PROCEEDINGS OF A WORKSHOP ON

BEAN VARIETAL IMPROVEMENT IN AFRICA

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P R E F A C E

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

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

Publications in this series include the proceedings of workshops held to assess the status, methods and future needs of research in selected topics that constrain production or productivity of this crop in Africa. Publications in this series currently comprise:

No. 1 Bean Fly Workshop, Arusha, Tanzania, 16-20 November 1986.
No. 2 Bean Research in Eastern Africa, Mukono, Uganda, 22-25 June 1986.
No. 3 Soil Fertility Research for Bean Cropping Systems in Africa, Addis Ababa, Ethiopia, 5-9 September 1988.
No. 4 Bean Improvement in Africa, Maseru, Lesotho, 30 January - 2 February 1989.

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

Regional Co-ordinator, SADCC/CIAT Regional Programme on Beans in Southern Africa, P.O. Box 2704, Arusha, Tanzania.

Regional Co-ordinator, CIAT Regional Programme on Beans in Eastern Africa, P.O. Box 67, Debre Zeit, Ethiopia.

Coordinateur Regional, CIAT, Programme Regional pour l'Amelioration du Haricot dans la Region des Grands Lacs, B.P. 259, Butare, Rwanda.

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A C K N O W L E D G E M E N T S

The organisers wish to express their appreciation of the efforts of the many people who made possible the original workshop and these proceedings, including in particular the following:

The Hon. Thesele Motsoene, Director of Special Field Services, Lesotho, who formally opened the Workshop.
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SESSION I - INTRODUCTORY SESSION

AGRICULTURAL RESEARCH IN LESOTHO

Trower Namane

ABSTRACT

Lesotho covers an area of 30,600 km^2 and is entirely surrounded by the RSA. It has three major ecological zones: the mountains, the foothills and the lowlands. Arable cropping is practised mainly in the lowlands. Beans are the fifth most imporatnt crop in terms of area and production. Research is the responsibility of the Agricultural Research Division, the structure, operations and staffing of which are briefly described.

INTRODUCTION

Lesotho is a small country (30,600 km^2) that is entirely surrounded by the Republic of South Africa. The country is divided into three major ecological zones: the mountains (2200-3900 masl); the mountain foothills (1800-2200 masl); and the lowlands (1500-1800 masl). The lowlands are further sub-divided into the high rainfall (800 mm) northern region with relatively good loamy soils, and the low rainfall (450 mm) southern region, where sandy soils predominate. The mountains receive most rainfall (1000 mm).

Lesotho has a temperate climate, making it an exception in the Tropical/Sub tropical SADCC region. Mean maximum and minimum temperatures in the three ecological zones are listed in Table 1.

Table 1. Mean maximum and minimum temperatures in Lesotho

	Temperature (^{o}C)	
Ecological zone	Maximum	Minimum
Mountains	24	-6
Foothills	26	-4
Lowlands	28	-3

The mountains, which occupy more than fifty percent of the total land area are characterised by mostly range lands, with only a limited amount of crops agriculture taking place. This region is therefore very important for livestock, including Merino sheep, Angora goats, cattle, horses, and donkeys. The crops in this region are wheat, peas, beans, with limited maize and sorghum. The foothills host mixed agriculture (crops and livestock), with dairying becoming important in the region. The lowlands are very important in crops agriculture, with maize being most important, and followed by sorghum, wheat, beans and peas. The total areas, production and yields of the major crops in Lesotho from 1973 to 1984 are shown in Table 2. Those for beans on a district basis are in Table 3.

Table 2. Area sown (000s ha), production (000s tonnes) and yield (kg/ha) of important crops in Lesotho from 1973 to 1984.

Year	Maize			Sorghum			Winter wheat			Summer wheat		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1973/74	140.9	122.5	869	84.8	84.0	981	48.4	25.1	519	33.7	31.9	947
1974/75	126.3	70.2	556	68.4	37.4	547	31.4	16.9	537	31.9	28.4	889
1975/76	115.5	49.1	425	55.4	24.5	443	18.0	9.9	554	41.6	34.6	832
1976/77	92.6	125.9	1359	46.8	62.3	1331	12.9	82.6	638	309.9	538.6	1712
1977/78	11.5	143.1	1284	62.0	85.7	1383	16.0	16.5	1033	295.5	413.2	1398
1978/79	122.3	124.8	1821	54.1	68.9	1274	9.5	5.6	595	284.4	27.9	983
1979/80	118.4	105.6	892	64.5	59.2	919	10.7	8.1	759	198.6	200.4	1009
1980/81	136.5	104.1	763	63.7	47.7	749	4.3	1.7	415	19.2	15.2	791
1981/82	136.6	83.0	608	58.6	25.1	446	7.4	4.9	666	19.5	94.9	486
1982/83	126.8	76.2	601	56.9	30.6	539	18.5	9.1	495	13.3	56.5	424
1983/84	138.6	79.3	572	62.5	33.7	541	20.6	7.7	377	12.8	93.4	728
Mean	124.2	98.5	793	61.6	58.9	827	180.1	104.8	577	255.5	251.8	986

