the most prevalent species in the study areas. Other species identified included *P. acanthicum, P. dissotocum, P. indigoferae, P. oligandrum, P. salpingophorum, P. spinosum, P. tolorusum,* and *P. vexans.*

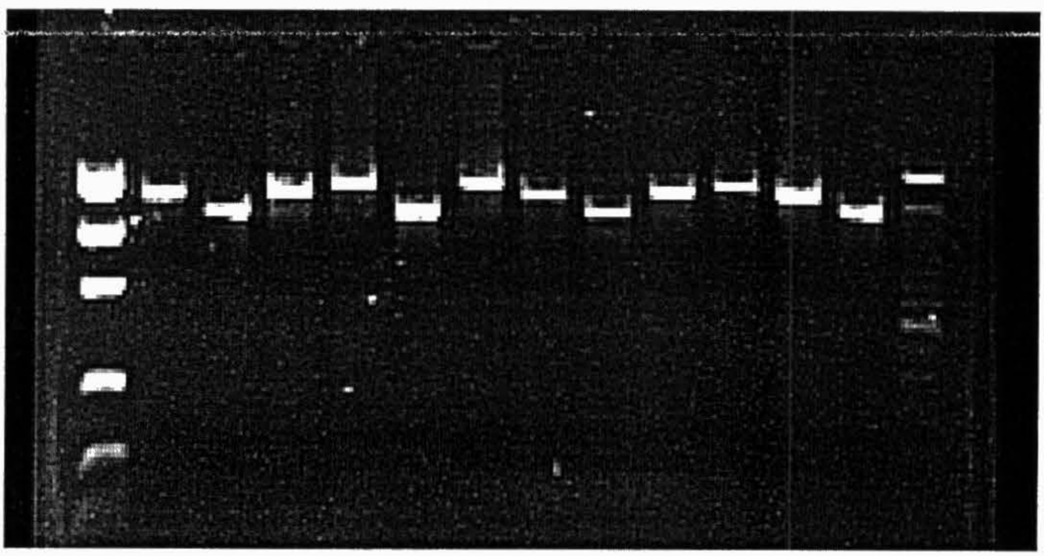

Figure 2. Banding patterns from amplifying ribosomal DNA spacer region using Oomycete specific primers and used to distinguish between *Mortierella* spp and *Pythium* spp. Lanes 1, 3,4, 6,7and 9 –11 represents DNA from *Pythium* spp, while DNA in lanes 2, 5, 8 and 12 contains DNA from *Mortierella* spp. Lane M a DNA molecular ladder.

Of interest were new putative species found in association with beans, and whose sequences were significantly different from their closest match (*Pythium torulosum)* among the neo (type) strains. Additional characterization studies are underway to look at the morphology and pathogenicity of these isolates, as well as other parts of the genome to establish if indeed these isolates represent new species within the genus *Pythium*. Also of interest was the occurrence *Pythium oligandrum,* a known potent biocontrol agent, effective against a number of soil borne pathogens including *Pythium* species. We are currently verifying its effectiveness to manage soil-borne pathogens. Other species identified, *P. vexans* and *P. indigoferae,* have been implicated as possible biocontrol agents. This study demonstrates the complex nature of the genus *Pythium*. More samples are being collected to ensure adequate coverage of the bean growing areas affected by root rot problems.

Contributors: R. Buruchara and S. Mayanja; G. Mahuku (CIAT-IP1); A. Levesque (Agriculture and Agri-Food Canada).

Characterization of pathogen diversity of *Phaeoisariopsis griseola* in Africa

Rationale: Understanding diversity structure and distribution is important in designing strategies and deploying durable resistance against as variable and economically important pathogen as *Phaeoisariopsis griseola* (causing angular leaf spot). Characterization so far in Africa shows occurrence of Mesoamerican and Andean pathogen groups; in addition, an Andean subgroup named Afro-Andean has been identified. Knowledge of diversity and distribution is inadequate in many African countries where ALS is important, and continuous monitoring for emerging new races is also essential.

Methods: An extensive collection was initiated in an effort to characterize pathogen diversity in Kenya, Uganda and Rwanda, giving consideration to spatial, ecological, cropping systems and varietal variation. A total of 16 isolates from different districts of Kenya were characterized on the basis of a set of 12 host differentials (6 Andean and 6 Mesoamerican).

Results and Discussion: Twelve races comprising Mesoamerican, Andean and Afro-Andean pathogen groups were identified in Kenya from 16 isolates collected showing a high degree of variability (Table 3).

Table 3. Virulence diversity of *P. griseola* in Kenya

Isolate Identification	*Race*	Andean						Mesoamerican					
		A[x]	B	C	D	E	F	G	H	I	J	K	L
Eb-5	10-0		b		d								
Eb-8	14-0		b	c	d								
Tt-10	14-0		b	c	d								
Mk-1	31-32	a	b	c	d	e							l
Eb-11	34-0		b				f						
Eb-15	46-0		b	c	d		f						
Eb-3	58-18		b		d		f		h			k	
Eb-2	6-0		b	c					h	i			
Tt-4	62-32		b	c	d	e	f						l
Kb-10	62-39		b	c	d	e	f	g	h	i			l
Eb-17	63-39	a	b	c	d	e	f	g	h	i			l
Eb-1	63-55	a	b	c	d	e	f	g	h	i		k	l
Eb-10	63-55	a	b	c	d	e	f	g	h	i		k	l
Mk-5	63-55	a	b	c	d	e	f	g	h	i		k	l
Eb-24	63-7	a	b	c	d	e	f	g	h	i			

[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.

Further characterization is underway and information will go towards developing a race distribution map for *P. griseola* in Africa and as a basis for monitoring of new races.

Contributors: I. Wagara (University of Nairobi); R. Buruchara; G. Mahuku (CIAT-IP1); F. Opio (NARO); A. Musoni (ISAR).

Pathogen population structure of *Phaeoisariopsis griseola* in varietal mixtures

Rationale: Mesoamerican and Andean pathogen groups of *Phaeoisariopsis griseola* occur both in Africa and Latin America. But the occurrence, only in Africa, of the Andean sub-group (Afro-Andean) is thought to have been influenced by farming practices that include growing together, or as varietal mixtures, germplasm belonging to the two major *Phaseolus* genepools (Mesoamerican and Andean). Studies initiated last year continued, to determine the population structure and diversity of *P. griseola* in varietal mixtures, their significance and implication in developing management strategies for ALS.

Methods: Twenty-five isolates were recovered from naturally infected bean plants grown at Kawanda research station, consisting of two variety mixtures originally from Rwanda (Seeds of Hope project) and Kisoro in southwest Uganda, and from determinate cultivars K131 (small seeded), CAL 96 (large seeded) and a local variety Kanyebwa (medium). Mixtures from Uganda consisted mainly of indeterminate medium-sized seed components while the Rwandan mixtures consisted of determinate and semi-climbing large, medium and small seeded types.

Molecular variation of the 25 isolates was assessed using two Random Amplified Microsatellites (RAMs) primers [(CA)n and (GT)n].

Results and Discussion: The isolates could be separated into two broad groups (Figure 3). The first group with the majority of isolates (20) was largely derived from medium and large seeded components of the two varietal mixtures while the second group (5 isolates) was recovered from mainly small seed components. Most isolates (in group 1) belonged to Andean pathogen group and a possibility of including some Afro-Andean given the infection on small seeded Mesoamerican varieties. The results so far indicate that type of varieties in mixtures influence pathogen groups recovered from them, and therefore the pattern of variation of the pathogen.

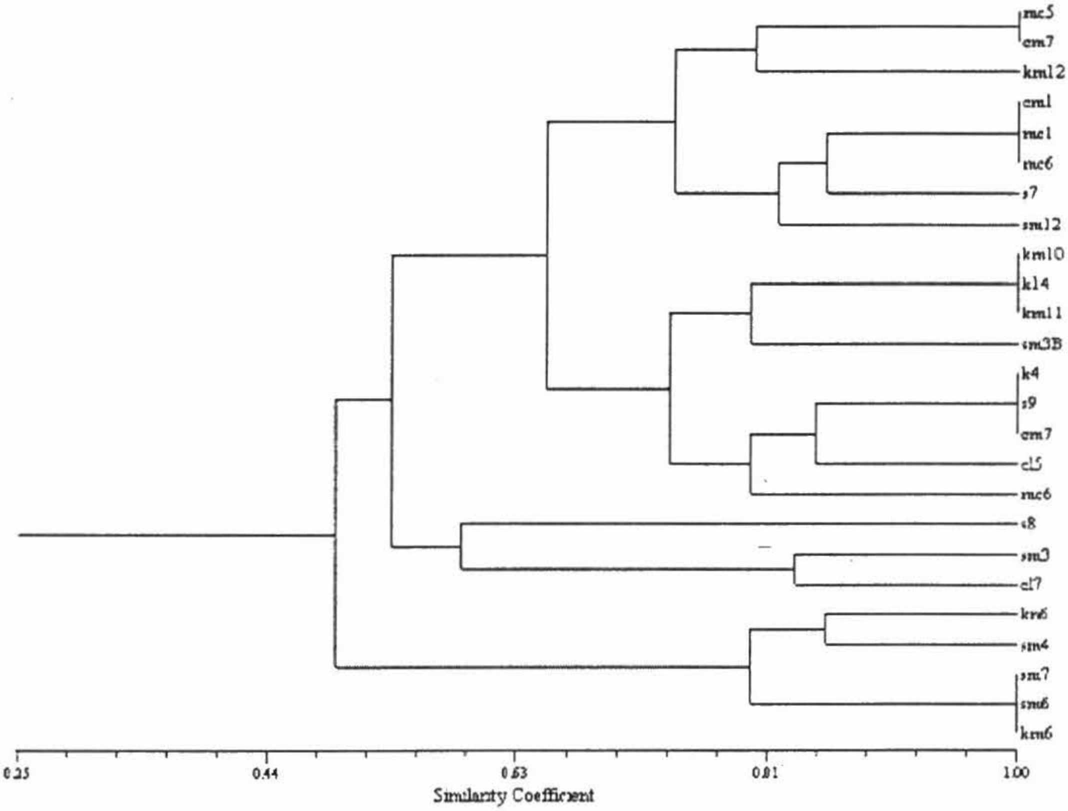

Figure 3. A dendogram of 25 isolates of *Phaeoisariopsis griseola* based on UPGMA analysis of random amplified microsatellites [(CA)n and (TG)n] primers data using NTSYS-pc ver 2.02I

Contributors. R. Buruchara and S. Mayanja; G. Mahuku (CIAT-IP1).

Identification of resistance to *Pythium* root rot within main market classes of beans

Rationale: Two of the nine seed classes of beans grown in Africa, the red kidneys and red mottles, account for about 10% and 22% respectively in production, and account for 50% of the marketed volume in eastern and southern Africa. However, most commercial varieties of these classes are susceptible to *Pythium* root rot and hence we need potential sources of resistance within these classes that may be used for varietal improvement or grown by farmers.

Methods: A total of 632 entries consisting mainly of red mottle (267) and red kidney (233) bush beans, assembled from diverse types of germplasm, was evaluated. Also included were red mottle climbers (29), advanced lines (13) from Rwanda's breeding nurseries, and a part (90) of the CIAT-IP1 nursery IBN-96. Entries were grown in soil, artificially infected with *Pythium spp* in the screenhouse and evaluated using a CIAT scale of 1-9.

Results and Discussion: As anticipated most entries gave susceptible reactions and less than 25% in each of the two market classes gave intermediate reactions (Table 4). No entry gave a resistant reaction (≤ 3.0), but materials with disease severities of ≤5 are practically useful and perform satisfactorily under field conditions the best are shown in Table 5). Several materials with tolerant reaction in the red kidney and red mottle classes were sister lines. Following evaluations, 159 single plant selections were made and seed increased for further evaluations and inclusion in a Pythium Root Rot Nursery.

Table 4. Reaction of selected germplasm to artificial inoculation with Pythium spp in the screenhouse. Kawanda, Uganda, 2001.

Nursery	No. entries	Frequency of disease severity groups			
		1-3.0	3.1-4.9	5.0-6.9	≥7.0
MCN (Red mottle)	267	0	6.7	8.9	84.4
MCN (Red kidney)	233	0	14.6	12.4	73.0
IBN-96	154	0	10.0	14.6.	75.4
Red Mottle climbers from Rwanda	29	0	3.4	0	96.6
Advanced lines from Rwanda	13	0	7.6	61.0	34.4

Table 5. Best entries selected from multiple constraint nurseries (MCN) against Pythium root rot in the screenhouse, Kawanda, Uganda, 2001.

Entry	Nursery / Seed Type	Reaction[x]
AND 1055-1	MCN (Red Kidney)	3.3
AND 1062-1	-do-	3.5
DFA 52-1	-do-	4.1
NR 12793-8-1	-do-	3.2
NM 12803-11	-do-	3.2
NM 12657-5C-2	-do-	3.1
NM 12646-3-1	-do-	3.0
AND 1056-1	MCN (Red Mottle)	3.2
NR 12797-8C-1	-do_	3.6
NR 12632-4E-1	-do-	3.1
NR 12632-11A	-do-	3.1
NR 12633-4E-1	-do-	3.4
NR 12633-5-1	-do-	3.4
NR 12631-7-1	-do-	3.3
NR 12633-5B-1	-do-	3.8
RWK 10	Rwanda	3.4
RWR 1742	-do-	3.8
RWR 1873	-do-	3.3
DOR 703	IBN	3.2
CIFAC 91135	-do-	4.1
DOR 719	-do-	4.1

[x] = Based on a CIAT scale of 1-9 where 1 is resistant and 9 is susceptible.

Contributors: R. Buruchara, P. Kimani and S. Sebuliba

Development of bush bean lines with multiple-resistance to *Pythium* root rot and angular leaf spot

Rationale: Few materials are resistant to Pythium root rot, but some are susceptible to ALS and most do not belong to the popular market classes. We need to develop materials with resistance to both root rot and ALS, two very important diseases in Africa, and having characteristics that meet varied needs of producers and consumers.

Methodology: In 1998 multiple-crosses were made to combine resistance to root rots, ALS, CBB and BCMV in popular seed backgrounds. Previous results (Annual Report 1999) had shown that there is good variation within progenies and potential to identify lines with resistance to both Pythium root rots and ALS. Follow-up evaluations were carried out this year on 132 F_5 lines, derived from F_3 progenies for resistance to Pythium root rot. Forty-eight other progenies screened last year for Pythium root rot resistance were evaluated for resistance to Andean and Mesoamerican isolates of *P. griseola* under artificial inoculation in the greenhouse.

Results and Discussion: Of 132 progenies evaluated for Pythium root rot, four (2.2%) gave average reactions of ≤ 3; 40 (30.3%) gave reactions between 3.1 – 5.0; 52 (39.4%) gave reactions between 5.1 - 6.9; whereas 37 (28.0%) were susceptible (≥ 7). These progenies are to be evaluated for resistance to ALS. Of 48 progenies evaluated for ALS resistance, four were resistant (1-3), 28 gave intermediate reactions while 17 were susceptible. Of great interest was the identification of materials that combine resistance against Pythium root rots and angular leaf spot (Table 6).

Table 6. Selected F3-derived-F5 progenies showing single and multiple resistance to inoculation with *P. griseola* and *Pythium* spp. Screenhouse, Kawanda, 2001.

Progeny	Reaction[x] to *P. griseola* pathotypes		Reaction to *Pythium* root rot
	Andean	Mesoamerican	
BACO 4 - 5/2	3.8	2.5	2.8
BACO 4 -5/22	2.5	2.5	2.4
BACO 4 - 5/30	3.5	2.5	3.0
BACO 4 – 6/6	4.8	2.5	2.6
BACO 4 -5/32	2.7	3.2	2.6
BOA 5 - 1/24	4.3	2.0	2.3
BOA 5 - 1/16	3.0	3.0	3.8
BOA 5 - 1/19	2.0	2.5	3.2
BOA 5 – 1/15	3.2	2.0	3.8
BOA 5 - 9/1	8.0	5.6	4.2
BOA 5 - 1/23	8.3	6.6	2.6
BACO 4 – 5/3	8.2	5.8	5.3
BACO 2-4/7	5.4	2.5	8.3
CAL 96	8.0	7	9.0
MCM 5001	4.7	8.0	-

[x] = reaction based on a CIAT scale of 1 to 9 where 1 is resistant and 9 is susceptible.

Contributors: R. Buruchara, S. Sebuliba and P. Kimani.

Activity 1.3 Make available more options for managing soil productivity and bean pests

Achievements:

- In selecting within a root rot resistance nursery, farmers from seriously affected areas showed fair consistency in preferring small-seeded types and great flexibility in seed color and taste. Over 500 bean lines selected for disease resistance or tolerance were distributed to NARS.

- *Ootheca* biology and stem maggot population dynamics better understood. Farmers' own best bet practice proved to be an effective short-term deterrent against bean foliage beetles, with short-term results comparable to those obtained with the more widely recommended treatment with neem.

- Farmers in a Ugandan study area, aware of declining soil fertility confirmed by nutrient flow analyses, were interested in adopting simple inexpensive technologies requiring little labor.

- About 80% of collaborating farmers had continued growing Mucuna as a green manure cover crop, because early maturity made systems integration easier and seed was easy to recover.

Participatory selection for bean varietal resistance to *Pythium* root rots

Rationale: One of the effects of Pythium root rot in affected areas is a reduction in the number or change in types of varieties or components in varietal mixtures grown. Consequently there is great demand for varieties that are resistant to Pythium root rot and also meet other production conditions and needs of the farmer. Involvement of users in the identification and selection of germplasm has several advantages through taking account of farmers' criteria, indigenous knowledge and preferences.

Methods: A Root Rot Nursery consisting of 68 entries with diverse growth habits and seed types was evaluated by four farmer groups, largely composed of women members, in Kabale in southwest Uganda. Planting was in community plots, and farmers arranged visits and nursery assessment at different stages of plant growth. Selected materials are then increased for further evaluations in individual fields. The 68 entries had been chosen for their resistance to Pythium root rot. Regular visits were made to community plots to discuss farmers' observations and perceptions.

Results and Discussions: Insufficient rains affected two farmer groups resulting in inconclusive assessments, and these groups will evaluate the nursery next season. The other two groups, Bigaga and Rwanyena, selected 29 and 24 entries, respectively, on the basis of actual and perceived potential performance. Seventeen entries were common to the two groups, an indication of commonality in selection criteria, whereas specificity to each group implied local preferences or possible targeting of niches. Most preferred entries were small seeded because they "yield better and are tolerant to rain". Some entries were expected to perform better on different parts of the farm -- upper parts are considered poor while lower parts are considered to have better soil fertility. Late maturing varieties were not preferred but great flexibility was shown towards seed color and taste, as some grow mixtures with diverse seed colors.

Contributors: R. Buruchara and G. Manzi

Multiplication and distribution of selected disease nurseries to partners

Rationale: There is great demand for sources of resistance against main bean diseases that may be used either directly by farmers or as parents to improve popular but susceptible commercial varieties.

Methods: Disease nurseries and germplasm were multiplied and distributed according to needs of our partners.

Results and Discussion: Several hundred lines and nurseries with multiple or single resistance to angular leaf spot, anthracnose and Pythium root rot were multiplied. A total of 513 lines or materials were distributed to partners as shown on Table 7.

Table 7. Germplasm for disease management distributed to NARS in Africa

Nursery / Germplasm	Number of entries	Destination
Root Rot Regional Nursery	68	Uganda
MCR lines	143	Kenya, Uganda
VTTT lines	180	Kenya, Uganda
ALS differentials	12	Kenya
Pythium Root Rot and ALS nursery	132	Rwanda, Kenya

Contributors: R. Buruchara, P. Kimani, S. Sebuliba and C. Acam.

Biology and ecology of bean foliage beetle (*Ootheca* sp.) in support of IPM

Rationale: Farmers believed "*Ootheca* came with the rains and went with the rains". However, having realized that *Ootheca* developed in the soil within their own fields, they were eager to learn more about the biology and development in relation to their production circumstances. In addition we undertook a lab and screenhouse study to understand the details of *Ootheca* biology.

Methods: Mating pairs of *Ootheca* were collected from the field and caged with a petri dish of loose soil. They were monitored for oviposition and all eggs laid were collected, counted and incubated under ambient temperature conditions. Neonates were removed and placed in soil with a potted bean plant. There were 168 such pots. Each week 6 pots were removed randomly and sampled for larvae. Head capsule widths (HCW) of all larvae collected were measured. Frequency distribution of the HCW was plotted and the number of instars determined.

Results: Newly emerged *Ootheca* females had a pre-oviposition period of 2 to 3 days and laid up to 564 eggs over about 3 weeks (Table 8). The eggs took 2 to 3 weeks to hatch at ambient temperatures between 17 and 27°C. Egg viability was 97.6%. There were three larval instars with the larval stage lasting over 24 weeks from April until September. Mean head capsule widths of the different instars are presented in Table 9. Pupation started in September and early adults hatched in early October but remained in teneral diapause. These laboratory and screen house studies confirm field observations on *Ootheca* development but the lab studies shed more light on the biological parameters of the larvae.

Table 8: Some developmental parameters of *Ootheca* in northern Tanzania

Parameter	Mean ± SEM	Range
Pre-oviposition period	2.8 ± 0.34	2-3
Eggs laid /female	148 ± 107	20-564
Oviposition period	22 ± 13	3-52
Egg batch size	59 ± 5	53-67
Number of batches	4.5 ± 2.5	1-8
Incubation period (days)	16.9 ± 1.89	13-20

Table 9. Mean head capsule widths (mm) and duration of different larval instars of *Ootheca*

Instar	Head capsule width		Duration in weeks
	Mean ± SEM	Range	
First	0.485 ± 0.0664	0.345- 0.604	5
Second	0.695 ± 0.0244	0.604 – 0.734	8
Third	0.794 ± 0.0237	0.734 – 0.820	11

Contributors: K. Ampofo and H. Mziray

Understanding bean stem maggot population dynamics

Rationale: BSM ecology is not well understood and this leads to difficulties in predicting population changes. This year we monitored BSM species population dynamics in relation to various climatic variables and the incidence of parasitism. The data could be used to develop models for advisory forecasting of the pest's populations.

Methods: Beans were planted on weekly basis at Selian, Arusha (ca 3^0 S and 1380 m.a.s.l.). Plants were removed at 3 weeks after emergence and all insects extracted and sorted into species using puparial characters. Other plants from the same group on each sampling occasion were placed in a paper bag and sealed to determine adult or parasite emergence. Parasites are stored for later species determination. This research is joint between Projects IP-2 and PE-1 (IPM).

Results: *O. spencerella* was dominant throughout the monitoring period (Figure 4). There was always a decline in BSM populations to the lowest level during April each year, but populations were high in May to August. The population increases and decreases of the parasite population appear to follow the BSM population trends very closely. Rainfall does not appear to be a major factor, even though low populations in April coincided with periods of high rainfall. These periods also coincide with the planting of beans in the Arusha area. Delayed planting often results in high BSM infestation.

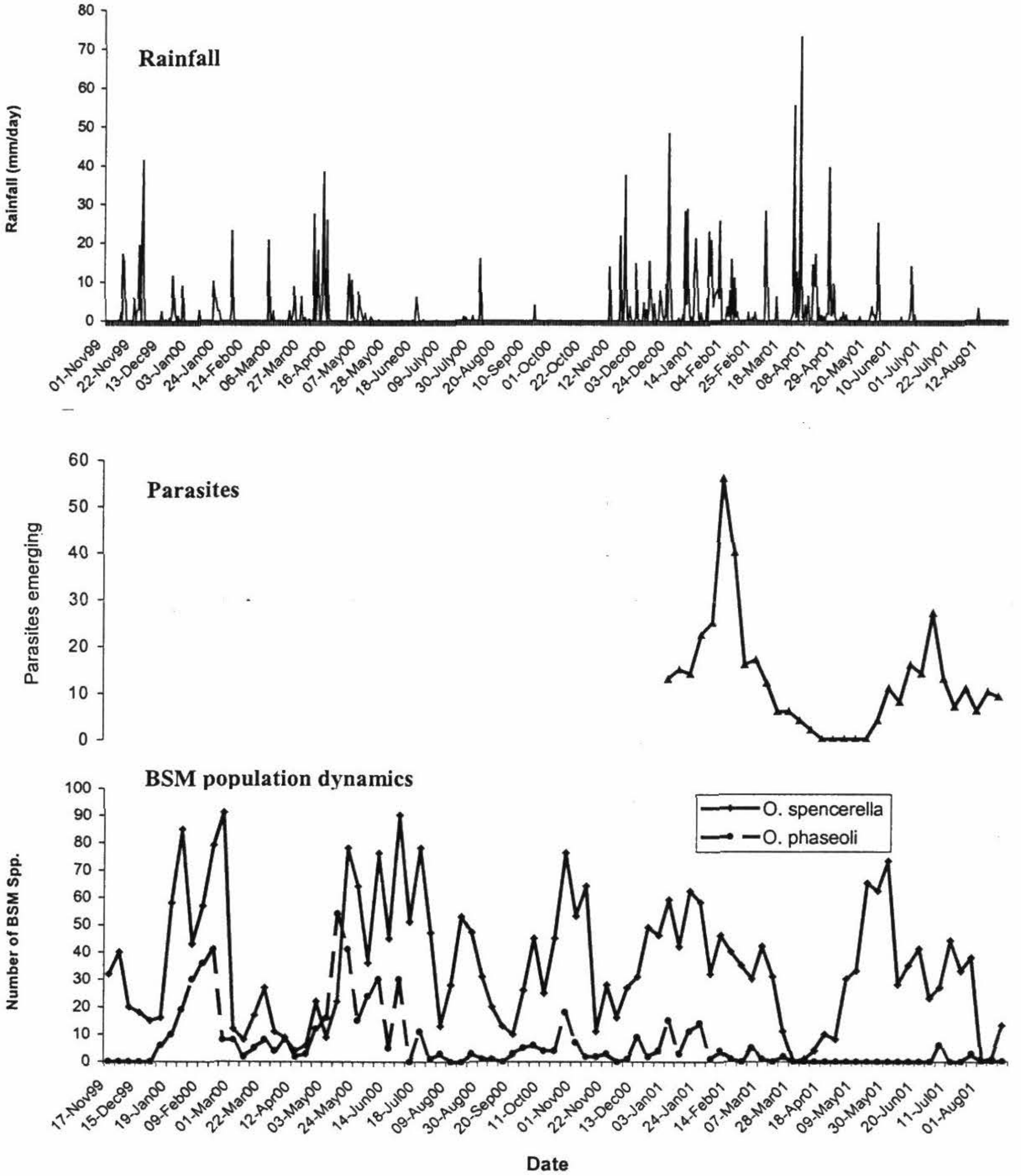

Figure 4: Relationship between rainfall patterns, the incidence of parasitism and BSM population dynamics in Arusha.

Contributors: K. Ampofo and H. Mziray

Studies on the efficacy of traditional IPM methods against bean foliage beetle

Rationale: Farmers' traditional IPM strategies often appear to be related to local traditions and vary from one group to another. These practices need to be assessed for effectiveness before they can be disseminated to other areas. We compared some of these traditional IPM practices to verify their efficacy and to provide information to farmer research groups, to the formal research sector and to IPM scaling up efforts (see Output 4, Activity 4.3).

Methods: We compared a set of pest management treatments originally proposed by farmer groups (see previous annual reports) with widely accepted "scientific" methods, in formal experiments on the research station. The Wasambaa people use plant based concoctions (e.g. *mkasha*, a Vernonia species), while the Wa-Arusha, Wameru and Wachagga preferentially use animal derived concoctions such as fermented cow urine. Treatments were cow urine fermented for one, 5 or 9 days (diluted at the rate of 1:3), *Vernonia* spp. leaf extract (1:1, vol/vol), and 0.5% Neem seed oil (at 2.5 ml:1 litre of water). All treatments were applied at the same day as foliar sprays. Bean foliage beetles were counted and damage daily; when insect counts went up and no difference between treatments could be seen, we applied all treatments a second time. Results were discussed with farmer-researchers in Tanzanian pilot IPM sites.

Results and conclusions: All treatments repelled *Ootheca* from the plots and reduced damage (Figure 5). However, for most of them the protection only lasted about three days after which there was no effect and the pest returned. A second application after seven days repelled the pest again. Neem seed oil and *Vernonia* leaf extract maintained infestations below the control, but cow urine applications wore off after about five days and needed repeated application. This confirms the efficacy of traditional IPM methods. After confirming that their traditional technologies were as effective, farmers were very eager to apply their traditional knowledge through the participatory IPM process to other crops and livestock.

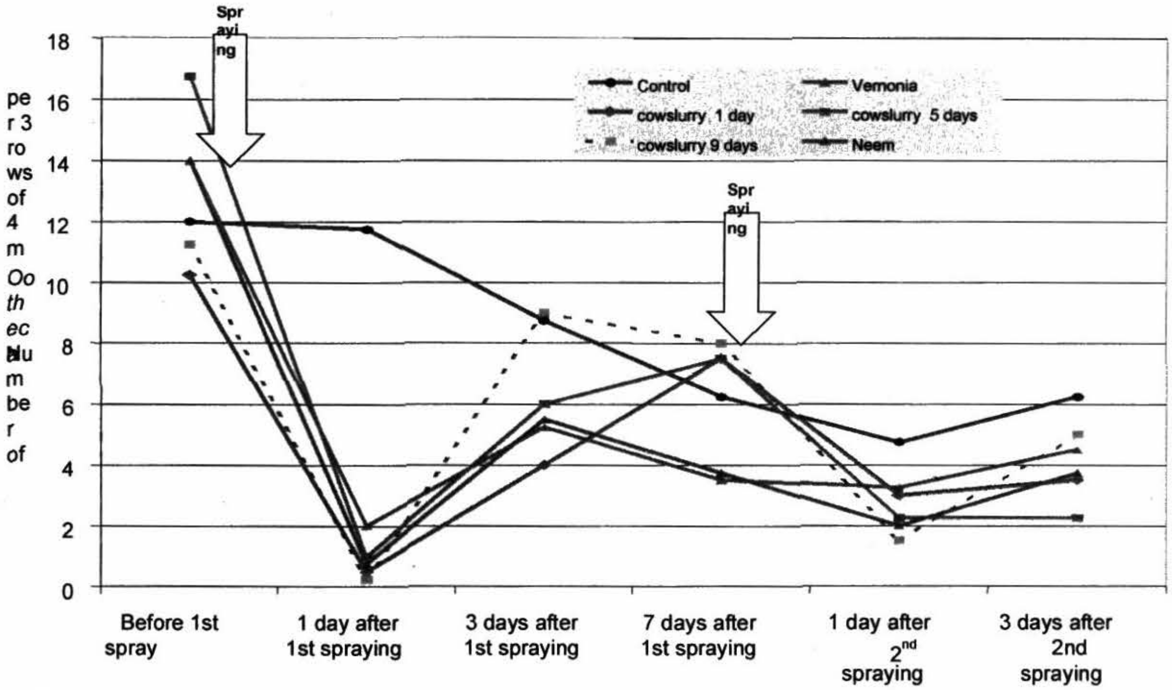

Figure 5: Effect of traditional IPM recommendations on *Ootheca* infestation and damage.

Contributors: U. Hollenweger, K. Ampofo and H. Mziray
Collaborators: Mrs. A. Koola, Hai District Extension Service

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

Rationale: Soil nutrient depletion, responsible for much of the decline in per capita food production in Africa, is most intense in East Africa due to outputs in harvested products, erosion and inherent fertility of many soils. Integrated nutrient management (INM) to arrive at a sustainable level of agricultural production is crucial, and better strategies are required that address farmer requirements and priorities.

Methods: A project under the Soil, Water and Nutrient Management (SWNM) systemwide program, developed in partnership with TSBF (for Eastern Africa), IFDC (for West Africa) and national researchers. The project aims in pilot sites 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 skills and tools of research and extension personnel to support that process. This strategic project has completed two years, and coordination is provided by CIAT jointly from Headquarters SWNM/PE2 and from Uganda IP2.

Results from eastern Uganda: This report presents the results of on-farm testing of INM strategies in eastern Uganda after two years of a Participatory Learning and Action Research (PLAR) process.

Farm characteristics and soil fertility management: Wealth ranking, soil fertility classifications and household surveys were used to understanding social dynamics in the Imanyiro community in eastern Uganda. Wealth ranking showed that 28% of farmers were wealthy or average, 20% were poor and 24% were very poor, and these ranks correlated well with current soil fertility practices. Farmers in class I, those practising improved soil fertility management (fertilisers, manure, compost, fallows, intercropping and crop rotations), are also those who tend to own their land, hire labour and to be members of farmer groups. None of the households in class 1 are poor or very poor. This quantitative analysis supports farmers' own perceptions of differences between classes and that soil fertility management is related to resource endowment. Thus in contract to the wealthy, poor farmers are poor soil fertility managers, have little contact with extension agents, are rarely members of farmer groups and hence have insufficient information on improved agricultural technologies.

Nutrient flows and partial nutrient balances: Resource flows were transferred into nutrient flows, using average N, P, K contents and partial nutrient balances calculated for the whole farm and for the crop production system (Defoer *et al.*, 2000). In class I farms the main exports of nutrients are related to coffee, food crops and banana crop residues fed to livestock and also used as compost; a good proportion of the nutrients leave the farm system, with a net negative nutrient balance of -59 kg N, -1 kg P and -84 kg K ha^{-1} in the crop production system (Figure 6). The animal production system had a net positive balance of 1 kg N, a net nutrient balance of 0 kg P but a positive balance of 14 kg K ha^{-1}; a positive balance in K is due to the substantial amounts of K in banana residues that are consumed by livestock. However, the small numbers of livestock (average 1.7 cows per farm) contributed little to the flow of nutrients. The household system had a net positive balance of 10 kg N, 0 kg P and 20 kg K ha^{-1} due to crop harvests and residues brought in. The main nutrient losses, which amounted to 47 kg N, 1 kg P and 60 kg K ha^{-1} during in the long rains of 2000, were due to produce sold in the market.

In class III farms (non-adopters of past fertility management efforts), main sources of nutrients leaving the crop production system were coffee, food crops and groundnuts, with a net negative nutrient balance of - 33 kg N, -2 kg P and - 7 kg K ha^{-1} (Figure 7). The household system had a net positive balance of 28 kg N, 1 kg P and 5 kg K ha^{-1}, due to crop harvests and residues brought to the household. Again, the main nutrient losses from the farm system during the long rains of 2000, amounting to 5 kg N, 1 kg P and 2 kg K ha^{-1}, were through produce sold in the market.

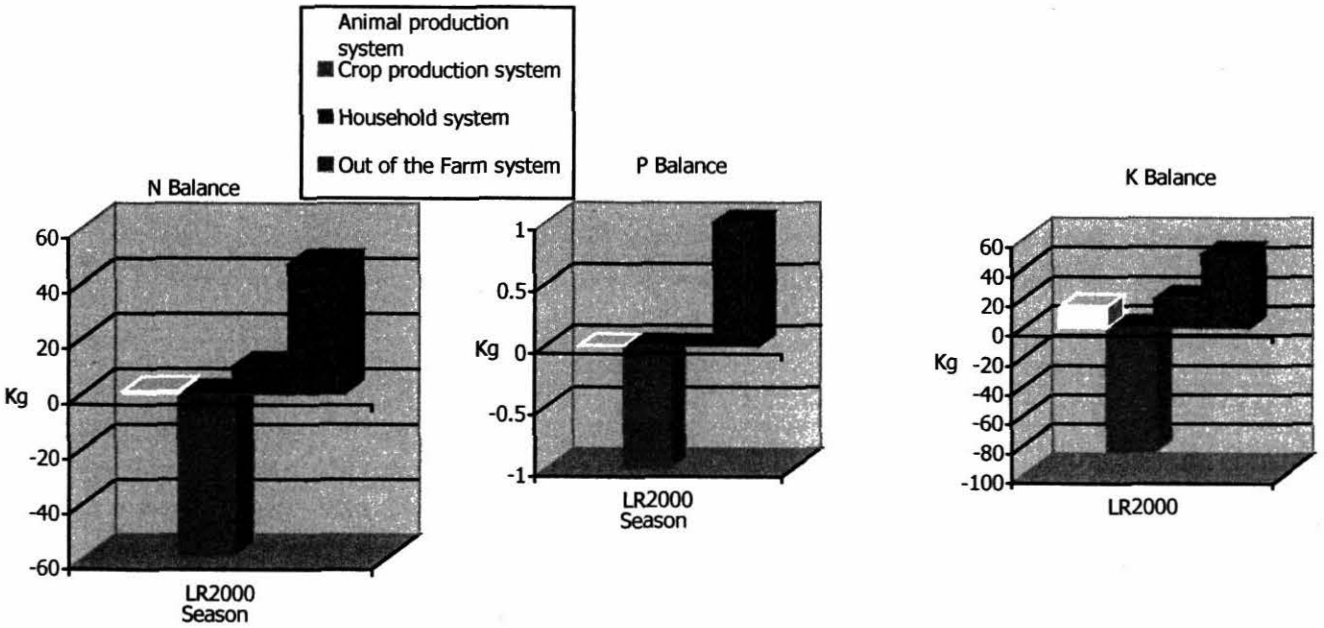

Figure 6: N, P and K balances per hactare of a typical class 1 farm in Magada village, eastern Uganda.

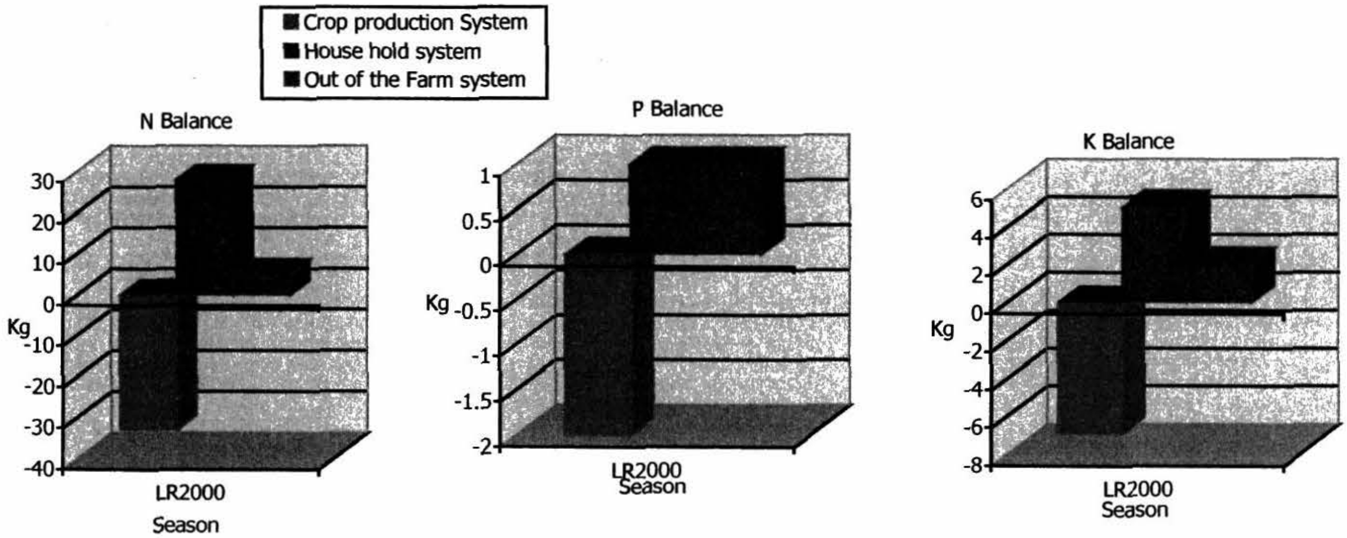

Figure 7: N, P and K balances per hactare of a typical class 3 farm in Magada village, eastern Uganda.

Farmer experimentation: In summary, Class I farmers implemented more experiments than Class II and III, with the latter being limited by land size, available household labour, lack of manure, mulching and composting materials, and seeds/planting materials.

Soil fertility: Soil analysis on test farms indicated the soils were sandy clay loams to loamy sand and some farms were deficient in N (0.08%), P (0.41ppm) and K (27.6 mg/100g). Most soils in the area should respond to nitrogen, phosphorus and potassium fertilisers. Soil fertility test strips (SFTS) established on test farms to determine whether N, P and K are limiting crop growth in season 2000A showed a significant response to N and P, and the N, P and K treatments and trends that indicate improved yields with the application of these nutrients in Buyemba and Magada.

Tillage: Although deep tillage and herbicide (glyphosate, Roundup) application did not improve maize biomass yield significantly farmers' practice of surface scraping, the farmers indicated a preference for using herbicides after socio-economic considerations during the evaluation meetings. The total cost of using Roundup was estimated to be US$40, against US$109 per hectare for manual cultivation and weeding twice.

Farmyard manure: Application of farmyard manure at 10 t ha^{-1} fresh weight improved maize grain yield in the two seasons in all the villages in Imanyiro. Although the grain yield differences were not significant, farmers had already observed treatment differences earlier in the season and were ready to adopt the technology on a larger scale. Previous studies indicated that an increase in maize yield of 700 kg ha^{-1} per season is expected with application of manure containing 22.6, 6.9, 3 and 33.7 kg ha^{-1} $year^{-1}$ of N, P and K, respectively (Wortmann and Kaizzi, 1998). Long-term studies on manure use are required to determine the impact of this technology on crop yields. However, the availability, quantity and quality of the manure in the area is a major constraint to widescale adoption of this technology. Improved crop and livestock integration in the farming systems would overcome some of the constraints to adoption of the manure technology.

Busumbu rock phosphate: There was significant response to various sources of phosphate fertilisers on maize grain yield during the two seasons in 2000. Minjingu rock phosphate (MRP) and triple super phosphate (TSP) significantly improved maize grain yields in Mayuge and Buyemba compared to Busumbu rock phosphate (BRP), Busumbu blend (90 % BRP and 10 % TSP) and the control (no fertiliser). TSP gave the highest yields followed by MRP, Busumbu blend, BRP and the control, respectively. The residual response to P in the second season followed a similar trend in the two villages, except for the second season in Buyemba where MRP had higher yields than TSP. In Magada, where soils are less acidic (pH 5.5) and sandy, there was no significant response to P fertilisers in the first season, although residual responses in the following season were significant except for TSP. Minjingu rock P appeared to be a better source than Busumbu rock P in two locations. Long-term P fertiliser studies need to be conducted at these locations to determine optimum rates, timing, application method, combinations of rock P with manure and compost, and residual value of the various P sources.

Minjingu rock phosphate Prep-pacs: Prep-pacs consist of N (urea at 40 kg N ha^{-1}) and P fertiliser (MRP at 100 kg P ha-1), rhizobium inoculant, seed adhesives and lime pellets. Although experiments on nine test farms gave insignificant improvement in crop yields, combined analysis for the two seasons on 41 non-test farms in 7 districts in Eastern Uganda show significant increases of 1244 kg ha^{-1} in maize grain yield (from 3085 kg to 4329 kg ha^{-1}) and of 881 kg ha^{-1} in bean yield (1316 kg to 2197 kg ha^{-1}). The soils in Iganga, of pH 4.0 to pH 5.9, include some that are insufficiently acidic conditions (pH < 5.5) to dissolve, while soils below pH < 5.2 are associated with toxic Al^{3+} and Mn^{2+} cations that greatly reduce crop performance (Okalebo, 1999). Profitability from use of Prep-pacs is dependent upon soil conditions and accompanying legume intercrops, as also reported by Nekesa *et al.*, 1999.

Green manure: Green manure dry matter yields in relay cropped trials in season 2000A indicated generally low yields for all species, from 200 kg ha^{-1} to 3505 kg ha^{-1}. Higher biomass yields were obtained during the second season except in Buyemba, from 116 kg ha^{-1} to 6029 kg ha^{-1}. Canavalia and mucuna had the highest yield followed by crotalaria and lablab respectively. Grain and stover yields of maize were not significantly improved by the green manure on 6 test farms in the two seasons. Maize grain yield on 39 other non-test farms was not significantly different except in the second season in Magada, where the highest yield was under lablab followed by canavalia, crotalaria, mucuna and the control. Farmers in Imanyiro have been using green manure for more than five years, and therefore they proposed that this technology should be disseminated without any further on-farm testing.

Mulching: Results from the demonstration plots at Ikulwe District Farm Institute showed improved fresh banana yields in the mulched plot (466 kg compared to 283 kg per 100 m^2 plot). The impact of these yield differences was so dramatic that, during evaluation meetings, farmers opted for this technology to be disseminated immediately without any further on-farm testing. However, farmers also proposed that they should adapt the trial by adding an additional treatment using lablab as a cover crop.

Soil conservation trenches: Although yield data are not yet available, trenches to control soil erosion and conserve moisture were established in coffee and banana plantations by 18 out of 65 farmers who attended the evaluation meeting in 2001. Farmers selected this technology as an important element of good soil fertility management and suggested that it too should also be disseminated without further testing.

Improved fallow and agroforestry in banana plantations: The mean dry matter yields of calliandra (9853 kg ha^{-1}) were significantly higher than from sesbania (6053 kg ha^{-1}) and tephrosia (3700 kg ha^{-1}) on 8 test farms after one year as improved fallow. Data on crop yield after incorporation of the legumes will be collected next season.

Conclusions: Farmers in the study area are aware of the declining soil fertility problem and the resulting declines in production. However, results from soil fertility classifications, wealth ranking and household survey approaches show that soil fertility management was related to the farmers' resource endowment -- different groups of farmers require different practices and technologies. Annual partial balances for N, P and K are negative at the field level -- soil nutrient reserves are being depleted. Farmer evaluation of on-farm experiments show that simple inexpensive technologies requiring little labour and locally available resources have a high potential for adoption.

Similar approaches are being taken in the benchmark sites in other countries. In Lushoto, Tanzania, decision support tools and guides were developed this year through farmer and researcher managed trials. On-farm fertility trials were conducted in farmers' fields using either farmyard manure or *Vernonia* in combination with N, P, Rhizobia and Minjingu rock phosphate, using as the test crops potatoes, snap beans, climbing beans and soybean. Farmers' knowledge and capacity for INM research was strengthened by applying principles of nutrient flows, with resource flow analysis conducted on 22 farms with three categories of farmers based on their resource endowment (farm size). Generally, food crops received less fertiliser resources compared to cash crops and vegetables. Exchange of information and experiences was mediated via farmer tour, and farmer and extension tools were developed and disseminated to various stakeholders. The impact of the various INM messages is being monitored.

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Integrating green manure cover crops in small-scale farming in Eastern Uganda

Rationale: Three green manure cover crops (GMCCs) or shrubs -- crotalaria *(Crotalaria ochroleuca*), mucuna (*Mucuna pruriens*), and lablab (*Dolichos lablab*) -- were introduced in Imanyiro subcounty, Iganga District, Eastern Uganda from 1994 to 1996 as alternative soil fertility improvement technologies for improving crop yields and control weeds in maize-bean cropping systems (Wortman *et al.,* 1998). At that time a decision guide was developed to enhance dissemination of these technologies, and the three species were recommended and disseminated to farmers in the area. This report is a follow-up study in the area.

Methods: The study was conducted in five villages of Buyemba and Mayuge Parishes in Imanyiro sub-county, eastern Uganda. The target population included all farmers who participated in the trials and were still continuing with the use of the green manure cover crops, farmers who dropped out of the trials, and neighboring farmers to the former. The sample size was 21 participant/continuing farmers, 22 neighbors and 9 participating farmers who dropped out bringing, the total sample being 52. Structured and semi-structured interviews and focus group discussions (FGDs) were used.

Results and discussion:
Integration of GMCCs into farming systems of participant farmers: There had been a decline in the proportion of farmers growing lablab and crotalaria, while mucuna experienced a slight rise by season 2000A. The main explanation for these declines was drought. Internal averages based on the number of farmers growing the particular technology reveal a higher level of consistent use over the 7 seasons (80%, 82%, and 62% for mucuna, lablab and crotalaria, respectively), attributed to improved soil fertility brought about by their use. This was also an indicator of

farmers' integration of GMCCs into their farming systems, which evidently has emphasised mucuna due to its prolific nature and easy seed harvesting which can be used in the next season. Lablab was constrained mainly by the ease with which its seed was attacked by pests, making seed saving difficult and loss of the species if seed harvested was limited also by drought. Crotalaria had the lowest proportion of farmers continuing to grow it, and registered an increasing decline of this proportion due to difficulties in getting seed, as the crop maturity required that it stay longer in the field and competed with other uses in an area of land scarcity.

These intermittent falls and rises did not imply, however, that farmers were giving up the GMCCs: farmers indicated decisions to grow the crops when conditions are conducive, such as availability of seed and rain. There had been improvements in soil fertility of farmers' fields at all topographical levels as perceived by the farmers after growing any of the three 3 species. Soil fertility improvement was reported as being least marked -- only to the "fertile" level (Figure 9) on hilltops at greatest risk of erosion -- whereas footslope soils changed from poor to very fertile. A good proportion of farmers with fields on level ground also reported a change to the fertile level, confirming the potential of the green manures to restore fertility of exhausted soils.

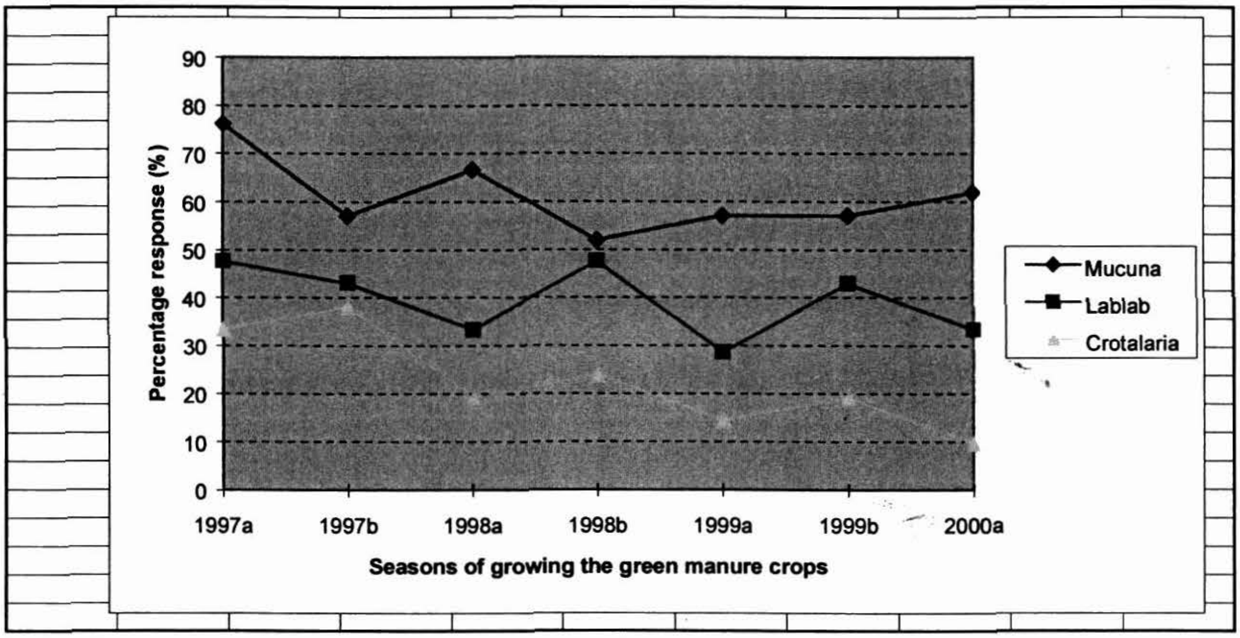

Figure 8: Farmer responses on growing green manure cover crops between the seasons of 1997a and 2000a.