Year	Beans			Winter peas			Summer peas		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1973/74	21.3	7.5	352	4.4	1.7	386	7.4	5.0	784
1974/75	30.6	13.3	436	6.8	2.0	344	8.4	3.7	441
1975/76	35.0	8.6	246	2.8	1.2	427	10.2	4.5	442
1976/77	172.8	208.6	1207	3.2	8.0	265	6.4	6.1	955
1977/78	142.7	10.7	756	1.2	6.2	518	4.4	3.7	845
1978/79	119.4	83.5	699	7.0	2.9	414	5.9	6.5	1109
1979/80	81.7	35.3	432	1.4	6.3	445	5.2	3.9	753
1980/81	91.3	35.1	305	5.0	5.5	96	4.9	3.1	641
1981/82	166.6	48.9	294	3.4	1.5	460	7.0	2.9	419
1982/83	6.3	1.6	255	5.8	2.2	392	5.4	1.0	196
1983/84	11.5	13.3	115	5.7	2.2	399	3.1	1.3	436
Mean	165.9	767.7	463	3.2	1.2	384	6.3	3.8	622

Adapted from Anon (1985).

Table 3. Beans - area sown (000s ha), production (000s tonnes) and yield (kg/ha) in Lesotho from 1973 to 1984.

Year	Butha-Buthe			Leribe			Berea			Maseru			Mafeteng		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
73/74	50.0	20.0	400	100,0	27.0	270	36.0	15.0	417	23.0	11.0	478	27.0	11.0	407
74/75	181.4	29.6	163	186.8	46.7	393	38.9	19.8	489	36.9	12.6	342	40.7	40.0	983
75/76	56.1	14.3	255	123.1	29.4	239	56.5	9.9	195	57.0	15.7	276	65.9	21.7	330
76/77	123.1	176.2	1433	62.3	89.6	1439	31.6	82.6	1278	11.9	11.1	938	28.3	23.0	814
77/78	84.8	73.2	863	55.1	35.9	632	22.2	16.5	718	99.8	72.7	728	23.3	17.3	743
78/79	75.7	190.5	2517	40.2	15.9	398	20.4	5.6	1008	11.9	6.3	528	17.6	6.9	392
79/80	23.3	13.6	584	23.8	9.1	381	9.9	8.1	347	14.6	9.1	625	16.7	5.6	336
80/81	24.2	5.1	211	14.8	4.4	317	9.1	1.7	127	22.7	10.6	469	23.0	6.8	297
81/82	62.7	18.3	292	39.3	11.9	383	3.8	4.9	303	27.3	9.1	333	22.0	6.5	296
82/83	9.6	1.3	135	15.5	2.9	191	1.9	9.1	281	8.4	3.7	443	13.7	5.1	373
83/84	48.2	2.2	46	46.9	4.9	105	1.0	7.7	108	89.8	1.6	186	19.8	1.2	66
Mean	67.2	49.5	737	58.1	25.2	435	26.1	12.8	491	21.1	89.5	423	27.0	13.2	489

Year	Mohale's Hoek			Quthing			Qacha's Nek			Mokhotlong			Thaba-Tseka		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
73/74	9.0	6.0	667	4.0	0.0	0	9.0	3.0	333	-	-	-	-	-	-
74/75	23.6	5.9	249	8.2	2.1	255	7.7	1.8	236	6.5	3.5	390	-	-	-
75/76	18.6	1.3	74	8.9	1.1	122	5.6	1.7	363	9.4	2.8	384	-	-	-
76/77	9.1	6.9	767	7.1	9.8	1391	4.9	7.7	1580	5.1	2.8	404	-	-	-
77/78	9.3	6.2	669	4.5	2.0	443	6.7	14.1	2093	2.8	1.6	556	-	-	-
78/79	6.4	5.0	782	6.5	3.3	506	5.2	4.0	762	3.5	2.3	663	-	-	-
79/80	3.6	1.2	351	2.4	7.9	319	2.6	1.3	509	2.9	1.9	661	2.4	1.2	522
80/81	11.0	5.5	499	2.3	1.2	517	1.1	2.0	196	1.8	2.4	1317	3.4	2.1	606
81/82	11.6	3.3	318	10.7	3.0	285	4.2	2.1	513	5.8	2.0	49	6.2	4.0	65
82/83	5.1	1.1	222	7.1	5.0	75	9.0	0.1	11	2.0	3.0	149	2.2	1.0	63
83/84	3.0	2.0	75	6.1	1.8	272	3.1	5.0	179	1.2	2.0	216	6.0	1.0	234
Mean	9.9	3.9	392	6.2	2.3	376	4.6	3.3	715	4.1	1.6	402	3.0	8.0	274