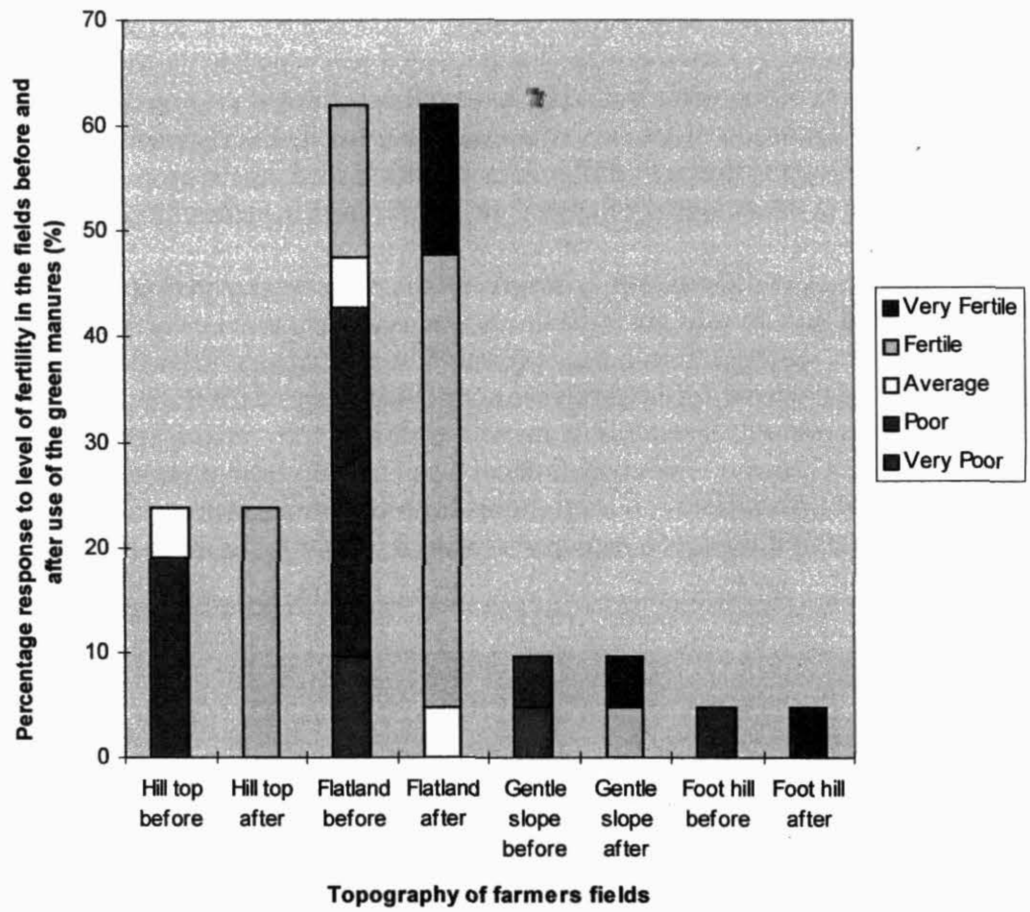

Figure 9: Soil fertility levels before and after farmers planted GMCCs along the catena.

Main constraints to integration included drought, limited land size and lack of tenure, and inadequate lablab and crotalaria seed. Neighbouring farmers were aware of the green manure cover crops but lacked practical knowledge on their use, while organisational and leadership problems explained why some farmers dropped out of the trials. Diffusion of the technologies took place, according to participant farmers (but not tested in a random survey). Women claimed to have contributed greatly to the diffusion process, and reached more women.

A diffusion study is needed, exploring gender roles and effects of the technologies on farming systems and household economy. This needs follow up on integrating the green manure cover crops, especially new findings, and facilitate self reliance and participatory propagation of the technologies within the wider community. Mucuna and lablab should be promoted among farmers with smaller fields, while crotalaria could fit for farmers with larger fields. Possibilities of making crotalaria an earlier maturing crop could also be explored. Finally, the availability of seed for the GMCCs should be a priority for the institutions involved, and opportunities to sell the seed should be formalised and equitably managed. The potential for widespread integration of GMCCs among small-scale farmers appears is high if these factors are addressed.

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Output 2. Technologies and improved market opportunities that raise household incomes from beans.

Activity 2.1 Improve understanding of local, regional and international bean markets

This an activity of the ECABREN and SABRN networks. Their results were reported here last year, and are now being applied in new priorities for bean breeding (see Activity 2.2 below).

Three proposals were developed with Moi University in Kenya, which proposed MSc students for conducting market studies on beans. The three studies focus on (i) cross-border trade in Arusha and Nairobi regions, (ii) structure, conduct and performance of bean marketing in western Kenya and Uganda, and (iii) marketability of bean types in urban Kenyan markets.

During this year's ASARECA-convened coordination workshop among Eastern Africa regional networks, ECABREN and other commodity networks agreed to collaborate in joint market studies, to include production and price data. Committed university departments of agricultural economics are expected to take the leadership in conducting market analyses. Technical assistance is being sought from FOODNET.

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Activity 2.2 Develop new bean varieties that address these market demands

Achievements:

- The regional breeding program developed through a strategic alliance with the University of Nairobi is making energetic progress in crosses to improve the main bean market classes, while ECABREN's decentralised approach to leadership in breeding has stimulated a great increase in the number and range of crosses made by national programs this year.

- Regional trials of the SABRN bean network identified further potential varieties for direct release in the smaller member countries, and of several useful grain types including a CIAT-Uganda developed small white highly tolerant to low soil fertility and three small reds bred by CIAT (Project IP-1) excellent against ALS disease.

General Rationale and Approach: Last year we reorganised the way bean breeding is organised and supported in Africa, by placing greater emphasis on specific market classes and decentralising CIAT regional activities to management by the networks. The market-led approach to generating and sharing genetic diversity is warranted because the importance of bean sales to smallholders has continued to expand in response to demand from local, regional and international markets, and our stakeholders are increasingly organising their research by market priorities. As preferences for bean types differ greatly across Africa and across kinds of market, many varieties are needed to meet this diversity. From this year, regional breeding for each priority market class is being led by one national program having particular need and/or experience in this type. Support to this lead program is provided through a strategic alliance between the University of Nairobi, ECABREN and CIAT for a shared position in bean breeding. The lead program then becomes responsible for coordinating regional evaluations of its segregating bean populations by collaborating countries across main environments, and here we report the first full year's progress. In Southern Africa, a more centralised approach is better suited to the diversity of NARS and the generally much smaller national programs in that region.

Breeding red mottled bean cultivars for smallholder farmers in East and Central Africa

Rationale: Red mottled beans grown by small farmers account for 22% of market share in Eastern and Central Africa and 10% in Southern Africa, and constitute one the main seed types grown and consumed in Burundi, Kenya, Malawi, Rwanda, Mozambique, Uganda and Zambia. Productivity is severely constrained by diseases (angular leafspot, anthracnose, root rots bean common mosaic virus and common bacterial blight), they perform poorly in soils low in N and P, and are adversely affected by Al and Mn toxicity and moisture stress. Local cultivars have low yield potential. A network-coordinated regional program involving University of Nairobi and NARO of Uganda was initiated in June 2000 to develop improved marketable red mottled bush bean varieties with resistance to two or more biotic and abiotic constraints, acceptable cooking and culinary qualities. Outputs are expected to be segregating populations for distribution to network member programs, advanced lines for further evaluation by smaller or weaker NARS and, eventually, red mottled varieties with multiple constraint resistance for farmers.

Methods: A working collection was assembled from segregating populations, multiple constraint nurseries and advanced lines from CIAT regional programs and from Colombia (Project IP-1). Potential parents for the crossing program were identified from old and current commercial cultivars contributed by national programs. F_5 and F_6 lines previously selected for resistance/ tolerance to angular leafspot, drought, anthracnose, rust, seed and other morphological characteristics were tested for yield at Kabete, Juja and Thika (Kenya) in a preliminary yield trial during 2000B (November 2000 to February 2001) and in an intermediate yield trial at Thika and Kabete in 2001A (April to August 2001). An advanced yield trial was conducted at three sites in Uganda (Namulonge, Ngetta and Kachwekano). Advanced red mottled lines were also evaluated on-farm by 10 farmers in each of five districts in Uganda.

Crosses were made to transfer resistance for angular leafspot, anthracnose, root rots, CBB, tolerance to low soil N, P and acidity at Kabete and Namulonge. To speed up the transfer of resistance, multi-parent and heterozygous males with two or more resistances were created in single, three-way and double crosses. These will be crossed with locally popular red mottled recurrent parents including GLP 2 (known as K20 in Uganda), Lyamungu 85 and Lyamungu 90. In these crosses, Mexico 54, G 5686 and BAT 332 were donors for resistance to angular leafspot, G 2333 for anthracnose, POA 2 and FEB 190 for CBB, SCAM 80 CM/5 and RWR 719 for root rots, and RWR 2075 and RWR 1946 for tolerance to low soil fertility. Backcrosses and simple crosses were made to correct deficiencies in simply inherited resistances.

Results and Discussion: Significant differences in yield were found among the 100 lines tested in both preliminary and intermediate yield trials (Table 10). Significant location and genotype x location interactions indicate that selection for adaptation to specific environments may be appropriate in subsequent evaluations by national programs and farmers. All selected lines matured in less than 95 days and are large seeded. Several materials highly tolerant to low soil fertility (AFR593, FOT 37, ECAB 0026, ECAB 0012, POA 5, RA 13170-1 and RWR 2075) were rated susceptible to rust. Several lines with I-gene were discarded due severe infection by bean mosaic and necrotic virus. Angular leafspot and anthracnose incidence was moderate at Kabete and Thika in 2001A, and all lines were rated intermediate or better.

POA 8 and AND 897 were the best yielding of the 20 lines evaluated in an advanced yield trial at Namulonge and Ngetta. Excess rain contributed to lower yields at Namulonge. Based on on-farm evaluations in five districts in Uganda, farmers selected POA 8 for high yield and tolerance to drought. In wetter districts, farmers reported that POA 8 was tolerant to excess rain but, although its seed colour was acceptable, farmers indicated that POA 8 was not as attractive as K132. Farmers also selected AFR 623 for high yield and marketability. A regional red mottled nursery was constituted by Uganda and distributed to national programs of DR Congo, Tanzania and Rwanda on request.

Table 10. Performance of the top 20 red mottled F_5/F_6 lines selected from segregating populations and other nurseries, 2000/2001.

Genotype	Days to 50% flower	Days to maturity	100-seed mass (g)	Yield (kg/ha)		
				PYT[a] (3 sites)	IYT[b] (2 sites)	Mean
VTTT 925-6-1	43	89	56.2	3038	2593	2815
[c]ECAB 0065	43	88	62.0	3063	2438	2750
AFR 709	43	88	56.7	2725	2624	2674
ECAB 0072	46	88	56.0	2956	2322	2639
UBR(95)19	44	89	59.1	2451	2679	2565
ECAB 0053	43	87	60.0	2343	2926	2634
ECAB 0063	46	93	54.7	2581	2672	2626
ECAB 0081	46	91	62.8	2994	2138	2566
ECAB 0051	42	86	55.4	2455	2694	2574
ECAB 0038	46	90	51.3	3019	1963	2491
ECAB 0092	46	89	55.5	2411	2573	2492
ECAB 0058	45	92	52.0	3088	1858	2473
ECAB 0064	47	91	52.5	3062	1745	2404
ECAB 0059	44	87	55.6	2690	2193	2441
ECAB 0071	46	91	53.6	2700	2161	2430
ECAB 0050	46	90	52.6	2576	2281	2428
ECAB 0054	43	88	57.2	2612	2209	2411
ECAB 0082	43	86	60.0	2652	2119	2386
ECAB 0084	44	89	54.0	1963	2930	2446
ECAB 0018	47	92	51.8	2313	2514	2413
Trial mean	45.5	89.3	53.2	2205	1997	2100
Genotypes	**	**	**	**	**	
Locations	NS	NS	**	**	**	
$LSD_{0.05}$	2.7	2.5	3.2	345.4	482.2	
CV(%)	5.2	2.4	5.3	23.1	21.3	

*, ** : Significant at 5 and 1% probability levels, respectively; NS= not significant.
PYT[a] = preliminary yield trial of F_5; IYT[b]= intermediate yield trial of F_6 and other advanced lines.
[c]ECAB = East and Central Africa Bush-line code for selection made by CIAT/ECABREN regional program.

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Breeding improved red kidney bean cultivars for smallholder farmers in Eastern Africa

Rationale: Red kidney bean is produced on more than 350,000 ha per year in East, Central and Southern Africa, accounting for about 11% of beans marketed in this region. They are of high to moderate importance in Tanzania, Ethiopia, Kenya, Madagascar, Rwanda, Burundi and Sudan. Their productivity is severely constrained by angular leafspot, anthracnose, root rots, low soil phosphorus and nitrogen, and drought. Most available cultivars are low yielding under low input management. A regional program was started to develop high yielding, marketable large red kidney bean cultivars with tolerance to a combination of three or more biotic and abiotic stresses.

Methods: Germplasm was assembled from multiple constraint nurseries, segregating populations, advanced lines, regional disease nurseries; the regional program at Kabete (Kenya) and Selian (Tanzania) assembled commercial cultivars. Crosses were made to transfer resistance to anthracnose, angular leafspot and root rots to commercial cultivars. Selections made from segregating populations were evaluated for seed yield at three sites in 2000B and at two sites in 2001A. They were also evaluated for tolerance to low P at Kakamega (Kenya), soil acidity at Mulungu (DR Congo) and low N at Selian.

Crosses were made at Kabete to transfer resistance to Canadian Wonder (GLP 24) and Selian 97. Canadian Wonder is the most popular and widely produced and marketed large red kidney in Eastern Africa but is susceptible to angular leafspot, anthracnose, root rots and is low yielding. Mex 54 and G5686 were the sources of resistance to angular leafspot. Vunikingi was a source of resistance to root rots, anthracnose and probably yield potential. SCAM 80CM/15 contributed resistance to root rots in these crosses. G2333 was a donor for anthracnose resistance. At Kabete we made 302 successful crosses in the program to improve resistance of Canadian Wonder and 326 crosses to improve Selian 97. The crossing program at Selian (Tanzania), which has the regional mandate for breeding red kidney beans, was restarted in 2001.

Results and Discussion: Yield differences among the 100 lines were highly significant, and the best yielding lines from the preliminary and intermediate trials are shown in Table 11. These lines had been previously been selected for resistance to angular leafspot, anthracnose and rust under field conditions. ECAB 0299, ECAB 0219, ECAB 0226, ECAB 0222, ECAB 0231, ECAB 0275, ECAB 0284 and RWR 1946 were rated susceptible to rust in 2000B at Thika and Juja. The significant location x genotype interactions indicates opportunities for selecting red kidney lines adapted to specific environments. AND 1055-1, among the top 30% best yielding lines in these trials, also showed high levels of tolerance to low P at Kakamega.

Table 11. Peformance of the top 10 red kidney F_5/F_6 lines selected from segregating populations and other nurseries, Kabete (Kenya), 2000/2001.

Genotype	Days to 50 % flower	Days to 75% maturity	100-seed mass (g)	Yield (kg/ha)		
				PYT[a] (3 sites)	IYT[b] (2 sites)	Mean
ECAB 00264	44	90	56.8	2520	2959	2740
ECAB 00271	49	92	55.5	2622	2613	2618
AFR 701-1	47	93	52.7	3029	1931	2480
RAA 31-1	48	93	50.7	2963	1993	2478
ECAB 00249	51	95	50.4	2372	2614	2493
ECAB 00278	51	96	59.9	2824	2053	2439
ECAB 00268	47	92	48.7	2939	1908	2424
ECAB 00270	49	93	64.0	2799	2028	2413
UBR(91)17-1	39	86	58.8	2479	2301	2390
ECAB 00223	46	91	46.3	2292	2435	2363
Trial mean	45.5	89.7	52.3	2074.8	1982	2028
Genotypes (G)	**	**	**	**	**	
Locations (L)	*	NS	**	**	**	
G XL	**	**	**	**	**	
LSD $_{0.05}$	2.6	3.2	3.0	406	634	
CV(%)	5.1	3.1	5.1	28.8	28.2	

*, ** : Significant at 5 and 1% probability levels, respectively; NS= not significant.
PYT[a] = preliminary yield trial of F_5 ; IYT[b]= intermediate yield trial of F_6 and other advanced lines.
Results pending from 294 red kidney lines and populations sown at Selian in 2001A.

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Breeding Small Red bean cultivars for East and Central Africa

Rationale: Small red beans account for about 20% of bean grown and marketed in East, Central and Southern Africa -- an estimated 670,000 ha sown each year. They are of high to moderate importance in Burundi, DR Congo, Ethiopia, Kenya, Madagascar, Rwanda, Tanzania and Uganda. Productivity is constrained severely by rust, angular leafspot, root rots, low soil phosphorus and nitrogen. A regionally coordinated program led by Ethiopia was initiated to develop high yielding, marketable small red bush bean cultivars with tolerance and/or resistance to a combination of three or more biotic and abiotic stresses and suitable for production in sole and intercrop systems.

Methods: A working collection was constituted from CIAT multiple constraint nurseries, segregating populations and advanced lines in Kenya, Uganda and Colombia, entries from regional disease and abiotic stress nurseries, and national programs' contributions of commercial varieties, landraces and breeding populations. Selected commercial varieties and donor parents for specific traits were crossed in Ethiopia and Kenya to combine resistances to biotic and abiotic stresses in single, three-way and double crosses. Lines selected from segregating populations were evaluated in preliminary, intermediate and advanced trials in Ethiopia, including by farmers in a participatory breeding program.

In Kenya, we made crosses to transfer rust, anthracnose, root rots and angular leafspot resistance to GLP 585 ('Red Haricot', a popular cultivar released in 1984 but very susceptible to rust, anthracnose, root rots and angular leafspot) and Maasai Red (a popular Tanzanian landrace susceptible to rust and other diseases). The recent Ethiopian releases Roba-1 and Awash were used as sources of rust resistance in these crosses; G2333 and Vunikingi contributed resistance to root rots and anthracnose; and Mexico 54 and G5686 were donors for angular leafspot resistance.

Four hundred and twenty successful crosses were made for the GLP 585 improvement program and 469 crosses for Maasai Red. The Ethiopian crossing program, started in 2001 at Awassa and will be expanded to Alemaya University, is based on improving Red Wolaita, the most popular and widely grown small red in Ethiopia but low yielding and susceptible to rust, angular leafspot, CBB, anthracnose and bean stem maggot. Donor parents included G6, EMP 376, G6450, DOR 794, DOR 716, EMP 375 and EMP 252. Additional donor parents selected for the expanded program include Mexico 54 (ALS), G5686 (ALS), XAN lines (CBB), G2333 (anthracnose), Beshbesh and Melka (for stem maggot), Awash-1 and Roba (for rust). In addition to simple crosses, the crossing programs are creating multi-parent males with multiple resistances for backcrossing to the recurrent parents.

Results and Discussion: From the Kenyan preliminary and intermediate yield trials at Kabete, Juja and Thika we selected 10 advanced lines (Table 12) having a yield potential above two tons per hectare and maturing in less than 95 days. Several materials proved susceptible to rust at Thika; BRB 71-1 and TLP 8-1 succumbed to black root and were discarded. FEB 200-1 showed moderate tolerance to low soil P at Kakamega. All lines showed consistent intermediate or resistant reactions to rust, angular leafspot and anthracnose.

In Ethiopia, advanced medium and small red lines were evaluated at 13 sites representing a wide range of production zones in the region. The most promising entries from national variety trials were DOR 527, DOR 711 and DOR 811. Farmers also evaluated and selected advanced lines in on-farm trials in Melkassa, Awassa and Alemaya in the PPB program.

Table 12. Performance of the top 10 small red F_5/F_6 bean lines selected from segregating populations and other nurseries, Kenya, 2000/2001.

Genotype	Days to 50 % flower	Days to 75% maturity	100-Seed mass (g)	Yield (kg/ha)		
				PYT[a] (3 sites)	IYT[b] (2 sites)	Mean
ECAB 00421	45	87.9	27.6	2586	2393	2489
ECAB 00419	45	90.0	27.5	2362	2269	2316
ECAB 00413	43	87.3	26.5	2413	2182	2298
ECAB 00406	48.8	92.5	25.2	1860	2624	2242
ECAB 00426	45.9	89.7	27.4	2442	2028	2235
ECAB 00417	48	92.2	26.9	2148	2243	2196
ECAB 00420	44	86.7	26.3	2665	1631	2148
ECAB 00414	44	87.8	24.9	2247	2046	2147
ECAB 00422	44	90.7	26.9	2025	2250	2138
Trial mean	46.3	90.3	26.0	2067	1944	2005
Genotypes (G)	**	**	**	**	NS	
Locations (L)	**	**	NS	**	**	
G x L	**	**	**	**	*	
LSD $_{0.05}$	2.8	3.0	1.8	290.2	665	
CV(%)	5.4	2.9	6.0	19.9	34.3	

*, ** : Significant at 5 and 1% probability levels, respectively; NS= not significant.
PYT[a] = preliminary yield trial of F_5 ; IYT[b]= intermediate yield trial of F_6 and other advanced lines.

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Breeding small white (navy) bean for smallholder farmers in East and Central Africa

Rationale: Smallholder farmers in East and Central Africa predominantly grow small white bean (also known as white pea or navy bean) for export and local canning industries. They are grown on an estimated 310,000 ha per year, account for 9.6% of total bean production in Africa and are particularly important in Ethiopia and Sudan. They are in high demand for the canning industries of Kenya, South Africa and Zimbabwe, and in urban areas where they are popular because of their taste, short cooking time and low levels of flatulence. Major constraints include susceptibility to diseases, drought, low soil fertility and bruchids. A regional program, coordinated by Ethiopia, was initiated to develop high yielding cultivars with desirable seed quality and resistance to three or more biotic and abiotic constraints.

Methods: The working collection was assembled from materials held by CIAT programs in Uganda and Colombia, and by the Kenyan and Ethiopian national programs. Selections were made for crossing programs at Kabete (Kenya) and Melkassa (Ethiopia). Segregating populations were selected for three cycles (F_2 to F_4) to identify lines with tolerance/resistance to priority constraints. The F_5 and F_6 lines were subsequently evaluated together with other advanced lines in preliminary and intermediate trials at three sites in Kenya. In Ethiopia, advanced lines were evaluated in multilocation trials.

Results and Discussion: At Kabete we made 133 crosses were made to transfer anthracnose and rust resistance from Roba-1 to Mexican 142, probably the oldest canning variety in the region but very susceptible to rust and anthracnose. This variety has type III growth habit, whereas farmers prefer type I habit for ease of harvesting and threshing. We also made 97 crosses to combine the high canning quality, tolerance to rust, BSM resistance and type 1 growth habit of Awash 1 with yield potential and resistance to anthracnose of Goberasha; the F_1 was backcrossed to Mexican 142 to generate segregating populations. In Melkassa, crosses were made to generate new breeding populations. The adapted parents in the new crosses were PAN 182, Dresden, Mex 142 and Awash 1. Donor parents were for anthracnose were Roba and Goberasha; PAN 182 and Awash for rust; HAL –5 for CBB; A262, A197 and TY 3396-3 for yield potential. Awash also contributed type 1 growth habit. Dresden has excellent canning quality but is susceptible to anthracnose, CBB, rust and angular leafspot. Single crosses were made in 2000 main season. Three-way, double and backcrosses were made in 2001off-season. Included in these crosses was 'Omar', a medium sized white bean that was identified by exporters for its quality but susceptible to rust and other diseases.

Table 13. Performance of best 10 navy/small white F_5/F_6 bean lines selected from segregating populations and other nurseries, 2000/2001.

Genotype	Days to 50 % flower	Days to 75% maturity	100-seed mass (g)	Yield (kg/ha)		
				PYT[a] (3 sites)	IYT[b] (2 sites)	Mean
BRB 148-1	45.5	89	23.7	3129	3002	3066
ECAB 00621	54.5	100	28.4	2690	2299	2495
BL 207562-1	46.9	90	27.0	2861	2084	2473
ECAB 00622	50.7	96	24.6	2210	2559	2385
ECAB 00612	50.5	94.7	18.4	2367	2348	2358
ECAB 00605	53.3	95	23.5	2936	1771	2354
ECAB 00624	52.7	97	24.8	2652	1972	2312
BRB 45-1	47.8	91	24.0	2713	1838	2276
ECAB 00623	55.0	99	21.7	2528	2015	2272
ECAB 00625	49.8	95	26.8	2777	1760	2269
Trial mean	49.9	94.7	24.5	2319	1911	2115
Genotypes (G)	**	**	**	**	*	
Locations (L)	**	NS	**	**	NS	
G XL	**	**	**	**	*	
LSD $_{0.05}$	2.6	2.9	1.9	423.2	621	
CV(%)	4.5	2.7	7.0	18.2	32.5	

*, ** : Significant at 5 and 1% probability levels, respectively; NS= not significant.
PYT[a] = preliminary yield trial of F_5 ; IYT[b]= intermediate yield trial of F_6 and other advanced lines.

We selected 10 high yielding small white lines from the preliminary and intermediate trials (Table 13). Mean yields across sites were above 2 t ha^{-1}. Lines that succumbed to rust at Thika were discarded, as were lines susceptible to black root. All lines showed tolerance to angular leafspot and anthracnose, although disease resistance will be confirmed with artificial inoculations. In Ethiopia advanced lines were evaluated in multilocation trials at 12 locations nationally, from which four promising lines were identified (UTT 24-131, UTT 27-24, NZBR 2-5, BZBR 2-8).

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Breeding disease-tolerant brown, carioca and pinto beans for smallholder farmers in East, Central and Southern Africa

Rationale: Cream colored beans account for 10% of the annual bean production in Africa – grown on 240,000 ha in Eastern and Central Africa and 120,000 ha in Southern Africa. Cream coloured bean include pinto, sugar/cranberries and carioca. Pinto beans, having good export potential but relatively low yielding and susceptible to rust, CBB, bruchids and stem maggot, are important in Ethiopia, Kenya, Madagascar, Tanzania and Southern Africa. Sugars are in high demand in South Africa and Zimbabwe, as well as being important in the domestic markets of Ethiopia, DR Congo, Rwanda, Tanzania and Uganda. Carioca types have high yield potential and good market potential for smallholder, resource poor farmers, and are in demand in the Copper Belt of Zambia and sugar estates of Swaziland, which are under-exploited markets for ECABREN countries. Major production constraints for speckled sugar bean cultivars include rust, CBB, haloblight, angular leafspot and bruchids. Brown and yellow seed types account for 11% of production and are in demand in many countries. However, available cultivars are susceptible to several disease and soil fertility constraints, and production is unable to meet demand in domestic and regional markets.

Regional programs were therefore started to develop new cultivars of these seed types with high yield potential, a combination of tolerance to three or more biotic and abiotic stresses, and acceptable to consumers in target markets.

Methods: Germplasm resources were collected from segregating populations, constraint nurseries, advanced lines, landraces and commercial varieties held by CIAT programs and by collaborating national programs in Eastern, Central and Southern Africa. Selections were made from segregating populations and heterozygous families for tolerance to biotic and abiotic stresses, plant and seed characteristics. Selected lines were evaluated in preliminary and intermediate trials to identify those with high yield potential.

Results and Discussion: A regional crossing program in DR Congo started in March 2001 for improving resistance to angular leafspot in three locally popular but susceptible cultivars: Kirundo (yellow), Munyu (brown) and Nakaja (tan). A total of 669 single crosses were made with A285, A235, Mex 54, G5686, MLB-36-89A and A339 as sources for resistance to ALS.

At Kabete we made 131 crosses to transfer rust and anthracnose resistance from Roba-1 to GLP 92 (locally known as 'Mwitemania'). Another 91 crosses were made to transfer rust and BSM resistance, and type I growth habit from Awash to GLP 92. GLP 92 is a popular pinto cultivar developed in Kenya and released in Ethiopia ('Ayenew') and Madagascar. It very susceptible to rust, intermediate for haloblight and has a type II growth habit.

Data is not shown here, although progress is comparable to that achieved in other market classes. Screening for tolerance at Kakamega (Kenya) and Mulungu (DR Congo) showed that pintos were generally intolerant to low soil N and P and low pH-complex. Following selection, a nursery of brown, tan and yellow and sugar/cranberry lines was sent to Congo for further evaluation. Similarly, a set of carioca lines was sent to Ethiopia for evaluation.

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Breeding climbing beans for smallholder farmers in East and Central Africa

Rationale: Although climbing beans a relatively recent introduction in most countries of the region, they have gained popularity among smallholder farmers because of their conspicuous yield advantage over bush types. Successful introductions to Rwanda in the mid 1980's spread rapidly to Burundi, DR Congo, Ethiopia, Kenya, Tanzania and Uganda. Continued expansion of climbing bean technology is constrained by susceptibility of available cultivars to diseases, low soil fertility and drought, and by limited adaptation of popular cultivars to mid-elevation stresses of low moisture, heat and low soil fertility. National programs also need cultivars that respond better to market preferences across the region. This regional program, coordinated from Rwanda with support from the ECABREN/University of Nairobi program, aims to develop high yielding, marketable climbing beans cultivars with resistance to two or more biotic stresses and wider adaptation.

Methods: A working collection was made from genetic resources maintained by CIAT Colombia and the national program of Rwanda, with additional germplasm from national programs of DR Congo and Sudan. The collection included entries from CIAT's core collection, advanced breeding lines, landraces and commercial cultivars. Parental lines were selected for crossing programs at Kabete (Kenya) and Rubona (Rwanda). Preliminary observations were made on 75 climbers constituting the working collection (25 from CIAT Colombia, 45 from Mulungu, DR Congo and 5 from Rwanda) in trials at three Kenyan locations during season 2001A.

Crosses were made in seasons 2000B and 2001A to incorporate root rot, Fusarium wilt, angular leafspot, anthracnose resistance and red mottled seed type into popular and well-adapted climbers. Adapted parents included the original set disseminated from Rwanda: Umubano, Vunikingi, Ngwinurare, Puebla and Urugezi. Umubano is resistant to anthracnose but susceptible to Fusarium wilt; Vunikingi is high yielding and resistant to root rots, wilt and anthracnose but is small seeded; Ngwinurare has marketable large red seeds but is susceptible to priority constraints; Puebla is tolerant to low soil fertility. Mexico 54 provided resistance to angular leafspot; SCAM 80/CM 15 tolerance to root rots. Rubona 5, PVA 8 and Urugezi are popular red mottled cultivars but with various disease susceptibilities. These parental lines were combined in single crosses in 2000B and, thereafter, three-way and double crosses are being used as males in complex crosses with well-adapted parents in the September 2001 season. More than 690 crosses were made at Kabete in 2001 to create populations segregating for red mottled, red kidney and other priority seed types and resistance to angular leafspot, anthracnose, root rots and Fusarium.

Results and Discussion: Performance varied with sites: Ol Jorok (2350 masl) was fertile, cool, wet and favorable for diseases; Kabete was intermediate in rainfall and temperature, with low disease pressure and moderate soil fertility; Thika was warm and drier with soils low in N and P. The best lines selected at Kabete and Thika are shown on Table 14. G50332, G20833, G20875, S31479 and G2333 (Umubano) were well adapted at both the high and medium altitude sites. Other lines that performed well at Kabete were M'Sole, MLB-6-90B, Nakaja, G59/1-2, MLV-56/96A, Cuarentino, MLV 227/97A, MLV-59/97A, Nginurare and Urugezi. Unsurprisingly, most lines were less vigorous at Thika and at Jorok lines were delayed in flowering from 64 to 90 days. Only a few lines were either completely free of the main diseases or showed very low levels of infection, and 11 lines were selected for their vigour and low infection (MLV-76/97A, VCB 87012, AND 10, VCB 81012, MLV 198/97A, MLV 222/97A, MLV 227/97A, MLV 216/97A, G24517, Urugezi and G20751). Urugezi showed moderate infection by viruses, and Umubano and Vunikingi were susceptible to BCMV. Lines apparently widely adapted to conditions prevailing at the three sites were G24517, G20751 and Urugezi.

Table 14. Climbing bean lines selected at Kabete and Thika (Kenya), 2001A.

Kabete (1860masl)					Thika (1450 masl)				
Genotype	DF[a]	DM[b]	100-Seed mass (g)	Yield (kg/ha)	Genotype	DF	DM	100-Seed mass (g)	Yield (kg/ha)
G20751	46	92	31.3	2382	G24517	41	85	26.8	2018
G20817	40	84	26.1	2194	G50332	40	83	25.8	2014
G20833	40	86	27.6	2784	G20833	43	88	25.5	2182
G20851	49	94	28.1	2588	G20875	49	92	20.9	2182
G20874	44	86	30.1	2818	S31479	41	85	25.9	2362
G20875	47	90	26.5	2618	G2333	40	90	28.1	2419
G24517	40	83	28.1	2814					
S31479	39	80	28.3	2683					
G2333	44	89	27.6	2688					

DF[a]= Days to 50% flowering; DM[b]= Days to maturity
Results pending from advanced lines in multilocation trials in DR Congo, Ethiopia, Rwanda and Uganda.

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Collaborators: University of Nairobi and ISAR bean teams.

Southern Africa regional trial and nursery

Rationale: Malawi co-ordinates the regional trials and germplasm exchange on beans for the Southern Africa Development Community (SADC) countries where bean is an important crop. Normally, two types of trials are distributed to the member countries. The Southern Africa Regional Bean Evaluation Nursery (SARBEN) contains improved germplasm generated by various national bean-breeding programs in the region, and the Southern Africa Regional Bean Yield Trial (SARBYT) contains outstanding or released bean cultivars from countries in the region. Upon request, specific nurseries are also distributed.

The main objective of these trials is to share germplasm within the network so that each national program or private sector can benefit from research carried out by others in the region. In particular, the beneficiaries are the weaker or smaller national programs that are unable to run a full-scale breeding program. These trials also provide way to monitor the occurrence of new and existing diseases and pests, allowing the network participants to take corrective measures.

Methods: The nursery consisted of 100 entries including one local check from each participating country. Entries in this nursery are at an early stage where some are still segregating, and most were contributed by CIAT and Malawi, and these were from two separate sources: introductions from CIAT (project IP-1) and those from the CIAT-Malawi breeding program, coded CIM. In total 25 sets were distributed in 9 countries: Mozambique (4), Zambia (2), South Africa (2), Swaziland (1), Tanzania (2), Zimbabwe (2), Angola (5), DR Congo (2) and Malawi (5).

The trial consisted of 20 entries contributed by countries in the region. Each country was required to add in one local control variety. The experimental design was a randomised complete block (RCBD) with 4 replications and 4-row plots of 4 m length. In total 23 trials were distributed to 9 countries in the region: Mozambique (4), Zambia (2), South Africa (2), Swaziland (1), Tanzania (2), Zimbabwe (2), Angola (5), DR Congo (2) and Malawi (3).

Results and discussion: Several countries have benefited from the germplasm exchange activity, and have released varieties that were distributed through the network. Almost all countries in the network have benefited from such exchange of germplasm (see Activity 5.2).

At the time of writing, data for SARBEN was available from five locations in Malawi, two locations in Zambia, two locations in South Africa, one location in Swaziland, two locations in Tanzania and one location in Zimbabwe. Angular leaf spot (ALS) was the most common disease (recorded at 11 out of 13 sites), followed by rust, common bacterial blight (CBB), floury leaf spot (FLS) and web blight (WB). In Malawi, ALS was most severe at Bembeke with scores ranging from 2-9 with Bvumbwe and Bunda in Malawi also providing good ALS pressure. Several lines showed good levels of resistance to ALS at Bembeke, with scores between 2-3, most of them from CIAT (Project IP-1), but some were from local crosses in Malawi and other sources in Africa. These include both large and small seeded materials in Andean and Mesoamerican gene pool. Common bacterial blight disease, observed in many sites, was most severe at Chitedze, where several lines showed good levels of resistance (score of 2), some like CAL 178 and BRB 178 being large seeded. Rust scores were relatively low. The level of incidence for floury leaf spot was relatively high in Malawi and southern Tanzania, and Nchena-chena in northern Malawi appears to be a hot spot. Grain yields were reasonably good in most sites except in Malawi and Zambia, with several lines yielding above 2000 kg ha^{-1} at some sites. Lines of both small and large seeded cultivars have been selected based on disease reaction and yield performance, and seed is being increased during this winter season in Malawi.

In the SARBYT, at the time of writing, data had been received from Malawi (5 locations), South Africa (2 locations) Swaziland (1ocationa) Tanzania (2 locations), Zambia (2 locations and

Zimbabwe (1 location). Severe crop damage was observed in Malawi and Zambia sites due to excessive rainfall. Disease pattern was similar to that in SARBEN (although not been included in the table). A few cultivars showed good level of resistance to ALS, including three small reds (APN 130, APN 136 and APN 138) originally developed for apion resistance at by CIAT HQ (Project IP-1). Other cultivars of interest were UBR (92) 25 (small white), OPS-RS1 (sugar), CIM9415-1 (mwezi moja) and C30-P21. The cultivar UBR (92) 25 is proving its worth and seems to have multiple constraint resistance, being good for low soil N, P and pH-complex. The navy type is of interest in the region for canning.

Yield analysis included highly significant variety x location interactions, indicating that different varieties may be recommended for different sites. The differences among sites and among varieties were also very highly significant. The mean location yields were very poor, below 1000 kg ha^{-1} at some sites in Malawi and Zambia due to excessive rainfall and severe disease pressure. Nevertheless, some cultivars selected (APN 130, APN 138, MG 38, CIM 9314-17, C30-P21 and UBR (92) 25) expressed their potential well even under such severe stress conditions.

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Collaborators: National programs of the SABRN region

Activity 2.3 Implement strategies that enable women also to benefit from increased household incomes

All bean varieties of the market classes being addressed described in Activity 2.2 (above) are also consumed and sold locally. Women usually control and retain local bean sales. We are starting to address the issue of how they might retain this control and benefit to the same degree from market class bean varieties and other new technologies primarily under Output 3.

Output 3. Pilot communities become better managers of their resources.

Activity 3.1 Catalyze improved organizational capacity in pilot communities

Achievements

- Communities in pilot sites developed action plans for management of natural resources and community capacity building, and identified indicators for monitoring project activities

Beyond Agricultural Productivity to Poverty Alleviation

Rationale: While increasing food supply is often a necessary condition for improving food security, increases in food supply and rural incomes do not guarantee improved rural livelihoods and food security at the household level. Farmers' financial benefits are often reduced by their limited opportunities for adding value to their agricultural produce, poor marketing information and low bargaining power with middlemen. Unless also resolved at the household level, factors such as chronic disease, lack of clean drinking water, gender bias, poor knowledge of nutrition and socio-cultural practices may also undermine the adequate utilization of available food. Ultimately, success of communities and of economically marginalized people depends upon their innovating, drawing in new resources and managing them well.

Transforming communities implicitly demands a radical process, such as the Freire's method of conscientisation through educating by dialogue. Changing social situations in the respective communities is not an easy task and cannot be done from outside. Communities need to define who they are, what they want and how they can get it. Positive social change and an improved quality of life requires that people themselves define that change.

As we seek an upward spiral out of poverty, it is sometimes assumed that provision of germplasm and NRM technologies is a sufficient contribution by research. Research and development projects typically focus on outcomes rather than the process by which these outcomes are achieved. Yet 'processes' are just as important as the technical targets if development efforts are to succeed and be scaled up. In this project we bring an action research perspective to poverty alleviation interventions and document the processes initiated with our development partners. We aim to influence research and development policy related to community-level natural resource management and poverty alleviation activities in the East and Southern Africa region.

Methods: In 2001, with new funding from CIDA, we initiated a pilot project in Eastern and Southern Africa entitled "Beyond Agricultural Productivity to Poverty Alleviation" (BAPPA). Design was assisted by discussion with CIAT Project SN-3. The project expects six outputs:

- Catalyze improved organizational capacity in pilot communities.
- Support farmers' experimentation and application of technical skills.
- Facilitate the ability of farmers to invest their potentially higher income in alleviating poverty
- Facilitate pilot communities to protect natural resources.

- Facilitate improved gender relations and support women's empowerment and leadership in the pilot villages.
- Develop guidelines for fostering inter-agency collaboration.

The project is now operating in pilot sites in southwestern Uganda (Rubaya Sub-county, Kabale District) and central Malawi Linthipe EPA, (Dedza District), with a third site being identified in Lushoto District of northern Tanzania (Table 15). In all sites, technologies introduced by our research partners have already enhanced agricultural productivity, e.g. through higher yielding bean varieties or soil improvement technologies. We established formal partnership agreements with NGOs which are already working in these areas to enhance food security and sustainable rural livelihoods for the poor while protecting the environment, and which also share our interest in these process issues. Initially, these are Concern Universal in Malawi and Africare in Uganda. Principles of participatory methods (equity, tolerance, self-determination and social justice, including a strong emphasis on gender aspects) are applied in addressing bottlenecks that hinder farmers from benefiting fully from research-generated agricultural technologies. CIAT facilitates access to improved technologies (e.g. for bean, forage crops and sustainable natural resource management) and approaches and tools for the participatory development of sustainable seed systems, rural agro-enterprises and natural resources management, while also establishing two M&E systems.

The two complementary M&E systems comprise one that is results-oriented and another focussing on processes. The former system is participatory in nature, whereby members of selected communities in past impact areas are involved in designing the monitoring system, and in collecting, analysing, compiling and sharing information. Process monitoring refers to the careful and systematic observation of the activities of a deliberate selection of processes, enabling us to consult with others on those processes, and learn how to steer them. Process monitoring, implemented as an in-built element of the Project (i.e. carried out by project staff), will be also used as a learning tool for capacity enhancement and organizational development. Process monitoring focuses at three levels: individual project activities corresponding to field-level outputs, relations of cooperation between institutional partners involved in the project, and cooperation among the actors within the project.

The following specific processes are being monitored:
- Negotiations, conflicts and dialogue among project beneficiaries at the village level for activities pertaining to the project's five field-level outputs.
- Empowerment of project beneficiaries fostered by the project's philosophy and approach.
- Negotiation and dialogue between CIAT and partner NGOs and the extent of learning resulting from the partnership.

Results: Pilot communities in Malawi and Uganda have started making action plans on environmental protection of the land, with gully reclamation and tree planting already taking place. In Malawi, farmers have started experimenting with new varieties of beans following training of researchers and extension staff in participatory methods.

Along with the action plans, farmers identified sets of indicators that will be used to monitor the progress of the project. Tables 16-19 show examples of indicators identified by farmers in

Kalambo village, Uganda, for environmental protection, income generation and marketing activities, improvement in gender relations and in organizational capacity. Monitoring will be conducted by farmer committees and by the project staff. Baseline surveys are underway at all BAPPA sites to document the situation at the start of the project.

Table 15. Description of BAPPA project sites

	Mugandu and Buramba Parishes, Kabale District, Uganda	Linthipe EPA, Dedza District, Malawi
Altitude (m)	*1800*	1660
Rainfall pattern	Bimodal	Unimodal
Population density	High	High
Major crops	Potatoes, beans, sorghum, cabbage	Maize, beans
Market-orientation	Moderate	Low
Access to roads	Good	Good
Level of absolute poverty	Moderate	High
Major causes of poverty	Small farm size, poor soil fertility, environmental degradation, low prices for agricultural produce	Poor soil fertility, drought, low agricultural production

Table 16. Indicators identified by farmers for monitoring improved environmental protection, Kalambo village, Kabale District, Uganda

Activity	Indicators
Control gullies by digging trenches and ditches	• Number of reclaimed gullies • Number of trenches and ditches made weekly
Restore contour bunds	• Number of restored bunds with 1m strips of grass left uncultivated
Plant agroforestry trees for firewood, climbing bean stakes, fodder, improved soil fertility (e.g. calliandra, Sesbania sesban, ficus, etc)	• Number of households that have planted agroforestry trees • Increased yields of potatoes, beans, sorghum where trees have been planted • Number of farmers using stakes from agroforestry trees
Plant hedgerows for stabilizing bunds, fodder, firewood	• Number of hedgerows planted • Number of stabilized bunds • Number of households harvesting firewood from hedgerows

Table 17. Indicators identified by farmers for monitoring income generation and marketing activities, Kalambo village, Kabale District, Uganda

Activity	Indicator
Introduction of new potato and bean varieties	• Number of households growing new bean and potato varieties • Increased acreage planted to new bean and potato varieties • Increased yields from new varieties
Higher crop yields and income	• Number of households that are food secure • Reduced number of households that suffer severe food shortages in a year • Reduced number of children suffering from malnutrition
Introduction of improved livestock (zero-grazed cows) and livestock for income generation (pigs, rabbits)	• Number of households with introduced breeds/animals • Number of introduced breeds/animals in the village
Income generating activities for women	• Number and type of income generating activities introduced • Number of women involved in new income generating activities
Introduction of new cash crops (pyrethrum, coffee, etc.)	• Number of households growing new cash crops • Price of new cash crops
Explore new marketing opportunities for potatoes, beans, wheat and sorghum	• Number of sale agreements organized • Increased number of buyers • Increased quantities sold at individual household level • Increased farm-gate prices for targeted commodities
Link community to institutions for training in small business development skills and marketing	• Number of people training in business skills

Table 18. Indicators identified by farmers for monitoring improvement in gender relations, Kalambo village, Kabale District, Uganda

Area of intervention	Indicator
More balanced division of labor between husbands and wives	• Increased number of husbands involved in agricultural activities • Increased number of couples who have mutual understanding or work together in development activities • Increased number of wives participating in planning for the family (e.g. budgeting)
Involvement of both husbands and wives in development activities	• Number of couples attending training activities and project meetings together
Improved relationship and cooperation between husbands and wives	• Fewer court cases related to domestic disagreements and domestic violence • Fewer divorce cases

Table 19. Indicators identified by farmers for monitoring improvement in organizational capacity, Kalambo village, Kabale District, Uganda

Activity	Indicator
Train community leaders in leadership skills	• Number of people trained
Train new/existing groups to improve organizational capacity	• Number of people and groups trained • Number of training activities conducted

Contributors: C. Chitsike and S. David
Collaborators: C. Musoke, J. Bariyanga and M. Besigye (Africare, Uganda); Mapemba and Sengole (Concern Universal, Malawi).

Activity 3.2 Support farmers' experimentation and application of technical skills

Achievements:

- A decision tool for integrating fertility-restoring legumes into low-input highland farming systems was developed by monitoring the behavior and criteria of an Ethiopia farmer research group in incorporating new cover crop options into various system niches.

- Introducing mixtures of early and late maize varieties created a promising new niche for incorporating legume cover crops into the less intensive and more degraded system in farmers' outfields.

Decision guides for integrating legumes into East African Highlands farming systems

Rationale: Nutrient depletion in arable lands is the main constraint to agricultural productivity in the East African Highlands, and is related to a combination of soil erosion, nutrient mining and an absence of fertility restoring practices. Most farmers have very low financial resources, so research needs to be directed to affordable, risk-averting and profitable amendments. Organic inputs in the form of green manuring or crop residue could increase nutrient balance, soil water content and availability of nutrients. However, strong competition for crop residues between livestock feed, soil fertility and fuelwood limits their use for soil fertility amendment. Integration of legume cover crops into the farming systems in Africa has been low partly because recommendations were in the form of packages without considering socio-economic factors. Guidelines could help farmers of differing socio-economic circumstances to target legumes types to different agro-ecological niches.

Methods: The research was conducted at the Gununo (Areka) in southern Ethiopia, characterised by steep slopes divided by v-shaped valleys of seasonal and intermittent streams and mean annual rainfall and temperature of about 1300 mm and 19.5 °C, respectively. Rainfall is unimodal with a long growing period from March to October and a short dry spell in June.

Seven species of legume cover crops (LCCs) -- trifolium (*Trifolium quartinianum)*, stylo (*Stylosanthus guianensis*), crotalaria (*Crotalaria ochroleuca*), mucuna (*Mucuna pruriens*), tephrosia (*Tephrosia vogelii*), vetch (*Vicia dasycarpa*) and canavalia (*Canavalia ensiformis*) -- were planted on three dates last year under farmer management. Two food legumes -- common bean (*Phaseolus vulgaris*) and pea (*Pisum sativum*) -- were also included. The trial also served as a farmer field school to introduce communities to soil improving LCCs. Once farmers made their choices, seeds of selected LCCs together with an improved pea variety were distributed to 19 interested farmers for evaluation over two years. We have used participatory procedures of Pretty et al. (1995) for data collection on farmer decisions and documenting their perceptions.

Results: Farmers' selection criteria went far beyond biomass production (Figure 10). After intensive discussion among themselves, farmers agreed on seven criteria, but having different weights for farmers of different categories. They considered the most important criteria to be: firm root system (strength of the plant during uprooting), rate of decomposition (strength of the stalk and/or the leaf), moisture conservation (moistness of soil under the canopy), drought resistance (wilting characteristics of the leaf on warm days), feed value (livestock preference), biomass production (a combination of early aggressive growth and dry matter production) and early soil cover. For resource poor farmers (who commonly own no or just a few animals), green manure crops with fast biomass production (crotalaria and mucuna) were the best. For farmers who own sloping land with erosion, mucuna and canavalia were considered to be the best -- mucuna for its mulching properties and canavalia for its firm root system that reduced risk of rill erosion. On the other hand, farmers with livestock selected legumes with feed value and fast growth -- vetch, trifolium and stylo. Vetch ranked highly despite low dry matter production, mainly for its early aggressive growth and easy decomposition.

Interestingly, none of the farmers mentioned labor shortage as a potential constraint. The overall sum of criteria, however, showed mucuna followed by crolataria and vetch as the best candidates for the current farming system of Areka. Since mucuna is competitive when grown in combination with other crops, it could be used to increase soil fertility in well-established perennial crop fields (e.g. homestead stands of the false banana *Musa ensete*), while crotalaria could be used on arable outfields. Farmers selected degraded corners of the farm for the LCCs and fertile areas of their land for food legumes, partly due to risk aversion and partly to avoid occupying land that could be used for growing food crops.

Guidelines for integration of legumes:
PRA studies, structured questions and informal discussion with farmers showed that nine factors affect integration/adoption of legumes. Comparing those factors in a pairwise analysis identifies four main indicators of different hierarchy:

- land productivity (associated by Gununo farmers with the fertility status of the soil);
- farm size (average farm size in Gununo is less than 0.5 ha per household);
- ownership (without ownership or security of tenure, farmers were unlikely to invest in new soil fertility amendment technology);
- livestock feed (an important criterion in evaluation of new crops and varieties).

These indicators, with experimental biomass data, were used to develop the decision guide presented in Figure 12 and Table 20. Land productivity is placed highest in the hierarchy. Farmers owning degraded arable lands were willing to integrate green manures, while those who own large and productive areas want food legumes that also have feed value. However, all farmers prefer food legumes regardless of farm size or land productivity; beans and pea are already in the system and farmers find niches to grow them as they are important in local dishes. Those farmers with degraded soils selected crotalaria, as they found it better performing even under extremely degraded conditions. However, about 45% of farmers with degraded arable lands are not willing to grow green manures, mainly because their farm management including crop choice is decided by a share holder or contractor.

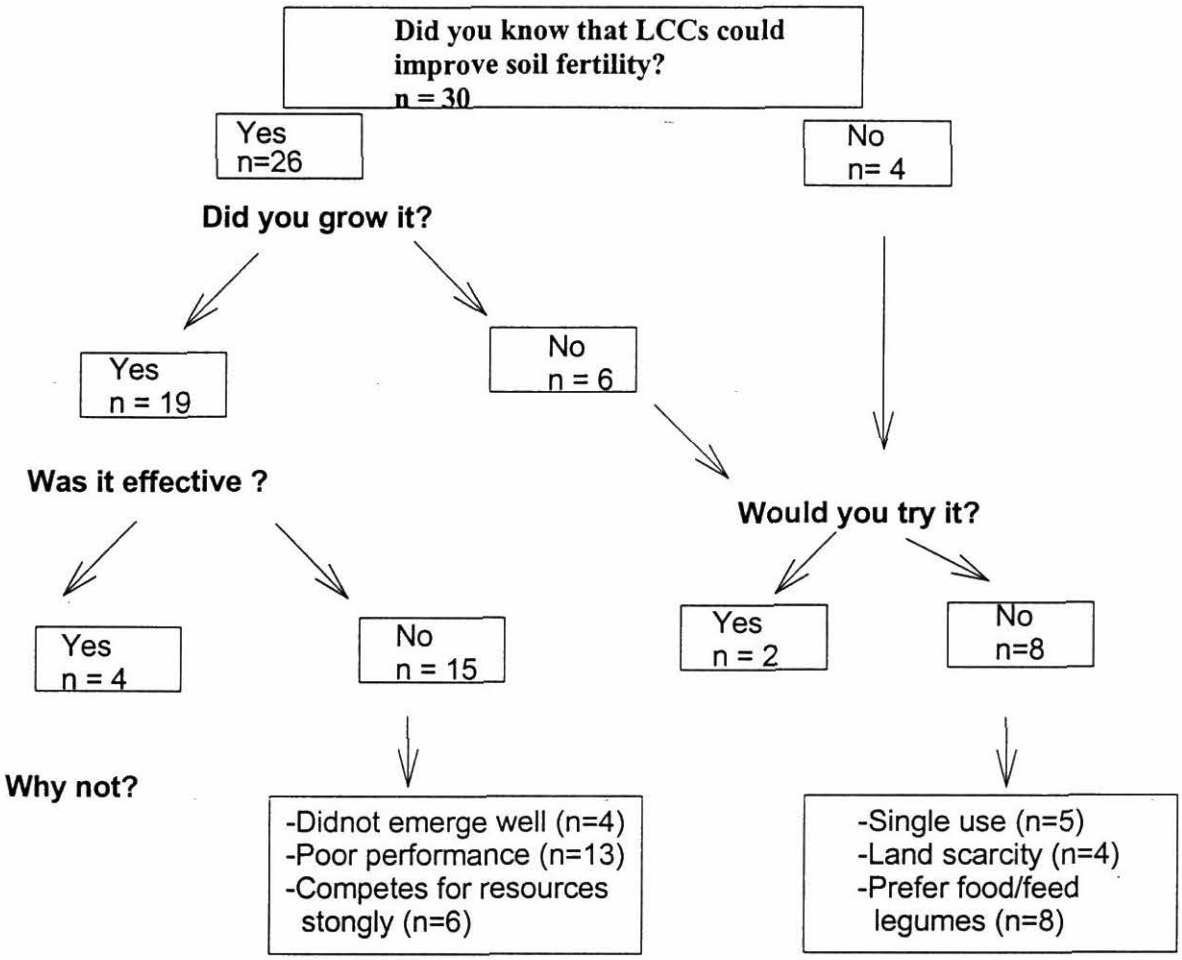

Figure 10. Processes in identification of factors affecting adoption of legume cover crops in multiple cropping systems of Areka, Ethiopia.

Given the serious land shortage, farmers in Areka may not allocate the full season for LCCs (Figure 10), especially when the land is relatively fertile. As the homestead fields are relatively fertile and used for intensive intercropping and relay cropping, growing LCC on that part of the land may not appear economic. On the other hand, farmers with larger farms and a high degree of degradation may go for selected green manures, with the potential niche currently available for their integration being the furthest outfield where potato is grown in rotation with maize. The length of the growing period together with its amount and distribution also dictate whether the system may allow legumes intercropped with maize or with perennials, relay cropped with maize or only monocropping. In regions distant from the Equator like Areka where the growing season lasts up to eight months, green manures that are less nutrient demanding could be appreciated for depleted outfields.

Maize is the staple crop in the region, and 45% of arable land in Areka is allocated for maize. Figure 11 shows a decision tree developed to improve nutrient availability in maize at low cost through using legumes alone or in combination with inorganic fertilizers. This decision tree is developed based on the following background information:

- food legumes are more favoured by farmers than non-food legumes despite soil degradation;
- the underground biomass of beans and pea is too small to effect soil fertility;
- use of legume crop residues or green manure as feed often leads to most nutrients being exported;
- green manures produce much higher biomass when relayed early into maize at the milky stage of maize, because end-of season drought affects short-term fallow;
- the homestead area is much more fertile than the outfield, so species sensitive to water and nutrient deficiency will do better in the homestead.

Table 20. Guidelines developed with farmers for identifying potential niches for legumes in multiple cropping systems of Areka.

Position in farm	**Farm size**	**Soil fertility status**	**Demand for fodder**	**Best-bets**	**Potential niche**
Homestead	Large	Productive	high	Beans	Intercrop under enset/coffee
				Mucuna/stylo	Intercrop under maize/taro
			low	Beans/ pea	same
	Small		high	Beans/Pea	Intercrop under enset/coffee
			low	same	same
Outfield	Large	Productive	high	a) Beans b) stylo/mucuna	a)sole/intercrop b) relay under maize
			low	a) Beans/pea	sole/intercrop under maize
		Unproductive	high	Mucuna/stylo	Relay/short fallow
			low	a)Crolataria b)Canavalia	a) relay crop b) intercrop
	Small	Productive	high	a) Beans/Pea Mucuna/stylo	Relay/intercrop under maize
			low	Pea/beans	same
		Unproductive	high	Stylo/mucuna	Relay crop Short fallow
			low	Crotalaria/ Canavalia	Relay crop Short fallow

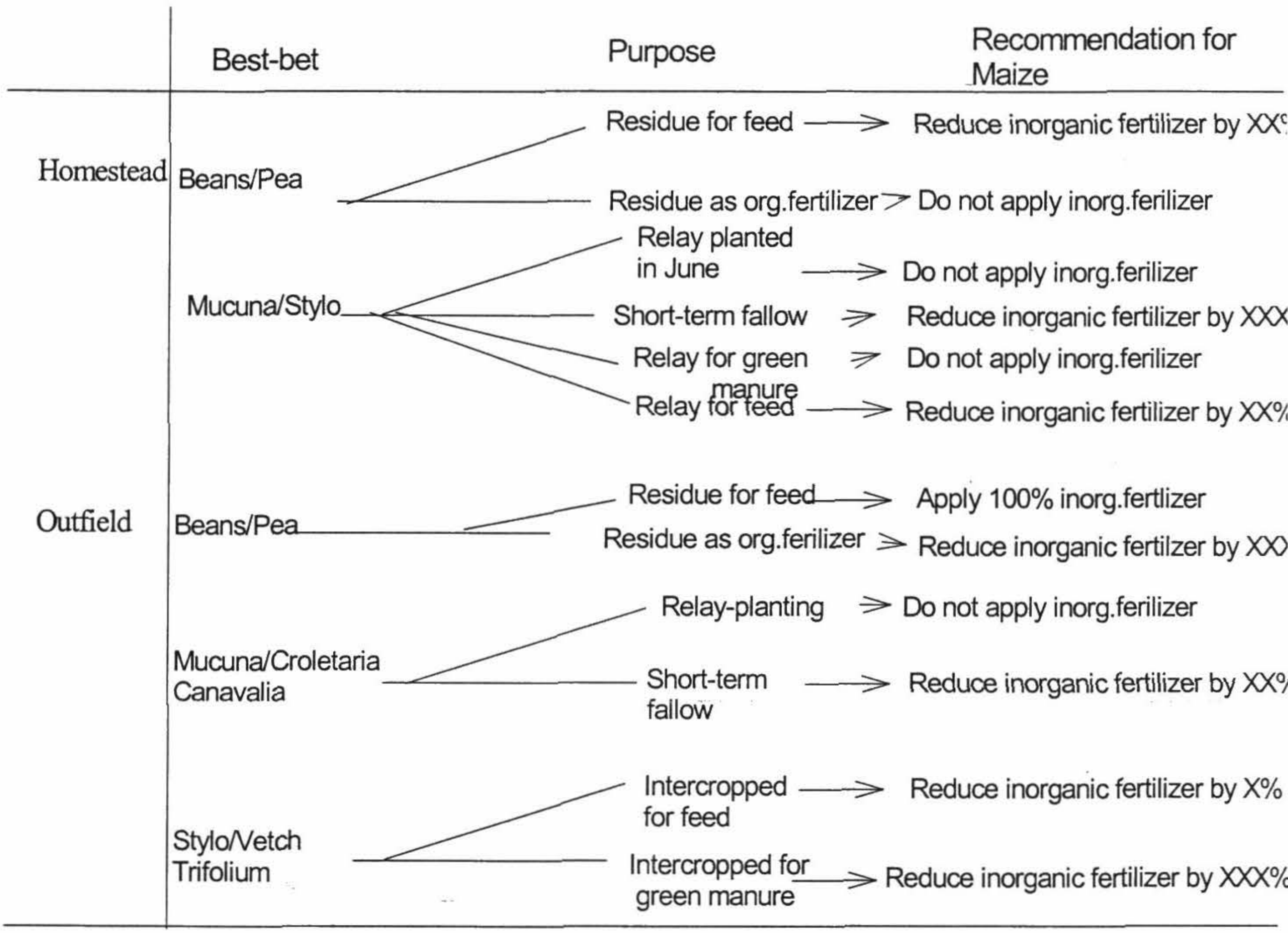

Figure 11. Decision tree for growing maize following food legumes or green manure.

Note: X%, XX% and XXX% indicates a small, medium or large proportion of inorganic fertiliser (mainly N) to be deducted from the recommended rate, respectively.

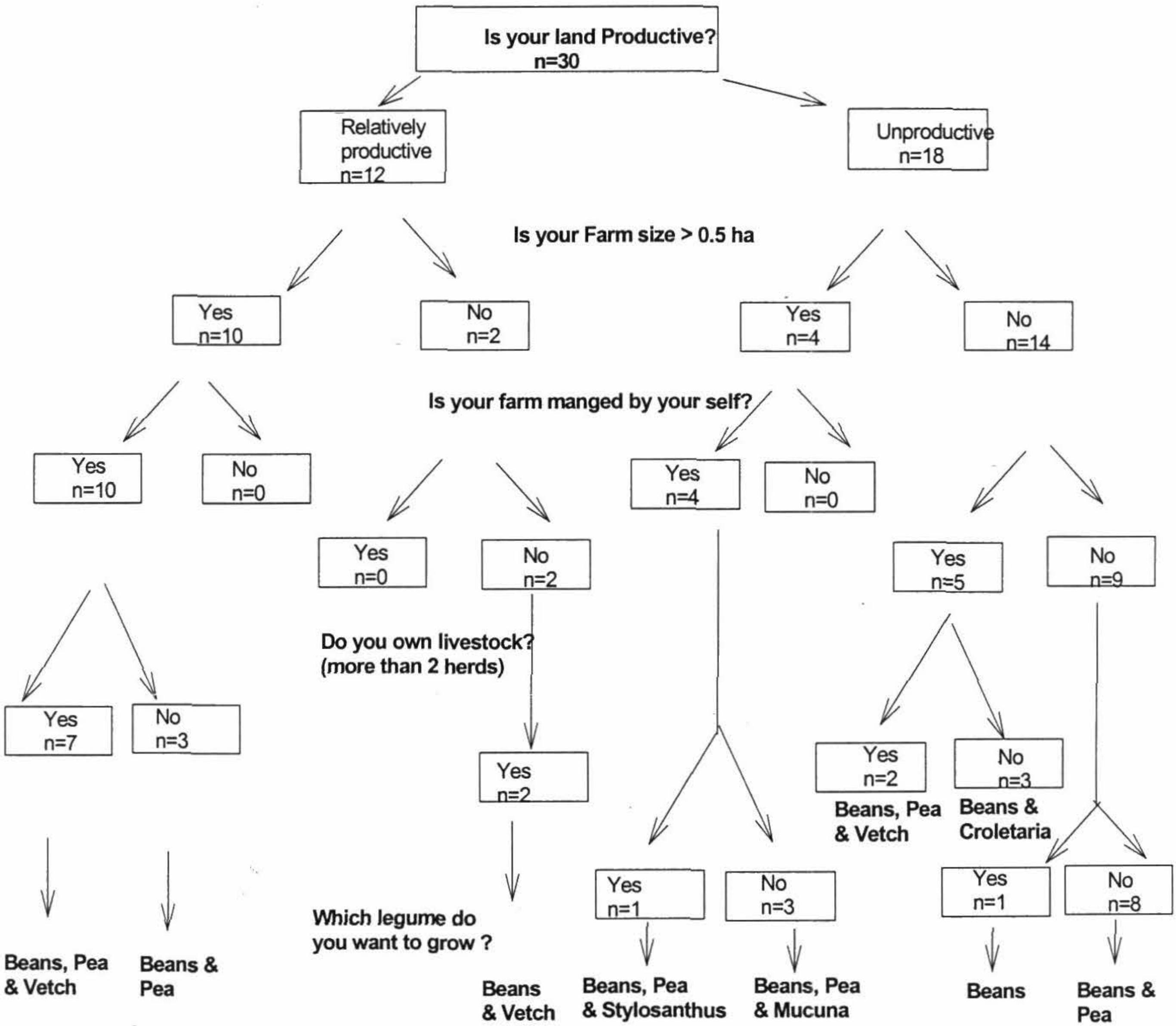

Figure 12. Guidelines for integrating legumes into multiple cropping systems of Areka, Ethiopia.

Contributor: Tilahun Amede
Collaborators: R. Delve (CIAT/TSBF); R.Kirkby; Team of Areka Research Centre.

Maize varietal mixtures: A niche for integrating multipurpose legumes

Rationale: Fallowing with legumes could be expensive in terms of land and labor. On-station studies showed that maize/legume intercropping may cause up to 30% yield loss in maize. On the other hand, relay cropping reduces biomass production of legumes exposed to end-of-season drought, especially in areas with short growing period. We hypothesize that legumes grown under maize varietal mixtures could produce higher biomass than if grown under sole varieties, and relay cropping is facilitated after harvesting the early maturing variety. Earlier on-station investigations showed that growing early and medium maturing maize cultivars in mixtures could also improve maize yield through reduced competition.

Methods: Sixteen farmers evaluated the effects of maize varietal mixtures on the growth and biomass production of LCCs was conducted with farmers in Areka, southern Ethiopia during the main rainy seasons of 2000 and 2001. A mid-late maturing maize variety (A511, 145 days to maturity, 245 cm tall) and an early variety (ACV6, 120 days, 204 cm), found to be compatible in earlier experiments, were mixed at equal proportion and planted simultaneously in mid April. Seeds of vetch (*Vicia dasycarpa*) were undersown 35 days after maize emergence. The vetch was harvested three months after planting. As soil fertility in the Areka farming system declines with distance from the home (the homestead being the most fertile and the outfield being less fertile), the experiment was conducted both on homesteads and outfields. Grain yield of maize, biomass of vetch and farmer perceptions on the technology was recorded.

Results and Discussion: Grain yields were significantly different between ACV6 and A511 varieties as reported earlier (Amede, 1995), due to maturity periods. Grain yield was significantly higher in homesteads than in the outfield (Figure 13) regardless of treatments, and grain yield in the outfield was about 50% less than that of the homestead field. Vetch biomass yield was more affected by soil fertility than maize varieties or mixtures. About 4 tonnes/ha of dry matter of vetch was produced in the homestead field within three months regardless of the type of maize varieties. Vetch biomass from the outfield was about 30% of the biomass produced under homestead fields. Vetch yield under mixtures was higher than under the mid-late maturing variety and, as maize grain yields of the mixtures and the late maturing variety were similar, growing maize mixtures may overcome reluctance to adopt forage legumes.

The outfield is the most degraded corner of the farm, where farmers do not apply organic resources because of the labor requirement and shortage of manure. In homesteads farmers grow mixtures of crops (coffee, maize, beans, sweet potato, rapeseed and others), while outfields grow either sole maize or potato. The outfield is therefore a potential niche for integration of legumes despite very low yield of vetch in this part of the farm. Other LCCs that are not sensitive to poor soils (e.g. Crotalaria) may be more effective in this niche. However, despite its low biomass, Areka farmers indicated they would like to continue with vetch as they obtained significantly higher maize yield afterwards (probably due to its high decomposition rate related to the low content of lignin and polyphenols) and appreciated its feed value.

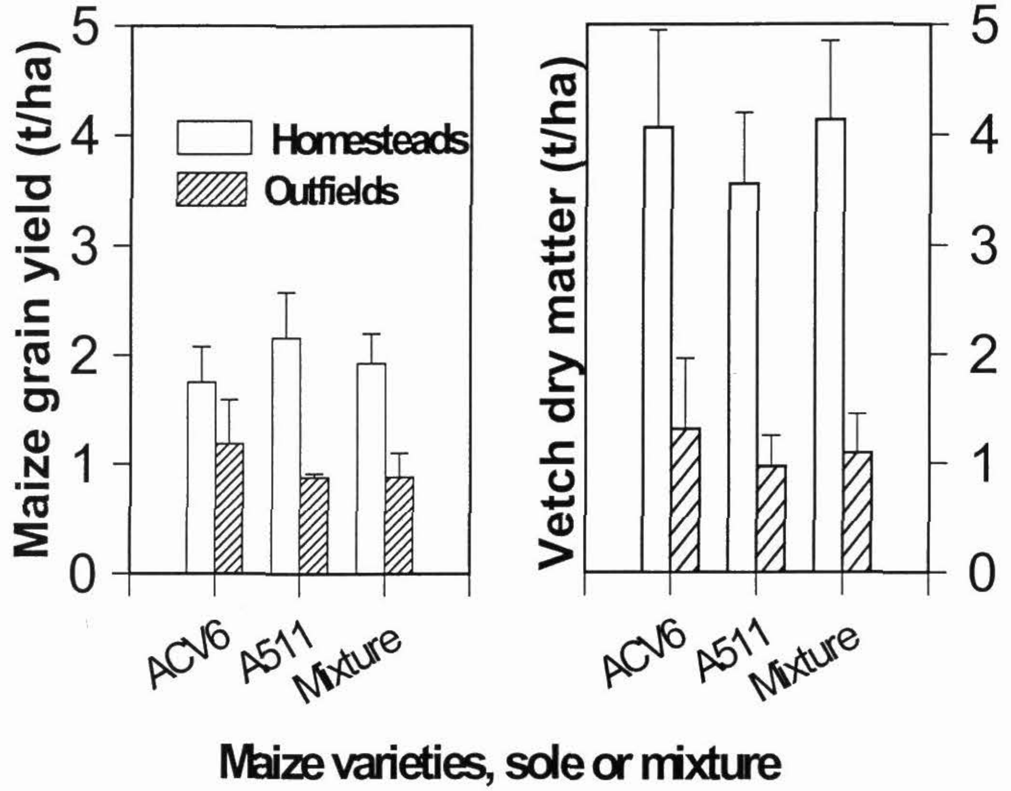

Figure 13. The effect maize (sole or in mixtures) on maize grain yield and biomass production of Vetch intecrop.

Contributor: Tilahun Amede
Collaborators: Teams from Areka Research Centre (Ethiopia) and AHI-Lushoto (Tanzania).

Activity 3.3 Develop an approach to strengthen community capacity to invest their potentially higher income in alleviating poverty

This is a current activity and future output from further development of BAPPA under Activity 3.1 above.

Activity 3.4 Assist farming communities to protect their environmental resources

Achievements:

- An Ethiopian farmer research group rapidly became enthusiastic about soil conservation once their testing of new forage species along contours led to increased production of milk and manure; the very poor, who lack livestock, prefer evaluating legume cover crops.

- Developing a farmer typology proved important in designing indicators for natural resource management.

Fostering system integration and intensification in the East African Highlands

Rationale: NARS and IARCs are under pressure to achieve impact on food security and natural resource management, although currently there is no consensus on how to increase real incomes and productivity of smallholders while sustaining the resource base. It is recognised that doing so is a more complex task than developing improved technologies alone (Eicher, 1987), in part because small farmers appear reluctant to invest in technologies that do not promise quick and reliable payoffs that satisfies immediate needs. An integrated farmer-led research agenda is needed where the farmer invests time and some limited resources on partnership and technology development. This strategic work contributes to the regional NRM research.

Methods: We worked intensively with the Ethiopian research system and its partners, in collaboration with the African Highlands Initiative (AHI), around Areka, southern Ethiopia, selected as a pilot site by EARO for testing NRM methods and approaches. The research team is multidisciplinary and involves five different governmental and non-governmental institutions. Several participatory tools for NRM have been employed since 1997 to facilitate and monitor the shift from commodity-oriented to more a holistic approach in which farmers were in the forefront throughout the processes of technology development, dissemination and impact assessment. Based on a stratified wealth ranking and social analysis, 24 farmers were selected as partners for participatory NRM research.

Results:

Implementing integrated approaches
Integration is a multi-faceted approach that treats components at different scales. Working closely with farmers has promoted a change of researchers' "mind sets" to add social and economic inputs into their traditional component/discipline approaches by infusing a systems perspective to achieve multiple goals by strategic combinations of technologies. The approach has involved other partner institutions, a better understanding of social group dynamics and variation in resource endowment, fostering a high level of farmer participation, and taking a "larger view" by encouraging specialists to work together to improve the system.

Evolution of farm-based integration
Experiences at Areka showed that farm level integration could provide a realistic jump towards implementing watershed and district level integration of disciplines, partners, institutions and

policy inputs. Medium and poor categories of the community at Gununo, representing about 75% of the population, face *declining land productivity*. These farmers do not own livestock, hence have no access to manure, lack cash to buy in inorganic fertilizers, organic residues and improved varieties, and also lack internal farm inputs (oxen for plowing, and seed). Hence, they usually offer their farm for share cropping to fellow farmers who have more resources. Under share cropping, those working the land want to maximize their harvest but are less likely to be interested in future productivity and therefore invest less in land care.

The entry point used with this group was strategic soil and water conservation. In the first year, collaborating farmers were encouraged to construct a soil conservation bund about 15m in length, the approximate width of individual farm outfields (usually strips oriented down the slope). They strengthened these bunds by planting elephant grass, multipurpose trees and pigeon pea on the top and sides. After witnessing the benefits, farmers constructed bunds totally about *seven times* as much in the following year, dividing their strip of land into as many as eight plots following the contour. As the soil bunds were planted with the new forage grasses, farmers produced a large amount of dry season feed, which they estimated as covering 35% of their feed demands. Next, farmers asked for ways to increase soil organic matter and nutrients. As many farmers did not own animals, crop residue management and legume cover crops (LCCs) were suggested by farmers and researchers together for testing as potential alternative interventions for this farmer category. The other measure they took was to stabilize gullies draining water from neighboring fields, firstly by stone blocks to reduce the velocity of run-off and then by planting indigenous trees. After having increased livestock feed resources through growing grasses and legumes on the soil bunds, farmers asked for credit and bought young calves, partly for fattening and selling, partly to grow into milk cows, and for recycling feed as manure. They have also planted more Eucalyptus trees to get more cash and fuel wood to reduce negative trade-offs. At least one farmer explained how doing this had enabled him to switch from burning maize stover to incorporating it for soil fertility improvement.

The evolution of improved integration among the different farm components was very fast for this group, mainly because their production system relies heavily on internal resource flows and rarely involves external inputs. Dissemination of the approach and technologies was much faster than anticipated, thanks to farmer-to-farmer exchange and also frequent visits and discussions among farmers of different communities through their farmers research committee. On the other hand, wealthier farmers followed a different path of integration, mainly by seeking improved inputs (Figure 14).

Elements of systems integration and a more holistic approach

Farmers started to try more technologies, to innovate, adapt and integrate them into their situations and, in the process, to derive many examples of "win-win" technologies that are useful for various categories of farmers. Notably, not all technologies were subjected to formal experimentation. The researcher role is therefore changing to one of introducing new ideas rather than design and control of experimentation, of monitoring with the aim of understanding farmers' innovations and evaluations, and of providing support to scaling up.

Strategically, different driving forces determine the mode of intensification in this subsistence farming system. The main elements (driving forces) determining the direction of intensification are: market, climate, land quality, household status and policy. In areas where market access is poor, such as in Areka (due to inaccessibility or poor policies) farmers tend to depend on internal resources. With the improved partnership with research and the improved cohesiveness of the community groups provided by the farmer research committee, farmers have adapted and combined technologies, and have become articulate in their understanding of system interactions.

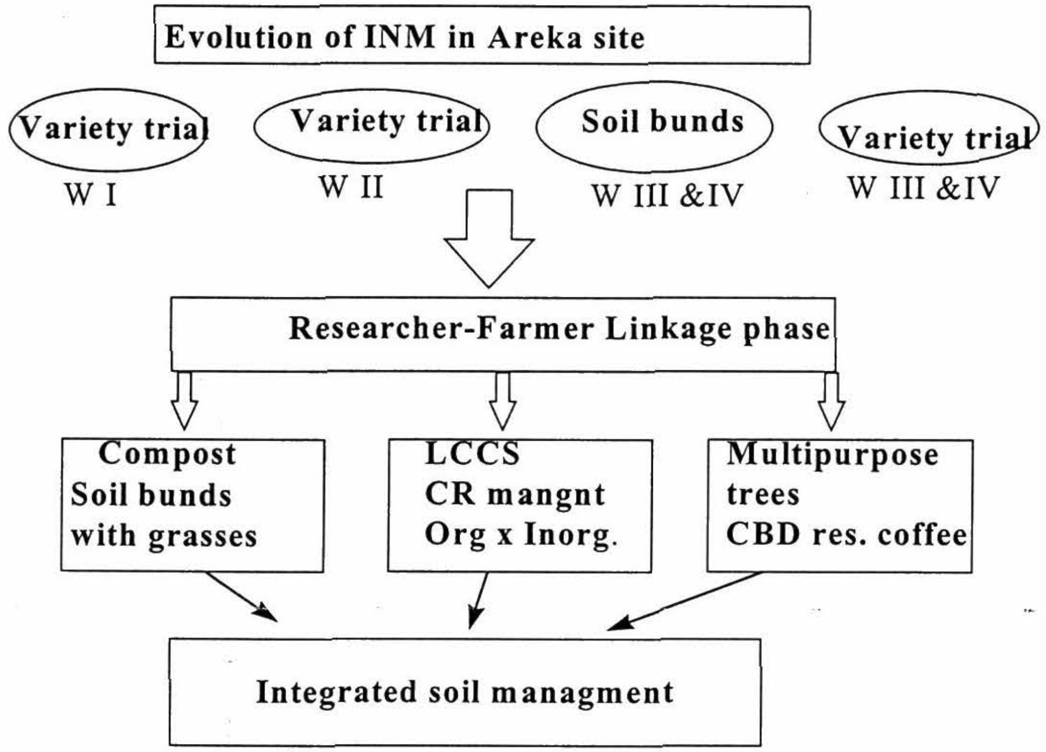

Figure 14. The evolution of participatory research from varieties to land management in Areka, Ethiopia.

Contributor: Tilahun Amede
Collaborators: A. Stroud (ICRAF/AHI); R. Kirkby; Team of Areka Research Centre.

Indicators of natural resource management: Farmer typology

Rationale: Land degradation in the East African Highlands ranges from decline in soil fertility to complete loss of arable lands, resulting in food insecurity and deterioration of livelihoods. Development workers, researchers and policy makers are interested in tracking the changes obtained through agricultural development or research projects, but analyzing changes in natural resource management is difficult. Different actors understand indicators differently the broad indicators of sustainable NRM, depending on resource base, education and other socio-economic features. Indicators may be employed across environments but rarely across communities unless the social dynamics are well understood.

Methods: Through discussions with individual farmers in an Ethiopian benchmark site for NRM research, we searched for locally meaningful indicators of NRM, from farm through watershed to landscape levels. After all potential indicators were assembled from individual farmers, a structured questionnaire was used. For data collection, two groups of farmers (relatively rich and poor, 15 from each) were selected after they grouped themselves on the basis of resource endowment. Seventy-two indicators, which could be categorized into 19 groups, were tested. A pair wise analysis was employed.

Results and Discussion: The African Highlands Ecoregional programme (AHI) identified five key elements for improving integrated natural resource management: improved economic status, increased capacity, availability of appropriate technologies, conducive policy and presence of cohesive social groups. The NRM indicators tested were intended to target one or more of those NRM elements. The most important indicators for relatively rich farmers were access to social amenities (health care, ability to send their children to school, village roads and presence of external services), access to land resources (tenure, farm size and number of plots), ownership of livestock (number and productivity), food security (seasonal distribution, food availability), soil depth, plant vigor, and access to firewood. Indicators of crop productivity or soil fertility status were ranked lower. Despite the frequent complaints about markets, these farmers did not appear to give it importance.

On the other hand, poor farmers ranked food security elements (number of food deficit months, food diversity and market price), labor issues (labor availability, labor productivity and access to family labor), access to social amenities, and availability of firewood as very important indicators. Both groups ranked social status (membership in organization, leadership in organization and status in community) as relevant but not fundamental indicators of wellbeing. The study will be repeated in other benchmark sites of AHI partners outside Ethiopia, so as to learn how farmers elsewhere respond, and quantitative data on scientific indicators will also be collected.

Contributor: Tilahun Amede
Collaborators: AHI-Areka team; AHI-Lushoto (Tanzania); P. Sanginga (PRGA/CIAT); C. Opondo (ICRAF/AHI).

Activity 3.5 Support women's empowerment and leadership at the community level

This is a current activity and future output from further development of BAPPA under Activity 3.1 above.

Output 4. Wider impact from bean technologies across Africa.

Activity 4.1 Reinforce sustainable approaches to decentralized seed systems

Achievements

- New evidence on seed demand from farmer seed enterprises suggests the need for a multi-commodity approach to commercial seed production.

- Surveys in Uganda showed the need for improving farmers' understanding and knowledge of bean diseases as a basis for their adopting crop and seed management practices that would contribute to seed health of predominantly farm-saved seed.

Revisit small farmer seed enterprises in Uganda

Rationale: A number of commodities, namely self-pollinating crops (beans, rice, groundnuts), vegetatively propagated crops (potatoes, sweet potatoes, cassava), crops with limited seed demand (indigenous vegetables, forages) and open pollinated maize bring little profit to seed companies for various reasons: uncertain and fluctuating demand caused by competition from farm-saved seed, a low multiplication rate or, in many cases, strong regionally specific preferences. PABRA/CIAT promotes decentralized seed production initiatives as a sustainable approach to disseminating seed of modern crop varieties and accelerating their adoption.

Methods: Between 1994 and 1997 CIAT worked with farmer groups in Uganda to promote small-scale commercial bean seed production. Monitoring of these groups has continued to assess the sustainability of farmer seed enterprises (FSEs).

Results: Two Ugandan farmer groups which started commercial seed production in 1993 and 1995 respectively, the Iganga Bean Farmers' Association (IBFA) and the Makhai Women's Group (MWG), were still producing seed in 2001, 6 to 8 years after they started. Although production figures are unavailable, anecdotal evidence suggests that the groups' level of production and sales has not increased significantly over the years. A 2001 survey of a small sample of randomly selected households in villages near where the groups operate in Mayuge and Mbale Districts showed significant differences in the two sites in awareness of the groups and the purchasing behavior of local farmers. Seventy percent of 30 surveyed households had heard of MWG, while only 11% of 45 households had heard of IBFA. Twenty-three percent of surveyed farmers had bought seed from MWG compared to 4% that had obtained seed from IBFA. In both sites, the majority of surveyed FSE customers were one-time buyers.

Discussion: New empirical evidence from Iganga District raises the question whether sites with low production, and therefore low seed demand, can support profitable seed enterprises. The insignificant number of repeat seed buyers, the ability of the Mbale group to sell seed to farmers from nearby areas and the spontaneous emergence of another seed production group in Mbale indicate that demand exists for new varieties but not necessarily for clean seed.

The evidence from Uganda also suggests generally that demand for bean seed, even from high potential areas such as Mbale District, is a serious constraint to small-scale seed businesses and that successful enterprise development requires specific market conditions and/or crop characteristics. Potatoes are a good example of a crop with high seed demand, attributed to several factors. Demand for potato seed derives from yield declines caused by seed- and soil-borne diseases such as bacterial wilt. Additionally, in the Ugandan case, demand for potato seed is linked to the time lag caused by seed dormancy and the timing of planting in wetlands. One strategy for promoting sustainable seed production is to emphasize multi-commodity enterprises. It is significant that in 2000, in response to continued low demand from local farmers, IBFA began multiplying planting material of new cassava varieties.

Contributers: S. David, C. Mukankusi.
Collaborators: Iganga Bean Farmers' Association (IBFA), Makhai Women's Group (MWG).

Characterize farmers' indigenous knowledge and practices likely to influence seed health

Rationale: Much of the seed used for small-scale bean production comes from home-saved or is purchased in markets from a regular crop harvest. Specialized seed production by farmer-run enterprises or groups is considered to have several advantages: lower production cost, timely seed delivery, selection and multiplication by farmers of locally preferred varieties, and maintenance or improvement of genetic diversity. Support needed by such groups includes training in seed production techniques for disease and pest management and post-harvest aspects to complement indigenous knowledge. In order to improve farmers' capacity to produce good quality seed, it is important first to understand farmer perceptions about bean diseases and how indigenous knowledge and crop management influence seed quality.

Methods: Informal and formal surveys were carried out in three districts of eastern Uganda (Mbale, Sironko and Mayuge) where three small-scale farmer seed enterprise groups are based. The informal survey was carried with 30 farmers living in 6 villages near the seed enterprises. A total of 90 farmers was interviewed in the formal survey.

Results and Discussion:
Sources and perceptions of seed quality: Seed is obtained from various sources but farm-saved seed is the most utilised source -- Mbale (94%) and Sironko (100%) followed by seed from local retail shops (33 to 53 %) and local markets (2 to 10%). Quality characteristics that influence preference for a seed source are germination, confidence of performance, purity, physical cleanliness, good appearance and price. In terms of quality, farmers claimed that their own saved seed was superior to other seed sources and was low-cost.

Seed management: Seed selection is a common practice, effected by visual selection of plants and pods during harvesting or sorting of seed at threshing and planting. Most interviewed farmers in Mbale (84%) and Sironko (73%) select seed at threshing only. A smaller percentage (mainly in Mayuge) selects seed more than once, i.e. at threshing (33%) and planting (37%). Between 10 and 20% of farmers do not practice seed selection. At threshing, seed criteria used in selection (sorting) include bright color, large size, not rotten, not attacked by weevils, not shrivelled, not discolored, etc.

Field crop management and seed quality: Management practices employed on a bean crop are primarily to improve yield rather than seed quality. However, factors which farmers believe could lead to production of poor quality seed are poor/tired/old soil, excessive rainfall during growth and maturity period of the crop, drought, weeds, late planting, late harvesting, pests (aphids and caterpillars) and diseases (Table 21). Excessive rainfall and drought were the factors that most farmers believe lead to the production of poor seed in the three districts.

Diseases and seed health: Farmers describe symptoms (e.g. burning, yellowing, rotting, etc) based on effects on the plant, and associate them with, or regard them as being caused by, environmental factors (excessive rains, poor soil, drought) or pests (such as aphids). Most farmers in the neighboring districts of Mbale and Sironko associate burning (58%), rotting (100%) and yellowing (48%) with excessive rainfall. Most (80 to 100%) farmers do not apply any control measure, these symptoms are regarded as effects of nature (rains and droughts) that cannot be controlled. Practices carried out some farmers and thought to have some useful effects are spraying, particularly against aphids (mainly in Mayuge), rogeing, land fallowing, early planting and use ash against insects.

Conclusion: Bean diseases are described by damage symptoms (e.g., burning or yellowing) but not all are regarded by farmers as diseases – to a large extent, damage is associated with or thought to be caused by environmental conditions. There is no clear distinction between damage caused by some insects and diseases, demonstrating the need for improving farmers' understanding and knowledge of diseases.

Field management practices are directed at the whole bean crop with the primary aim of increasing yields. These practices clearly have a direct bearing on the quality of seed although this may not be the farmer's primary concern. Seed quality becomes an issue after harvest when farmers employ indigenous and modern practices to select and preserve seed. Sorting, an indigenous practice routinely used for seed and grain, influences quality. The concept of seed health is even more obscure to farmers but "bad seed", usually described in terms of physical characteristics which seed sorting attempts to eliminate, is associated with factors similar to those that cause diseases on the crop.

Table 21. Factors leading to production of "bad" seed in three Ugandan districts.

	Responses as % of interviewed farmers		
Factor	Mbale	Mayuge	Sironko
Too much rain	66.7	55.6	80.0
Old/weak/tired soil	16.7	33.3	0.0
Weeds	46.7	37.8	66.7
Late planting	16.7	8.9	20.0
Drought	100.0	42.2	86.7
Pests	93.3	53.3	86.7
Diseases	30.0	28.9	60.0
Late harvesting	3.3	4.4	13.3

Contributors: R. Buruchara, C. Mukankuzi and S. David; S. Mathur (DGISP, Denmark).

Activity 4.2 Equip farmers for selecting among options for knowledge-intensive technologies

Achievements:

- Farmers in areas affected by root rots have changed to smaller-seeded and more tolerant bean varieties, but a learning approach is needed to improve their diagnosis and to reinforce use of manuring and sowing on mounds or ridges, currently practiced for reasons other than IPM.

- Farmers in target communities are now aware that bruchid (*Acanthoscelides obtectus*) infestation starts in the field and that delayed harvest increases infestation levels.

- An increasing number of farmer research groups continue to experiment on a wide range of issues that interest them, contributing their own treatments and re-evaluating their indigenous technical knowledge.

- Farmer experiments correctly reinforced their convictions on certain traditional practices against bean foliage beetle, while better understanding of pest biology and causes of outbreaks led farmers to disregard local myths about the pest.

Indigenous knowledge, perceptions and management of root rots in southwest Uganda.

Rationale: Bean root rots are associated with intensification in agriculture, declining soil fertility and, in Eastern Africa, with bean stem maggot, making diagnosis difficulty. Research efforts have characterized diseases, their causal agents and damage, and led to integrated management technologies that include varietal and cultural options. However, effective dissemination strategies depend upon adequate understand of local knowledge, farmer perceptions of the diseases and their importance relative to other constraints, and traditional management strategies.

Methodology: In-depth informal and formal surveys were carried out in two study sites in southwestern Ugandan districts of Kabale and Kisoro, where bean root rots (BRR) are a serious problem but where dissemination of management technologies had never been carried out. Informal surveys were designed to target "knowledgeable" farmers (35 in both study communities) and data collection procedures included participant observation, key informant and group interviews, informal discussions and field observations conducted over the 3-month crop growing period. The structured questionnaire survey was carried out with 100 farmers.

Results and Discussion: The local names for root rots are *Kiniga* (in Kabale) and *Churisuka* (in Kisoro). Literally *Kiniga* means, "is angry and commits suicide" while *Churisuka* means "coming home with only a hoe and no harvest", names that graphically depict the effect and importance of the disease symptoms. Generally, damage to beans due to diseases is categorized into "soil and rain diseases", with BRR being considered a soil disease because of rotting of roots (foliar diseases are regarded as "rain diseases" because of their association with rain).

Disease recognition: Most farmers (94 %) recognize and clearly describe above-the-ground symptoms of BRR (yellowing), while a smaller but significant number (64%) associate rotting of roots with BRR. A few think above-the-ground (yellowing) and below-the-ground (rots) symptoms are two distinct and unrelated problems. Development and appearance of symptoms is a well-understood process and 85% observe symptoms at the 2nd and 3rd leaf stage. However, symptoms and effects of root rots and bean stem maggot (BSM) are largely undistinguished.

Cause of root rots: Conditions associated or considered to cause BRR include poor soils, continuous cropping, use of poor seed, water stagnating in fields, too much rain or drought conditions. The latter further testifies the lack of distinction between the effects of BRR, BSM or even soil fertility. Too much rain implies heavy downpours resulting in high soil moisture.

Traditional management practices: The destructive effects of root rots were early on associated with bad omen by some communities, which used rituals unsuccessfully to "chase it away". Other traditional management practices that have been used are varietal changes and adjustment. Sixty percent of farmers have changed their traditional varieties: about 50% and 40% of farmers stopped growing varieties with large and medium sized seed, respectively, due to their susceptibility. Forty-eight percent introduced small seeded types because of their tolerance to root rots and high yields. Sixty percent adjusted components of varietal mixtures by removing large seeded (36%), planting only medium and small seeded (17%), increasing small seed proportions within the mixture (16%) or simply reducing the proportions of large seeded types (14%).

Cultural practices carried out routinely for reasons other than managing root rots include manuring (63%) to improve soil fertility, "seasonal rotation " (100%) to meet needs for other crops, fallowing (54%) in very poor plots to improve soil fertility, planting on raised beds or ridges (90% in Kisoro) to avoid flooding, growing beans as a sole crop particularly climbers (91%), intercropping (94%) and terracing (71%). Whereas some of these practices are useful IPM components (manuring or planting on raised beds) against root rots, farmers do not realise this.

Conclusions: The above clearly shows that:

- farmers have a good knowledge of above-the-ground symptoms and overall crop damage caused by BRR;
- farmers associate the disease with certain soil and environmental factors, but due to reliance on easily visible symptoms (yellowing, wilting), the "invisible" effects of BSM and soil fertility are easily confused as being due to root rots. This is a major diagnostic weakness that can result in the use of inappropriate measures or the rejection of appropriate management practices;
- traditional management practices having useful effects are limited to varietal manipulation leading to reduction or elimination of large and introduction of small seeded components in varietal mixtures; and
- manuring and sowing on mounds or ridges are routinely used for other reasons and are not appreciated as components in the IPM of root rots.

A learning approach is needed in introducing and dissemination of IPM technologies against root rots (and BSM) among the communities studied. However, this understanding of the farmer traditional knowledge of BRR should enable development of appropriate materials and information to fill gaps in farmers' knowledge.

Contributors: E. Ampaire, R. Buruchara and S. David; F. Opio (NARO); D. Teverson (NRI).

Relationship between pod damage characteristics, time of harvest and bruchid infestation

Rationale: Farmers experience high bruchid infestation in their harvested beans after a few weeks of storage. This forces them to sell their produce soon after harvest for low prices. They were unaware of bruchid infestation in the field.

Methods: A sequential harvest program was initiated with the farming community in Sanya Juu (N. Tanzania) to monitor the relationship between time of harvest and bruchid infestation. Beans were harvested at physiological maturity, and at two weekly intervals thereafter for 4 weeks. The harvested beans were grouped into split and intact clean pods and according to the number of holes (pod borer damage). The grains were extracted from the pods and stored in sealed paper bags for 8 weeks. The grains were then examined and all emerging insects were collected and recorded, grain damage was also recorded. The data were analyzed and discussed with farmers.

Results: Grains from pods that provided access for bruchid entry; pods with pod borer damage and split pods (as a result of delayed harvesting) were more attacked than intact pods (Figure 15). Also pods harvested at physiological maturity had significantly less damage than later harvested pods. Grain damage increased progressively with weeks after physiological maturity (Figure 16). Each week of delayed harvest resulted in 7 % grain infestation by *Acanthoscelides obtectus*.

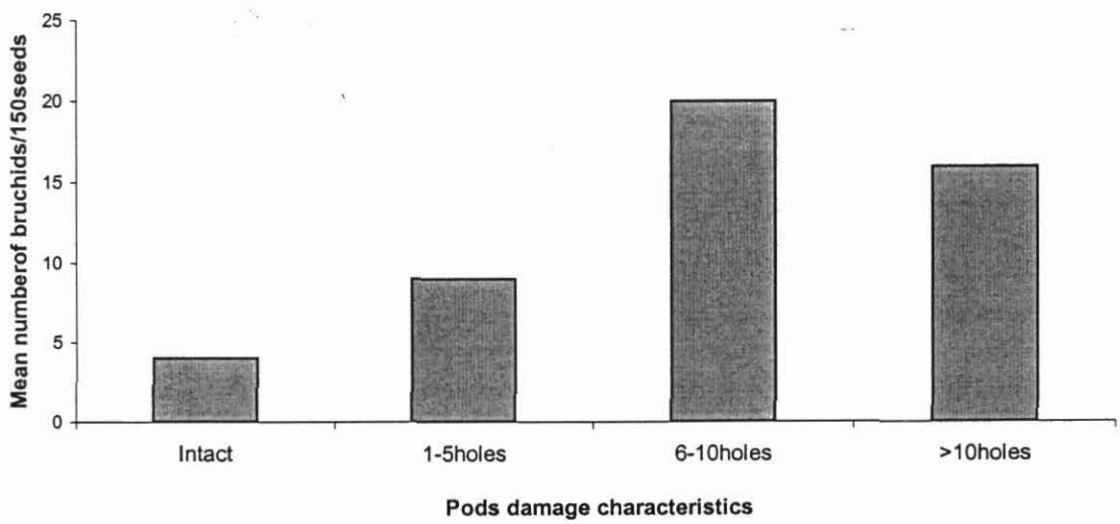

Figure 15: Pod damage characteristics at harvest and bruchid infestation

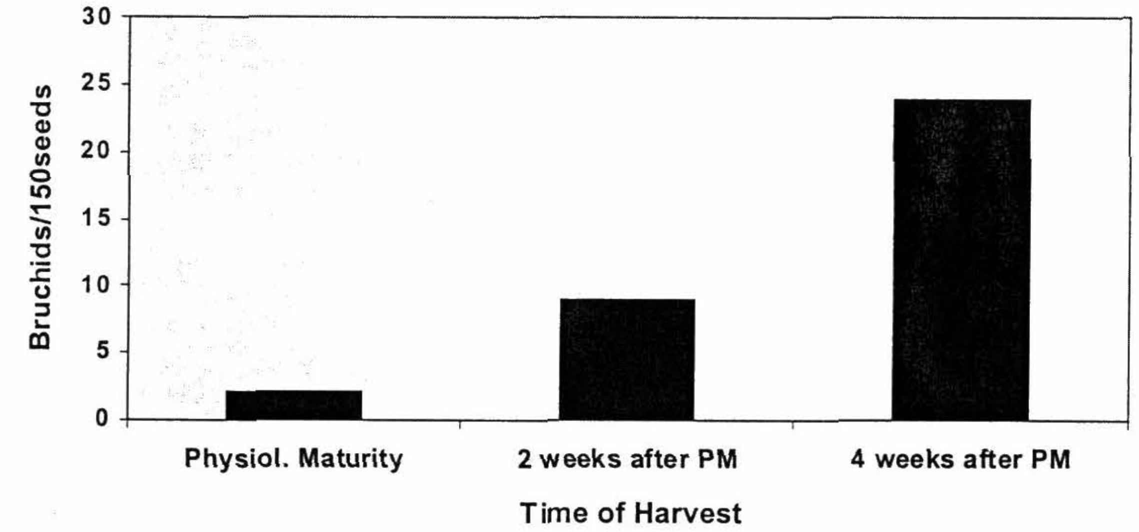

Figure 16: Relationship between time of harvest after physiological maturity and bruchid infestation.

Among the Wasambaa people in Lushoto District of Northern Tanzania, farmers harvest soon after physiological maturity (early) as a tradition and sell their produce soon after harvest without much time in storage, either because they are aware of the high bruchid infestation associated with delayed harvest or that by selling wet seed they take advantage of the seed weight. Farmers claim they gain more from the early harvest than by harvesting late. Grain harvested this way and air-dried was kept for 4 months without bruchid emergence. For successful longer term storage, farmers add dust or sun-dry or smoke the harvest.

Contributor: K. Ampofo.

Support to farmer experimentation and application of technical skills

Rationale: Empowering farmers through access to knowledge, encouragement and skills to experiment better with effective links to other farmer groups and back to formal research is part of our vision for the development of more sustainable R&D systems in Africa. Initial dissemination of new agricultural technologies is more likely to be effective if based on farmers' ways of learning and of passing on innovations to other farmers. In support of a network of local FPR practitioners and farmer research groups in the region, we carry out some action research directly so as to monitor the adaptation and dissemination processes.

Methods: Under an SDC-supported project and in collaboration with staff of several research departments of SARI, some trials continued in three villages in three agro-ecological zones of Arumeru District, Northern Tanzania. Our main focus was on how to phase out and empower the farmers to continue on their own. Each village decided on the research topics and the research plan was discussed together. The resulting small trials focused on evaluation of bush and climbing beans, maize, wheat and safflower varietal evaluation, production practices and pest management. The trials were farmer planned, implemented and managed. During meetings with the participating farmers, we discussed the outcome of this year's trials but also evaluated the past two years of collaboration. Researchers encouraged the farmers to continue with their research, and that although CIAT was leaving the area, they should continue to visit SARI for help when needed.

In other farmer experimentation in Tanzania, this time related to IPM, farmers were encouraged to experiment on and verify traditional IPM practices. Learning plots were also established to compare different crops (maize, cowpea, soybean, sorghum) and fallow for effects on *Ootheca* emergence from teneral diapause. The summarized data were discussed with all stakeholders.

Results and discussion: Two villages received varieties of climbing beans. They were planted on the grounds of the local primary school and on farmers' fields. The crop failed in one village as a result of heavy bean stem maggot infestation, in spite of the seed dressing (lindane + thiram) used by farmers. The farmer group identified their preferred varieties and the harvested seed was distributed to farmers, school children and teachers for further multiplication and testing.

In collaboration with the wheat section of SARI, three wheat varieties were sown on three plots in Kisimiri. One plot was lost to suspected manganese deficiency, while other plots performed well. In the same village, a few farmers continued to plant safflower (seed from last year's harvest) and had good yields. Farmers planted 10 highland maize varieties in search for a replacement of their traditional variety (which yields poorly, matures late and has smut and other disease problems) and 7 drought tolerant maize varieties supplied by the maize section. Even though lack of funds prevented the national research partners from evaluating the trials, the farmers identified a few preferred varieties. A collaborator from the animal husbandry section conducted farmer seminars on husbandry and disease recognition and treatment, and farmers established plots of new forage species.

In the farmer experimentation on IPM in Lushoto District, a farmer experiment on traditional IPM practices confirmed (Figure 17) researchers' assessments (see Output 3, Activity 3.2), and boosted farmers' confidence in using these traditional methods. Farmers became more eager to apply their traditional knowledge through the participatory IPM process to other crops and livestock. Indigenous technical knowledge has now been incorporated with farmer training in integrated nutrient management, and demand exists for integration also in other sites.

Crop rotation had also emerged as an option for the management of *Ootheca* and farmers wanted to evaluate it at their learning site in Hai District, Tanzania. They realized that part of the *Ootheca* population increase was due to continuous cropping of beans on the same land and were eager to learn more about this interaction. Farmers were now aware that *Ootheca* develops in the soil. Small replicated plots planted with different crops from which *Ootheca* emergence was trapped showed that beans and cowpeas were the only crops that hatched out any significant numbers of *Ootheca*. Emergence started soon after bean crop emergence and peaked at crop growth stage V3, thereafter there was a decline in the emergence pattern although emergence persisted until growth stage R5. Emergence from cowpea plots followed a similar pattern but the emerging population was smaller. The fact that the only beans and cowpea hatched significant numbers of *Ootheca* out of diapause suggest the presence of an emergence stimulus probably associated with root exudates. Experiments underway to study these exudates emphasise the need for a reiterative approach to participatory research and dissemination.

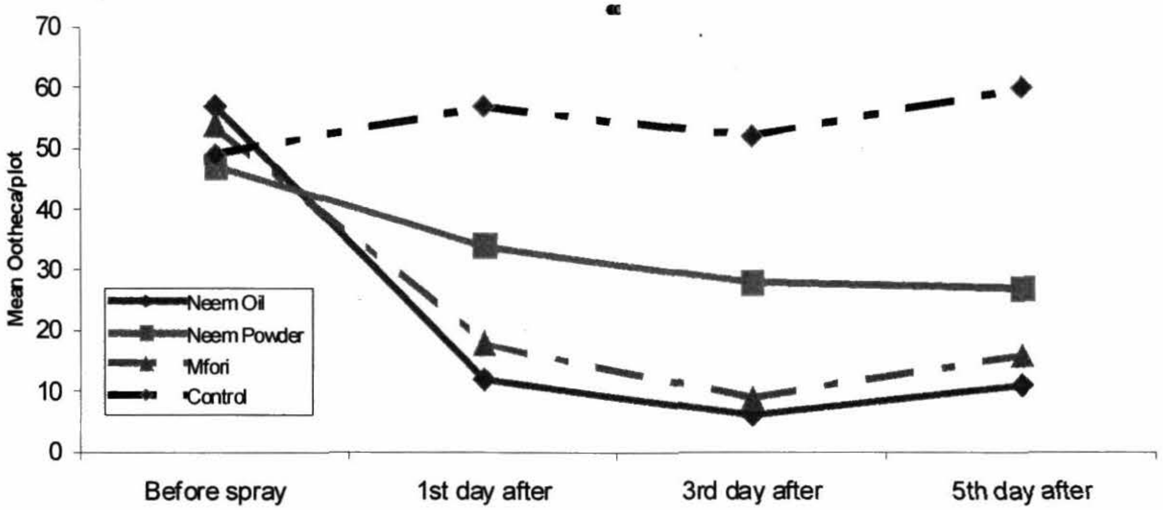

Figure 17: Effect of cowshed slurry (mfori) and neem on *Ootheca* infestations in farmer experimentation in Tanzania.

Contributor: U. Hollenweger, K. Ampofo and H. Mziray
Collaborators: K. Ampofo, D. Mohamed; Dr. Ndondi, Mrs. Ngulu, Dr. Mduruma, Dr. Massawe and Mr. Muhidini (SARI); H. Horsch (Development office of the Anglican church); Mrs. Amanda Koola (Hai District Extension Service)

Activity 4.3 Scale up proven technologies through strategic alliances

Achievements:

- Increasing farmers' knowledge about the biology and ecology of their common pests has enabled them to develop appropriate management practices

- Farming communities have been empowered to make IPM decisions with focus indigenous knowledge systems, and to rediscover value in their traditional IPM strategies.

Scaling up participatory IPM development and promotion

Rationale: Many technologies have been developed for the management of pest problems in smallholder production systems but most have remained out of reach. Community participatory approaches, combining farmer field school and participatory approaches, are needed to increase farmer awareness of the availability of IPM technology and encourage adaptation, and to develop skills in national research and extension services.

Methods: A new project, "Participatory IPM development and promotion in Eastern and Southern Africa" supported by the DFID Crop Protection Program, aims to scale up the approach developed by CIAT in northern Tanzania to Kenya, Tanzania and Malawi. The ECABREN and SABRN Networks also decided to link their IPM subprojects to this activity it and are funding the extension of the project to Madagascar, Mozambique and Sudan. A full pre-project stakeholders' meeting was held in February to ensure a common understanding and enable all collaborators to share their work plans, and the project was initiated in April 2001. Collaborative links for dissemination have been developed with GTZ-IPM and the NGOs Farm-Africa in Tanzania and Concern Universal in Malawi.

Participating extension officers and farmer extensionists were trained in IPM methods including pest identification, and in the fundamentals of participatory research. Local knowledge and the available scientific knowledge were discussed for their suitability in the management of the selected priority problems. Common strategies were the use of community participatory approaches, inclusion of traditional pest management strategies for evaluation, and training of extension staff and farmers on IPM concepts and approaches. Farmer groups, in collaboration with their research and extension partners, established learning plots at several sites within each target area to verify and learn the new management practices. At all sites there was a strong collaboration between researchers, farmers, government extension and development NGOs, with regular meetings to monitor and assess observations from the learning plots. The original pilot project in N. Tanzania is now fully led by the extension service and their farmer communities, with technical backstopping from CIAT and the Tanzania National Program for methodology development and on-station and laboratory research to answer basic questions that could not be done in the farmers' fields.

Results: At each site farmers contributed their traditional knowledge for managing the various pests they encounter in bean production. The traditional IPM practices at the different sites were different and appeared to be related to local traditions or cultures. Among the Meru and Chagga peoples of northern Tanzania, the traditional IPM practices were related to animal products (cow urine and cowshed slurry), whereas among the Wasambaa (also of north-eastern Tanzania), the Nyakusi of southern Tanzania and the people of northern Malawi, the IPM practices were related to botanical products and other concoctions such as ashes of the offending pest (N. Malawi). There were differences also in farmers' knowledge about the pests they encountered: in Malawi, many farmers could describe their pests and their management strategies well but in northern Tanzania many farmers did not know difficult-to-see pests. This difference is probably due to the level of contact with extension services.

Contributor: K. Ampofo, U. Hollenweger and H. Mziray
Collaborators: R. Chirwa; D. Kabungo (DRD Uyole); E. Ulicky (DALDO, Hai District); J. Ogecha (KARI-Kisii).

Monitoring and evaluation of IPM dissemination process

Achievements:

- Dissemination channels preferred by farmers are better understood and are applied in re-orientating dissemination activities

- A study on diffusion pathways of agricultural technologies in Uganda confirms findings from elsewhere in the region of the importance of social ties, gender and wealth as determinants of diffusion behavior.

Rationale: Participatory research requires regular monitoring and evaluation of progress by all stakeholders. The objective of the project was to identify appropriate pest management strategies and dissemination pathways in smallholder production systems through participatory approaches and use lessons learned to scale up IPM technologies to the large community.

Methods: Farmers and their partners held a field day to share what they had been doing with others within the community. Farmers and other stakeholders were invited to the Sanya Juu community-learning site where they viewed different IPM practiced. The participating farmers explained the activities; other farmers shared their experiences and the whole group discussed the process and the technologies. We took advantage of the large gathering to administer a questionnaire to evaluate the dissemination process.

Results: Farmers that participated were very appreciative of the process. What they liked best was the new knowledge they had acquired and the fact that the activity was focused on issues that concerned them directly. They also liked the fact that research was working with them and that new findings were shared directly. The farmers were very confident in sharing their knowledge and direct experiences with others. Participants in the field day were predominantly male (66%). A summary of stakeholders' responses, disaggregated by gender, is presented in Table KA3. Most farmers felt working in groups enhanced community cohesion, enabling them to "educate one another", and made it easier to for them to communicate with "experts" (outsiders e.g. researchers, who are supposed to be more knowledgeable). Many group participants were however appalled by lateness and absenteeism by others, which they saw as a drag on progress.

The preferred pathway for dissemination of IPM technology was: field visits by extension officers, group demonstrations, seminars and radio programs; drama, newspapers and television were rated quite low. One farmer group had initiated a radio program "Ukilima Wakisasa" with funding support from the local administration on a local Christian station Radio Sauti Ya Njili that gave them the clearest reception but, as our survey suggested that this station was not greatly used by farmers, they are considering switching to a more popular station. The extension service is planning to use the data to sensitize the district administration for more support and also to review current extension pathways to focus on increased community participation.

Table 22. Farmer evaluation of participatory IPM development and promotion activities in Hai District, northern Tanzania.

Question/Category	Male (N=191)	Female (N=89)
	% Responding	
Desire to learn through group activities	2.6	77.5
Participation in Bean IPM and other group activities	33.0	61.0
Gets help from extension whenever needed	24.6	27.0
Frequently visited by village extension officer	17.3	9.0
Awareness of IPM promotion activities in district	41.4	50.6
Knowledge of traditional IPM methods	29.9	51.8
Recommendation for IPM dissemination channels:		
Participation in group learning activities	42.9	40.4
Visits to community learning plots	46.1	36.0
Radio programs	40.3	40.3
Visits from extension officer	33.5	27.0
Seminars	45.0	49.4
Drama	4.2	4.5
Newspapers	9.9	3.4
Radio station frequently tuned into:		
Radio Free Africa	1.0	4.5
Radio One	52.9	43.8
Radio Sauti Ya Njili	13.6	25.8
Radio Tanzania	22.5	16.9
Expectations of members of farmer groups:		
Acquisition of knowledge	12.6	25.8
Other support	1.6	9.0
How expectation was met:		
Increased yield	3.1	3.4
More knowledge	54.5	49.4

Contributors: K. Ampofo, U. Hollenweger, H. Mziray and D. Mkalimoto

Causal paths by which interventions result in impact are mapped

Rationale: Researchers involved in community-based participatory research typically work with selected farmers and assume that new technologies developed together with those farmers will spread rapidly to other farmers through social and other networks and processes. This process is not well understood and there is little research on factors that influence diffusion.

Methods: Last year we reported a study on technology diffusion within and between communities in central Ethiopia. This year a study was undertaken to investigate the diffusion of different types of agricultural technologies: bean (K132 and K131) and cassava (Nase 1 and Nase 2) varieties, composting and trenches for soil and water conservation. Thirty-three farmers

(26 women and 7 men) were involved from three villages (Magada, Luubu and Budhwege) in Iganga District, Uganda where the BMZ-funded Integrated Nutrient Management Project operates. Farmers were asked to map out their experience with sharing and exchanging agricultural technologies and information.

Results: Farmers primarily shared technologies with close relatives, followed by friends and neighbors. Women shared technologies with their own relatives, who in many cases live long distances from their marital homes, and at the same time introduce new varieties from their natal to their marital homes. Farmers in the area rarely or never sell seed or planting material of beans and cassava. The majority of farmers studied offered bean seed to others, while cassava cuttings and information about trenches and composting were mainly given on request.

Wealthy and very poor farmers did not participate in diffusion of any of the technologies under investigation. Bean seed, mainly a subsistence crop in this area, and compost, mainly used on banana, a food crop, were mostly shared between women. In contrast, both men and women were involved in sharing cassava planting material and information about trenches. Cassava is both a food and cash crop grown by both men and women, and trenches are associated with coffee.

Discussion: The study confirms findings from elsewhere in the region showing the importance of social ties, gender and wealth as determinants of diffusion behavior. Other factors of social differentiation such as ethnicity should also be considered when designing technology dissemination strategies. In a multi-ethnic community, it might be important to target individuals or organizations from represented ethnic groups. Farmers who have fields on the roadside should be targeted as such fields serve as demonstrations. Farmers' groups should also be targeted as much sharing goes on within these groups.

Contributors: A. Nakiganda (NARO); S. David, A. Esilaba.

Activity 4.4 Assess and document impact at household and country levels

Achievements:

- Massive impact has been achieved from the introduction of root rot resistant bush and climbing bean varieties in areas of Western Kenya, and farmers can map the outcomes

Impact of root rot resistant bean varieties in Western Kenya documented

Rationale: In the early 1990s farmers in Western Kenya experienced a significant decline in bean production, a major food crop in the area. This decline was associated with root rots. In some areas, the problem was so acute that some farmers stopped growing beans completely. Researchers from KARI-Kakamega and CIAT responded to the crisis by experimenting with integrated crop management strategies. Measures included rapid introduction and dissemination of bush and climbing bean varieties known to be tolerant to the disease from work in the Great Lakes region and Uganda. The most acceptable bush varieties, identifies by their Kenyan release names, are: KK 8 and KK 15 (both developed by D.R. Congo), KK 22 (CIAT-bred), KK 20 and

KK 14. Climbing varieties are Umubano, Vunikingi, Ngwinurare, Gisenyi, Flora and Puebla, all introduced from or via the Great Lakes region. Although adoption of the new bean varieties was reported to be high, there had been no systematic study to assess the adoption and impact of the new varieties.

Methods: Both qualitative and quantitative methods were used to assess the impact of the new bean varieties. Group interviews and impact diagramming were carried out in 2000-2001, and a formal survey of 300 randomly selected households was conducted in mid 2001 in Kakamega and Vihiga Districts. Impacts were assessed on four main areas: food security, household income, loss of varietal diversity and household resource allocation (with emphasis on labor). In August 2001 traders were surveyed to assess the prevalence of new varieties in markets.

Results: Although results are not yet available from the household and market surveys, informal discussions suggest that the new varieties have had massive impact largely because of the severity of root rots. Few farmers are not growing at least one of the new varieties. Farmers' receptiveness to a range of seed types is evident in the widespread popularity of KK 15, a small black seeded variety. Farmers continue to grow local varieties and often even resume planting varieties previously found to be susceptible to root rots.

A diagram of the impact of KK 22 (Figure 18) shows that this bush variety has significantly improved food security, increased cash incomes and reduced fuel consumption. Women farmers reported that both men and women benefit equally from bean earnings, although women sell beans and control the income. Farmers reported that they harvest 12-16 kg from sowing 2 kg of local varieties, compared to 18-20 kg from 2 kg of KK 22. Negative impacts include reduced planting density to achieve high yields (traditionally farmers sow maize and bean seed together; those growing KK 22 and KK 15 have switched to sowing one row of beans between two rows of maize) and the late maturity of the variety.

Discussion: The impact of the new varieties on food security is impressive. Many farmers now have beans in storage from season to season, whereas previously beans lasted for 2 months only. Farmers benefit both directly (more food, more income) and indirectly (saving income that would have been spent on food) from the new varieties. Bean earnings are used for larger expenditure such as school fees, animal purchases and hired labor, while savings are used to purchase food, household and other items.

It was observed that, where climbing varieties were introduced first and bush beans later, many farmers dropped the climbers and switched to growing the new bush varieties. The major constraints to the adoption of climbing beans are: lack of staking materials, insufficient labor for staking, need for highly fertile soils and not being able to intercrop. The intercropping problem has two dimensions: a land shortage problem and a cultural perception that maize must be planted with beans.

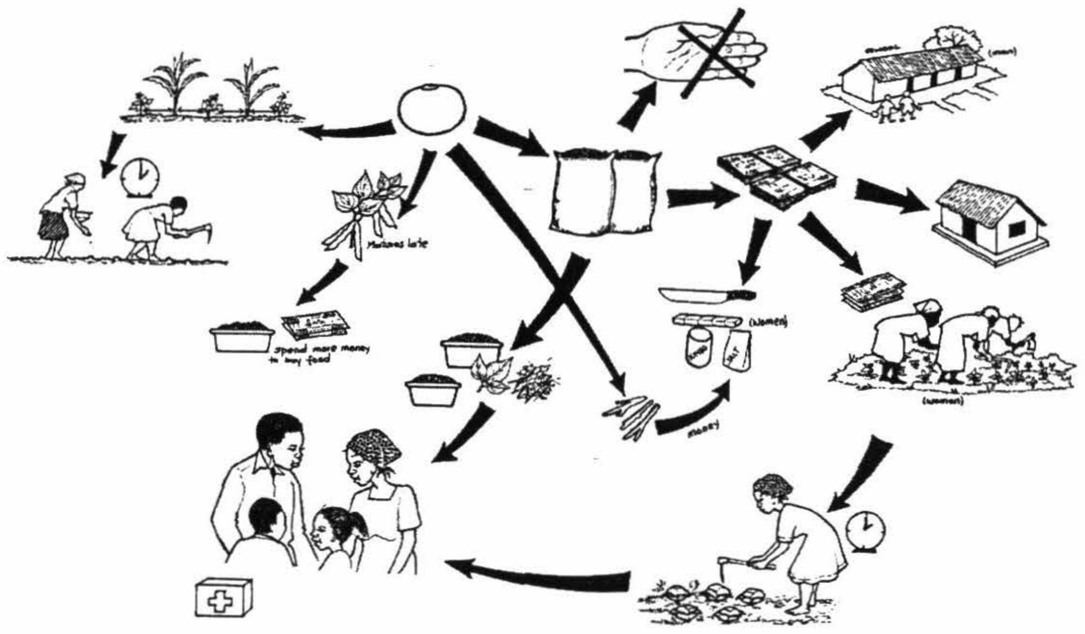

Figure 18. Impact of root-rot tolerant bean variety KK 22 (RWR 719) diagrammed by Mkumu Farmers' Women's Group, E. Tiriki, Kenya (redrawn from original diagram)

***Contibutors*:** S. David; M. Odendo (KARI-Kakamega).

Output 5. The institutional base of the Pan-African Bean Research Alliance (PABRA) is consolidated

Activity 5.1 Support wider partnerships within ECABREN through a more integrated network approach

Achievements:

- An impact oriented research and development framework has been applied.
- Partnership and multidisciplinary principles are being accepted in member countries, with regionally coordinated activities implemented and backstopped efficiently; more development partners are now involved in scaling up of improved technologies in the region.
- NARS scientists and development partners trained under PABRA partnership

Developing coordinated research and development activities within ECABREN

Rationale: With the shift from constraint to customer-oriented research in ASARECA member countries, it was important for the bean network to support market-oriented research activities that aim for impact, while phasing out and/or re-orienting on-going research activities to respond to the new research strategy. A monitoring and evaluation system is needed to allow network members revise research priorities and strategies for coordinated research that contributes to overcoming food insecurity, poor nutrition, poverty, and soil degradation in the region.

Methods: Previous studies on production and marketing constraints have enabled the network to determine intervention areas in such domains as crop improvement; agronomy, soil management, disease and pest management, seed production, technology promotion and dissemination. Promotion and scaling up of IPM, participatory research, market studies and documentation of adoption and impact have dominated project approvals and funding. The network now favors regionally focused activities rather than country specific activities, unless the latter aim to develop methods that could benefit other network members. Other criteria considered include partnerships across network countries and a interdisciplinary team approach for developing and delivering integrated technologies. Efforts are made to group activities for better coordination.

Results: Research projects being implemented by institutions in ECABREN countries are presented in Table 23. However, a large number of proposals submitted have revealed some deficiencies in scientists' agility in shifting to market or development-oriented projects. In some countries, individual scientists still do not give importance to interdisciplinary team spirit, leading to many rejections of proposals by reviewers. Although projects in such areas as technology promotion and dissemination, adoption and impact studies are usually independently conceived by scientists, the development of decision tools for soil fertility and those on IPM are organized and submitted for backstopping by experienced regional scientists, either from CIAT or AHI partners.

Development of extension materials, leaflets, and brochures for technology dissemination and promotion still needs backstopping and support for countries with limited resources. Follow up and backstopping of individual scientists needs attention to detect and overcome deficiencies if network and PABRA goals are to be achieved.

The regional breeding programs recently established (see Activity 2.2) are well coordinated regionally and constitute a model on which other programs and thematic research activities should be based. PRIAM (farmer experimentation) and BILFA (Activity 1.2) are based on the same principle. However, reporting is often deficient even in these coordinated activities.

Regrouping of working groups within PABRA to three (crop improvement, soil and pest management, and socio-economics and participatory research) constitute one way of enhancing scientists' interactions and developing team spirit, and promoting joint activities for developing technology that end users really need. The collaboration established at network level with other partners (CIAT and AHI) to use available regional resource persons for collaborative research with or advice to national scientists has started having positive effects. Current collaboration with other research groups on INM and drought resistance research is expected to help in effective coordination and improving research quality in NARS institutions.

Table 23. ECABREN research and development activities being implemented in ECABREN countries and organised by PABRA outputs for 2001.

Outputs	Institution/Country
1. Household food security and nutrition of women, children, and the rural and urban poor is improved	
1.2 Exploiting genetic diversity of bean to address marginal environments	
1.2.1 Screening beans for low soil fertility (BILFA)	DR Congo, Kenya, Madagascar, Tanzania
1.2.2 Screening for drought resistance (BIWADA)	DRC, ETH, KYA, SDN, TZA, UGA
1.3 Making available more options for managing soil productivity and bean pests	
1.3.1 Nitrogen budget in climbing bean based cropping system	INERA Mulungu/DR Congo
1.3.2 Developing decision guide tools for soil fertility management	DRC, KYA, MDG, TZA, UGA
1.3.3 Enhancing and sustaining smallholder farmers' fields through improved soil fertility management and BNF	NARO Kawanda/Uganda
1.3.4 Assessment of rice-bean based cropping rotation under different soil management	FOFIFA Antsirabe/Madagascar
1.3.5 Promotion and dissemination of IPM technologies for bruchids control	DRD-Selian/Tanzania
1.3.6 Studying on-farm bean storage techniques	FOFIFAAntsirabe/Madagascar
1.3.7 Biological management of bean bruchids with botanical insecticides	CRSN Luiro/DR Congo
1.3.8 Promotion of bean stem maggot strategies	FOFIFA Antsirabe/Magdagascar
1.3.9 Managing BSM with botanical insecticides	INERA Mulungu/DR Congo
1.3.10 Promotion of IPM strategies of major bean pests: A participatory approach	ARC Hudeiba/Sudan
1.3.11Participatory promotion of ICP technologies	DRD Selian/Tanzania
1.3.12 Common bean yield enhancement through cultural practices	ARC Hudeiba/Sudan

Table 23 (continued).

2. Improved agricultural incomes for small holder farmers	
2.1 Improving understanding of local, regional, and international bean markets	
2.1.1 Economic analysis of cross-border trade: case of Arusha and Nairobi regions	Moi University/Kenya
2.1.2 Structure, conduct and performance of bean marketing in EA: case of W. Kenya, eastern & south-west Uganda	
2.1.3 Marketability of different bean types in various urban Kenyan markets	
2.2 Developing new bean varieties that address market demands	
2.2.1 Breeding programmes for different market classes:	
2.2.1.1 Red mottled beans	NARO Namulonge/Uganda
2.2.1.2 Dark red kidney beans	DRD-SARI/Tanzania
2.2.1.3 Medium and small red beans	EARO Awassa/Ethiopia
2.2.1.4 Pinto bean	KARI Katumani/Kenya
2.2.1.5 Sugar bean and yellow & brown	INERA Mulungu/DR Congo
2.2.1.6 Carioca bean	EARO Nazareth/Ethiopia
2.2.1.7 Red mottled climbers	ISAR Rubona/Rwanda
2.2.1.8 Bush snap beans	NARO Kawanda/Uganda
2.2.1.9 Climbing snap and runner beans	KARI Thika/Kenya
2.2.1.10 Navy beans	NARO Nazareth /Ethiopia
2.2.1.11 Large white beans	FOFIFA Antana/Madagascar
2.2.2 Dissemination of improved root rot varieties	RUFAO Bungoma/Kenya
2.2.3 Promotion of (banana) ropes as staking options for climbing beans under banana plantations	INERA Mulungu/DR Congo
2.2.4 Promotion of climbing beans in lower Congo	INERA M'vuazi/DR Congo
2.2.5 Socio-economic impact of improved bean varieties in farmer based agricultural system	INERA Mulungu/DR Congo
3. Pilot communities become more competitive and better managers of their resources	
3.1 Catalyzing improved organizational capacity in pilot communities	
3.1.1 Initiation and support of PRIAM activities in ECABREN countries	DRC, ETH, MDG, TZA
4. Wider impact achieved across Africa	
4.1 Reinforcing sustainable approaches to decentralized seed systems	
4.1.1 Production of breeder and basic seed	All countries

Contributors: M. Pyndji (ECABREN/CIAT) and P.Kimani (ECABREN/CIAT/Univ.of Nairobi).
Collaborators: ASARECA; R. Kirkby; NARS and scientists of network countries.

Supporting NARS to develop research and development activities with partners

Rationale: The vision of ECABREN -- increased and sustainable agricultural productivity, improved nutrition and income in ECA region -- can only be achieved by developing environmentally sound technologies in partnerships including universities, government organizations (GOs), NGOs, private sector, farmers and farmers' associations/groups in each participating country. Partnerships are necessary for NARS to create impact.

Methods: Identifying potential partners in each participating country has been one of the roles that network members have been playing in the last 15 years of existence of the African bean networks. Research and non-research institutions are identified based on their comparative capacity to implement regional/country activities. In some countries, government services, NGOs and agricultural research institutions gather to discuss their activities and possible partnerships or alliances are then initiated. Since last year, the network coordination invites potential partners to participate in network planning meetings. To encourage scientists to seek these partnerships, the network requires the involvement of partners in planning and implementation if a project is to be considered for support. This offer is also addressed to well-structured local or international NGOs willing to be involved in scaling up validated technologies.

In some countries, scientists invite non-research partners (farmers, NGOs, seed companies, extension services) to local or national planning meetings. ECABREN and CIAT also fund training courses that encourage involvement of these institutions in the implementation of joint activities.

Results and Discussion: Numerous contacts and discussions have taken place with seed companies, NGOs, and farmers and farmers groups collaborating or willing to establish collaboration with NARS. Most of the institutions are involved in producing, distributing/disseminating, and/or marketing seeds of improved bean varieties that are often developed in partnership with farmers in countries where participatory research is applied. As a result, NARS institutions are becoming more efficient in developing technologies that create impact, although institutionalization of partnerships is still needed. Some examples are:

- In Sudan, the Arab Sudanese Seed Company and Lower Atbara Development Co. have links with Hudeiba Research Station on seed production and marketing.

- In Rwanda, NGOs and projects such as Projet d'Appui au Secteur Semencier, World Vision International, ATDT project and Catholic Relief Services have strengthened links with ISAR for development activities. CRS has brought in new strategies for collaboration with research, including strengthening capacity of existing farmer associations, training community selected extension services, organizing farmer managed trials around farmer field schools and working with researchers in data collection, analysis and reporting.

- In northern Tanzania, the Arusha Foundation Seed Farm, farmers' seed producers and Dodoma Transport Co are benefiting from the bean program, with small farmer groups exposed to seed production and marketing and to community development activities under PABRA support.

- In eastern DR Congo, INERA scientists have developed linkages/partnerships with NGOs (e.g. CARITAS, Christian Aid, CICR). Sometimes they receive material support during this difficult time to produce bush and climbing bean seeds that are purchased by NGOs and disseminated in production areas. Farmer research groups and PRIAM communities play a significant role in implementing activities on soil and integrated management in this hilly province.

- The East African Seed Company in Kenya have met with ECABREN steering committee members to develop or strengthen national partnerships for seed production; multiplying seeds of released bean varieties for countries other than Kenya is also a possibility.

- The Uganda bean program is a particularly successful example, with government encouragement, of partner involvement in planning and implementation.

- Ethiopia's regular annual review and planning meeting has involved seed agencies, but so far not the NGOs that could play a role in scaling up validated technologies.

- The Participatory Research for Improved Agroecosystem Management (PRIAM) project established by ECABREN and CIAT in some network countries (DR Congo, Ethiopia, Madagascar, and Tanzania) has been an effective method for developing partnerships with individual farmers and/or farmers' groups, NGOs, and local authorities to test and disseminate diverse technologies (beyond beans) that fit farmers' needs and situation. Some of these empowered communities in eastern Congo and Madagascar decide on the diversification of crops for food and income generation such as vegetable, wheat, soybean peanut, and fruit trees serving also as staking materials for climbing beans.

Contributors: M. Pyndji (ECABREN/CIAT) and P.Kimani (ECABREN/CIAT/Univ.of Nairobi).
Collaborators: ASARECA; CIAT (IP-2); NGOs; NARS scientists of network countries.

Activity 5.2 Enhance regional coordination and effectiveness within SABRN

Achievements:

- The SABRN network borrowed from ECABREN experience by launching more cross-network activities, while continuing the strategies approved by the steering committee in 1999 that place increased emphasis on crop management and impact assessments.

Innovations within the southern Africa network

Rationale: The Southern Africa Bean Research Network (SABRN) has 10 active country members (Angola, DR Congo, Lesotho, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe) within the SADC grouping.

Methods: The network has lead-collaborating institutions in each countries, including agricultural research institutes, universities and private institutions. The network operates from Lilongwe, Malawi, where the Government of Malawi provides office, laboratory and field research facilities at Chitedze Agricultural Research Station, while SACCAR provides operational funds from its African Development Bank grant. CIAT, through the Pan-African Bean Research Alliance (PABRA), provides support to the network by funding the co-ordinator's position and a set of activities that cut across the two bean research networks. Additional activities on bean research in the region are carried out through the university-led research program funded by USAID through the Bean-Cowpea Collaborative Research Support Program (CRSP). Malawi, through its bilateral funding for bean research from the EU, provided additional financial support this year. As such, this network arrangement does reflect a true partnership among various stakeholders. The coordinator is supported by national program scientists and CIAT staff from Africa and HQ for technical backstopping to the network.

Financial support from SACCAR, though limited, has been very beneficial, enabling the network to maintain, and recently to increase, a small core set of research sub-projects. In 1999, SACCAR increased its support to cover operations costs for the network coordinator; and in year 2001 new sub-projects were mostly on farmer participatory research, adoption studies and impact assessment related topic. Table 2 shows the list of research subprojects.

Results and Discussion: Regional germplasm exchange has proven very useful. A few countries, not having breeding programs of their own, rely solely on germplasm exchange through the network for access to improved bean varieties. Observations from country progress reports indicate notable progress in releasing similar bean varieties across countries due to regional exchange. The varieties CAL 143 and A 197 are already being grown by farmers in Angola, Malawi and Zambia; the southern highlands of Tanzania has both under pre-release; while Swaziland, Lesotho, and Zimbabwe have CAL 143 on pre-release (Table 3). There is great potential here for similar varieties to be released in multiple countries, being beneficial for seed security because seed can be moved across borders in times of drought; in addition, seed demand would create opportunities for commercial seed producers to market bean seeds regionally. Other varieties developed through the network, like A 286 (carioca) are already being marketed in several countries in southern Africa by seed companies like PANNAR (of South Africa) and SeedCo (of Zimbabwe). A sugar bean variety, SUG 131, is showing promise in Malawi, Swaziland and Zimbabwe as one of the most popular bean market classes in the SADC region with regional demand in Zimbabwe and South Africa. South Africa often imports sugar bean from China because local production is inadequate.

Malawi remains the model in the SADC region for community based bean seed multiplication; Lesotho, Swaziland, Tanzania and Zambia have initiated similar programs. The remaining countries (except South Africa where commercial farmers produce bean seed) have plans to initiate community based multiplication programs as part of the strategy to achieving wider impact through improved bean varieties. During 2001 the program through its collaborating partners (government extension, NGOs and farmers) project that approximately 75 tons of bean seed will be produced in Malawi, where for the first time farmers have been organised to multiply and market seed as groups. This is part of an initiative to build local capacity in communities to better manage their resources and make seed production and marketing a viable business for sustained local seed supplies in the rural areas (see also Output 3).

A different initiative to promote new bean varieties and sustain funding for bean research at national level is underway in Zimbabwe, where the national research institution is considering a contract with a local seed company to promote and market MCM 5001, a bean variety bred by CIAT (IP-1) and released in Zimbabwe through the network. The national research institution would in return collect fees from the company and use the proceeds to support bean research activities. This way of financing the national research might be of interest to other countries.

During the 1999 steering committee meeting the network resolved to place more effort on social studies on such topics as technology transfer, adoption and impact assessment (Table 4). This year we carried out adoption studies on improved bean varieties in Zambia, while Malawi and southern highlands of Tanzania carried out impact assessments (results pending).

For the first time in the SABRN, Malawi has initiated a PRIAM site, tapping experiences from ECABREN. The activity involves various stakeholders, extensionists, NGOs, researchers and farmers. Training for all participating stakeholders and planning with farmers at the selected site has been completed. Other cross-network activities that have been initiated in Malawi include promotion of IPM technologies in northern Malawi and BAPPA see Activity 3.1).

Contributors: R. Chirwa (SABRN/CIAT).
Collaborators: SACCAR; NARS, SC members and scientists from Angola, D.R. Congo, Lesotho, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe; R. Kirkby.

Table 24. Regional research sub-projects implemented by SABRN countries in 1995-2001

a. Old sub-projects

Title	Country	Institution	Startup
Breeding for tolerance to drought	Tanzania	SUA	1995
Breeding for bruchids resistance	Tanzania	SUA	1994
Dissemination of new varieties	Lesotho Malawi Mozambique Tanzania	MoA Maseru DARTS Chitedze INIA DRD-Selian	1995
Pathogenic variation of rust	South Africa	ARC/GCRI	1995
Bacterial diseases	South Africa	ARC/GCRI	1995
Physiological races of angular leaf spot	South Africa	ARC/GCRI	1995
First and secondary multiplication of two varieties	Angola	MoA	1997
Evaluation of BSM resistant lines in Southern Highlands	Tanzania	DRD-Uyole	1997
Ootheca management in Southern 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-Chitedze	1996
Screening germplasm for drought tolerance	Malawi and Tanzania (CRSP)	Bunda, SUA, DRD-Uyole	1997
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

NB: Due to luck of funding some sub-projects may not have been carried out.

b. On-going sub-projects approved in 1999-2000

Title	Country	Institution	Startup
Identification and characterisation of available resources of integrated nutrient management in Southern Highlands of Tanzania	Tanzania	DRD-Uyole	1999
Evaluation of advanced progenies for improvement of common bean for the best lines	Tanzania	DRD-Uyole	1999
Race identification and breeding for resistance	South Africa	ARC/GCRI	1999
Angular leafspot race identification and breeding for resistant lines for SADC countries	South Africa	ARC/GCRI	1999
Selecting multiple resistant lines for diseases and BSM in South Africa	South Africa	ARC/GCRI	1999
Screening common bean lines for low soil fertility and adaptation: N, P and low pH complex	Malawi	DARTS-Chitedze	1999
Effect of green manures and inorganic fertiliser on maize/bean cropping systems in medium altitude production areas of Malawi	Malawi	DARTS-Chitedze	1999
On-farm evaluation, multiplication and dissemination of bean seed	Malawi	DARTS-Chitedze	1999
Developing bean germplasm with multiple constraint resistance	Malawi	DARTS-Chitedze	1999
Potential of crotolaria as a green manure crop for bean production in Swaziland	Swaziland	MoA	1999
Screening bean genotypes for maturity period and soil fertility stresses	Lesotho	MoA	1999
Verification of common bean integrated pest management strategies with small scale farmers	Mozambique	INIA	1999
On-farm diagnosis of plant nutrition constraints to bean productivity in Northern Mozambique	Mozambique	INIA	1999
On-farm evaluation of promising climbing bean lines in Zambia	Zambia	MoA	1999

c. New sub-projects approved in 2000-01

Title	Country	Institution	Start-up
Assessment of Adoption of new Bean varieties and their impact on food and income generation for smallholder farmers in the Southern Highlands of Tanzania	Tanzania	DRD-Uyole	2000
Impact assessment of bean varieties developed by the bean improvement project (BIP) in three selected major bean producing ecologies of Malawi.	Malawi	DARTS	2000
Post harvest assessment of improved Bean varieties under farmer condition (adoption)	Zambia	MoA	2000
On-farm evaluation of bean varieties in Mozambique	Mozambique	INIA	2000
On-farm evaluation of different fertiliser levels/methods in beans	Zambia	MoA	2000
Screening bean genotypes resistance to angular leafspot and common bacterial diseases in Malawi	Malawi	DARTS	2000

Table 25. Distribution of SABRN regional research sub-projects by discipline

Discipline	On-going	New	Total
Seed	2	0	2
Entomology	4	0	4
Breeding	5	0	5
Pathology	3	1	4
Technology Transfer	1		1
On-farm trials	1	2	3
Adoption studies	0	2	2
Impact assessment	0	1	1
Systems agronomy	5	0	5

Table 26. Bean technologies developed for farmers in SABRN

Country	Recommended to farmers	Restricted availability	Very promising for future
Angola	Elvilria, Catarina, Mantega (local cv.) A286, A344, A197 and CAL 143		New CIAT lines
Lesotho	Introduced cvs: Harold, Nodak, Teebus & A 286	G22501, PAD 3, CAL 143, RAO 55, SEA 12 & XAN 76.	Introduced (CIAT), S/A and Malawi lines
Malawi	Local cv: Chimbamba, Nasaka, Namajengo, Bwenzilawana, Kanzama, Sapelekedwa and Kamtsilo Bred cv: Bunda 93 Introduction: *Kalima* (=PVA 692), Kambidzi (A286), Mkhalira (A344), Sapatsika (DRK57), Napilira (CAL 143), Maluwa (CAL 113), Nagaga (A197)	Introduced cvs: AFR 699, LSA 191. Integrated pest management technologies Integrated nutrient management technologies	Introductions: RAO 55, SUG 131, several BSM resistant lines: PAD 3, EXL 52, Mlama 49.
Mozambique	Local cvs:INIA-10, Encarnado. Introduction: PVA773.	Introduced cvs: A 286, Diacol Calima, ICA Pijao. Local cv: INIA-Zambeze.	Intodutions: CAL 143, A 197, CAL 113, DRK 57 AND 628, Colombia.
South Africa	Mkuzi (A 286), Vulindlela (A344), OPS-RS3, OPS-RS4, PAN 150, PAN 109, PANN 107, PAN 143 & PAN 159		
Swaziland	Introduced cvs: BAT1713;PVA 894; Carioca.	Jenny, Teebus, Alubia, OPS-RS2, CAL 143, SUG 131 & A 286	Introduced cv: Puebla Cafe.
Tanzania	Introduced cvs: Lyamungu 85 & 90; Uyole 84, 90, 94, 96, 98 . Local cv: Ilomba, Selian 94 Herbicides: Flex, Galex, Stomp.	Introduced cvs: EP4-4, SUA 90, PVAD 1156, EAI 2525, CAL 143 & A 197. Hedgerow macro-contours.	*Introductions:* G8864, PVA773. IPM against stem maggot; IPM against bruchids.
Zambia	Introduced cv: Carioca (A 286), Chambeshi (197) Lyambai (CAL 143) and Lukupa (PEF 14). Stem maggot seed dressing.	Introduced cvs: PAT 10, Wartburg & AND 717. Local cv: Pembela	2 local cvs: Solowezi Rose, ZPV 292; also introductions
Zimbabwe	Introd. cvs: Ex-Rico 23, MCM 5001, C20. Bruchid control: silica dust and sun drying. Plant population.	Introduced cv: H140-Z2PE & Carioca (A286).	Introductions, PVA 773, CAL 143, SUG 131 and CIM lines from Malawi.

Highlights show common varieties across two or more countries: "The strength of networking".

Activity 5.3 Catalyze efficient pan-African collaboration in research and information exchange

Achievements:

- Regional frameworks for monitoring impact were developed by the bean networks and by PABRA, so that workplans of CIAT and the networks are interdependent and CIAT complements network activities in a transparent manner.

An integrated PABRA strategy linking communities, empowerment and market demand

Rationale: The ECABREN and SABRN networks are self-governing under the policy direction of ASARECA and SABRN, their respective regional NARS organisations. CIAT is an active member of each grouping. Many important constraints and opportunities occur across the boundaries of each network, and efficiencies can be expected from coordinated activities. While coordination used to be mediated by CIAT, this is not a sustainable or desirable arrangement. Also, the stronger NARS are in a position to undertake some of the strategic research otherwise expected of CIAT, a shift that is reducing costs substantially.

Methods: The fifth Annual Meeting of the steering committee of the Pan-Africa Bean Research Alliance (PABRA), in Rubona, Rwanda in May 2001, again brought together representatives of the two networks, CIAT and principal donors to bean research in Africa.

Results and discussion: The meeting venue enabled participants to witness the considerable adoption and impact achieved with climbing beans, and the important continuing role that this small NARS is playing in developing bean technologies that also benefit several other countries in the region.

The ECABREN and PABRA impact frameworks constitute important tools to define research and development activities that are needed to create short and long-term impacts in the region. They also clarify the interactions among PABRA partners, for example by obliging CIAT and network coordinators to develop their annual workplans and project proposals in very close consultation. Achieving impact needs collaboration between scientists, institutions and countries and remains a key ingredient in developing research projects that could are both environmentally friendly and address the immediate needs of users.

Contributors: R. Kirkby and K. Ampofo; M. Pyndji (ECABREN/CIAT) and R. Chirwa (SABRN/CIAT).

Activity 5.4 National and regional specialists take more responsibility within PABRA

Achievements:

- Three regional senior scientists acquired skills and knowledge in writing convincing proposals to donors.

- New methods for evaluating germplasm resistance to drought were exposed to NARS scientists; regional breeding programs were effectively monitored by regional scientists.

Strengthening capacity of NARS scientists to manage regionally coordinated activities

The ECABREN coordinator participated in PABRA millennium workshop organized in Arusha, Tanzania from May 28 - June 1, 2001 and presented a paper entitled: 'Shifting from production to market oriented research'.

The regional bean network coordinators (ECABREN and SABRN) and the ECABREN/ University of Nairobi regional bean breeder participated in the workshop on 'How to write a convincing proposal: Strengthening project development, donor relations, and resource mobilization in agricultural research", organized at ISNAR, The Hague, The Netherlands from July 23-28, 2001.

The bean program leader from Selian Agricultural Research Institute, Tanzania participated acquired skills and knowledge in management during a two-week Agricultural Research Training for NARS Program leaders in sub-Saharan Africa held in Accra, Ghana from 14 to 28 October, 2001.

The Bean Improvement for Water Deficit in Africa (BIWADA) moderated by a regional drought specialist held its first planning meeting in Nairobi from 30-31 August. Nine scientists from DR Congo, Kenya, Rwanda, Sudan, and Tanzania attended the meeting whose main objective was to harmonize drought evaluation methodologies and set strategies for drought research in ECA and ESA regions.

Regional resource persons from the NARS of DR Congo and Madagascar continued to act as regional coordinators for collaborative research under BILFA and PRIAM. The coordinator of PRIAM not only visited existing sites but also supported the startup of new sites in Malawi and Tanzania and convened a regional planning workshop for her collaborators.

Contributor: M. Pyndji (ECABREN/CIAT); R. Kirkby.
Collaborators: P. Kimani (ECABREN/CIAT/Univ. of Nairobi); T.Amede (CIAT/AHI); B. Rabary (FOFIFA); L. Lubanga (INERA).

Activity 5.5 Improve the research and dissemination capacities of scientists and institutions

See Activities 3.2, 3.4, 4.3, 5.1, 5.2, 5.3 and 5.4.

PUBLICATIONS

Refereed publications

Abate, T., Van Huis, A. and Ampofo, J.K.O. 2000. Pest management strategies in traditional agriculture: an African perspective. Ann. Rev. Entomology 45:631-659

David, S., L. Mukandala and J. Mafuru. Seed availability, an ignored factor in crop varietal adoption studies: a case study of beans in Tanzania". Journal of Sustainable Agriculture (forthcoming).

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Amede, T., Birhane Dea, Belay Gebremedhin, Mergia Abera, R. Kirkby and A. Stroud. 2001. From farmer strategies to sustainable rural livelihoods: Experiences from the African Highlands Eco-regional Programme (AHI). A paper presented at the SEAAFSR-E Conference, Nairobi, Kenya, 20-24 August 2001.

Amede, T., Takele Belachew and Endrias Geta, 2001. Reversing the degradation of arable land in Ethiopian Highlands. Managing African Soils. No. 23. International Institute for Environment and development, IIED- London.

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Amede, T. and Roger Kirkby, 2001. Guidelines for Integration of Legume Cover Crops into the Farming Systems of East African Highlands. Proceedings of TSBf - African soils network (Afnet) 8th workshop, 7-10 May, 2001. In press.

Amede, T. 2001. Physiological Indicators of Drought Resistance in Common beans (Phaseolus vulgaris): a Review. A paper presented at CIAT PABRA Millenium Conference, Arusha, May 28-June 1, 2001. In press.

Ampofo, J.K.O., U. Hollenweger, S.M. Massomo, and E. Ulicky. 2001. Participatory IPM development and extension: the case of bean foliage beetles in Hai, northern Tanzania. A case study presented during the Workshop on Advancing Participatory Technology Development, September 17-21, 2001, IIRR, Silang Cavite, Philippines.

Ampofo, J.K.O., S.M.S. Massomo and U. Hollenweger, 2001. Using participatory approaches for IPM development and extension: Two case studies from northern Tanzania. Presented at the PABRA Millennium Synthesis: A Workshop on Bean Research and Development in Africa over the last Decade. Arusha, May 28-June 1, 2001

Ampofo, J.K.O. 2001. IPM Research and Development in the CIAT Africa Program. A seminar at the Department of Applied Entomology, Swiss Federal Research Institute (ETH) Zurich, June 2001.

Buruchara, R.A., R.A. Kirkby, H. Gridley and P.M. Kimani. 2001. Decentralized and Participatory Breeding Strategies for Beans in Africa: Evolution and Potential. Paper presented at the Africa-wide workshop on Participatory Plant Breeding, Bouake, Cote d'Ivoire, 7-11, May 2001.

Kimani, P.M., H. Gridley, R. Buruchara and R. Kirkby. 2001. Decentralized and participatory breeding strategy for bean in Africa: Its role and potential for institutionalization. Paper presented at the Africa-wide workshop on Participatory Plant Breeding, Bouake, Cote d'Ivoire, 7-11 May 2001.

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Buruchara, R., Mahuku, G., Opio, F. Kijana, R., Liebenberg, M., and Ngulu. 2001. F. Angular leaf spot research in Africa: An overview. Presented at the PABRA Millennium Synthesis: A Workshop on Bean Research and Development in Africa over the last Decade. Arusha, May 28-June 1, 2001.

Kimani, P., R. Buruchara, K. Ampofo, M. Pyndji, R. Chirwa and R. Kirkby. 2001. Breeding bean for smallholder farmers in Eastern, Central and Southern Africa: Constraints, achievements and potential. Presented at the PABRA Millennium Synthesis: A Workshop on Bean Research and Development in Africa over the last Decade. Arusha, May 28-June 1, 2001.

Musoni A, Kimani P, and Buruchara R. 2001. The development and status of climbing beans technology in Rwanda & ECABREN region. Presented at the PABRA Millennium Synthesis: A Workshop on Bean Research and Development in Africa over the last Decade. Arusha, May 28-June 1, 2001.

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David, S., G. Luyima and M. Ugen-Adrogu. 2000. Promotion of new bean varieties and technologies among farmers in Kampala, Uganda. Paper presented at the Stakeholders' and Planning Workshop for the CGIAR Strategic Initiative on Urban and Peri-Urban Agriculture, ILRI, Nairobi, Kenya, November 1-4, 2000.

David, S. 2000. Impact diagramming: a tool for participatory monitoring and evaluation. Paper presented at a mini workshop during the International Seminar of the PRGA Program "Using Science and Participation in Research", ICRAF, Nairobi, Kenya, November 6-11, 2000.

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Hollenweger, U. and K. Ampofo. 2001. No one has a monopoly on good ideas: Learning through sharing in IPM technology development in Tanzania. A paper presented at the SEAAFSR-E Conference, Nairobi, Kenya, 20-24 August 2001.

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Hollenweger, U. and D. M. Mkalimoto. 2001. Researchers learn from farmers: A participatory study on technology dissemination, farmers' knowledge in pest management and farmers' influence in research. A paper presented at the PABRA Millennium Synthesis: A workshop on bean research and development in Africa over the last decade, Arusha, Tanzania, May 28-June 1, 2001.

WORKSHOPS AND CONFERENCES

Technical meetings convened by CIAT

International Seminar of the PRGA Systemwide Program "Using Science and Participation in Research", ICRAF, Nairobi, Kenya, November 6-11, 2000.

PABRA Millennium Synthesis: A workshop on Bean Research and Development in Africa over the last Decade. Arusha, May 28-June 1, 2001

Other workshops and principal meetings

Stakeholders' and Planning workshop, CGIAR Strategic Initiative on Urban and Peri-Urban Agriculture, ILRI, Nairobi, Kenya, November 1-4, 2000.

Workshop on Advancing Participatory Technology Development, IIRR, Silang Cavite, Philippines. September 17-21, 2001.

Meetings of the Global Forum and the Sub-regional Research Organizations

TRAINING EVENTS

Involving CIAT in Africa [not exclusively IP2]

Agricultural Research Training for NARS Program leaders in sub-Saharan Africa, Accra, Ghana, 14 to 28 October, 2001. [Led by ISNAR, ECABREN sponsored DRD Selian bean program leader, Tanzania].

Training of trainers regional workshop on identifying and classifying local indicators of soil quality, Arusha, Tanzania, May 6 – 8, 2001 [Organised by Project PE2 and SWNM].

Regional course on agro-enterprises development (Foodnet), Entebbe, Uganda, May 2 - 12, 2001 [Led by Project SN1 and Foodnet/IITA, participants sponsorship by IP2].

Participatory research for productivity enhancement of smallholder ruminant livestock systems, Nairobi, Kenya, May 3 – 11, 2001 [convened by ILRI, technical support from PRGA].

Bean IPM participatory rural appraisal training course for technicians, Mzuzu, Malawi, May 22 – 26, 2001.

Regional course on characterization of fungal pathogens and introduction of marker assisted selection techniques, Kampala, Uganda, 16 – 20 July, 2001.

ECABREN Regional course on potential strategies to cope with drought in bean production systems, Nairobi, Kenya August, 30 – 31, 2001.

PRIAM national training course, Dedza, Malawi, September, 3 – 8, 2001 [led by SABRN].

DONORS

Donor	Project	Duration of current funding
CIDA (Canada)	Pan-Africa Bean Research Alliance	2000-2002
DFID (UK)	Participatory Plant Breeding	1998-2001
HRI (from DFID)	Epidemiology of bean root rots	2000-2003
ICRAF (donor consortium to AHI)	Ecoregional research (systems intensification)	1998-2001
ICRISAT (from USAID)	Seeds of Freedom (Angola)	1997-2001
Rockefeller Foundation	Genetic Improvement of Bush and Climbing Beans	2001-2003
SDC (Switzerland)	Pan-Africa Bean Research Alliance	1998-2001 2001-2004
	Associate Expert in Agronomy (Tanzania)	1998-2001
USAID (USA)	Eastern and Central Africa Bean Research Network	1998-2003

Notes:

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

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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
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
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
CU	Concern Universal, Malawi
DARTS	Department of Agricultural Research and Technical Services, MoA, Malawi
DALDO	District Agriculture and Livestock Development Office (Tanzania)
DGISP	Denmark
DRD	Department of Research and Development, Ministry of Agriculture, Tanzania
EARO	Ethiopian Agricultural Research Organization
ECABREN	Eastern and Central Africa Bean Research Network
FOFIFA	Centre National de la Recherche Appliqué au Développement Rural, Madagascar
FORI	Forestry Research Institute, Uganda
HRI	Horticultural Research Institute (UK)
IACR	Rothamsted (UK)
ICIPE	International Centre for Insect Phyiology and Ecology
ICRAF	International Centre for Research in Agro-Forestry
IBFA	Ikulwe Bean Farmers Association (Uganda)
IFDC	International Fertilizer Development Center, Africa Regional Program, Togo
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
MAAIF	Ministry of Agriculture, Animal Industry & Fisheries, Uganda
MoA	Ministry of Agriculture
MU	Makerere University, Uganda
MWG	Makhai Women's Goup (Uganda)
NARI	National agricultural research institute
NARO	National Agricultural Research Organisation, Uganda
NARS	National agricultural research system
NGO	Non-governmental organization
NRI	Natural Resouces Institute (UK)
PABRA	Pan-Africa Bean Research Alliance
RF	The Rockefeller Foundation
RUFAO	[NGO in Kenya]
SABRN	SADC Bean Research Network
SACCAR	Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training

SADC	Southern Africa Development Community
SARI	Selian Agricultural Research Institute, DRD, Tanzania
SDC	Swiss Agency for Development and Cooperation
SUA	Sokoine University of Agriculture, Tanzania
SWNM	Soil, Water and Nutrient Management, a system-wide program of the CGIAR
TSBF	Tropical Soil Biology and Fertility Program
UoN	University of Nairobi
USAID	United States Agency for International Development