Note 1: When Thaba-Tseka District was created, it included substantial areas of Maseru and Mohale's Neck and smaller areas of Leribe and Mokhotlong. From 1979-80 onwards the bean areas and production are accordingly reduced for these four districts.

2: The mean yields for the period are calculated by dividing mean production by mean area.

Adapted from Anon (1985).

AGRICULTURAL RESEARCH IN LESOTHO

In Lesotho, the Agricultural Research Division falls administratively under the Department of Field Services, with sister Divisions of Agricultural Information, Extension, Nutrition, and all District Agricultural Offices. There are nine districts (Figure 1).

Research Programmes

There are thirteen activities which may be separated into three groups in the Division. They include :

(a) Research

- Agronomy (Field Crops)
- Animal Science
- Farm Management
- Horticulture + Pomology
- Human Nutrition
- Range Management
- Rural Sociology
- Rural Structures

(b) Research and Services

- Soils Laboratory
- Plant Protection Laboratory

(c) Services

- Extension and Communication
- Seed Testing Laboratory
- MOA Library

Research Sites in Lesotho

The Agricultural Research Division is currently operating in thirteen research sites, including the main station in Maseru, four stations in the mountains, two in the mountain foothills and six in the lowlands.

The number is large for the size of scientists that we have, and indeed for the size of budget that we operate under. As a result the Division is in the process of reducing the number of sites that we have and strengthening research in the major ecological zones. We are hoping to have four branch stations, one in each of the major ecological zones - the mountains, the foothills, the northern lowlands, and the southern lowlands. Each station will have a focus of its own, and each will be staffed with a scientist or scientists trained in disciplines relevant to the predominant agriculture of the region.

Staffing

In this regard, the Agricultural Research Division of Lesotho is probably one of the smallest in the SADCC region. Table 4 summarises the staffing situation. We currently have six expatriate staff with PhDs, eight MSc holders (locals), eight BScs (local), and fourteen Diplomates. Currently undergoing long term training are five PhDs (who will start returning in May 1989), three MScs and six BScs. These are expected to return before the end of 1991.

Table 4. The current staffing situation of the Agricultural Research Division by existing research programmes, 1988.

	Available				Training			
Discipline	PhD	BSc	BSc	Dipl.	PhD	BSc	BSc	Dipl.
Administration	(1)	3	1	0	1	0	0	0
Agronomy	(1)	0	0	2	1	0	2	0
Soils	(1)	0	1	2	0	0	1	0
Seed technology	0	0	1	0	0	0	0	0
Horticulture	(1)	1	1	2	0	0	1	0
Plant pathology	0	0	0	1	1	0	0	0
Entomology	0	1	0	0	0	0	1	0
Animal science	(1)	*	1	0	1	0	1	0
Range	0	0	2	1	0	0	0	0
Human nutrition	0	1	0	1	0	0	0	0
Marketing	0	0	0	0	0	2	0	0
Farm management	0	0	1	0	1	0	0	0
Rural sociology	(1)	1*	0	0	0	0	0	0
Agriculture engineering	0	(1)	0	1	0	1	0	0
Extension	0	0	0	2	0	0	0	0
Farm foreman	0	0	0	1	0	0	0	0
Library	0	0	0	1	0	0	0	0
Total	(6)	(7)	8	14	5	3	6	0

( ) Expatriates with projects
* Qualified person resigned

Despite our limited resources, regional programs are impressed with the work that we are doing, and we feel, with continued support for our efforts, our future is very bright.

LITERATURE CITED

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STRUCTURE AND OBJECTIVES OF WORKSHOP

J.B. Smithson

INTRODUCTION

At a conference in Malawi in 1980 involving representatives of national programmes in Africa and other international and donor agencies, CIAT was charged with the establishment of a bean research network in Africa (CIAT, 1981). Following lengthy discussions with donor agencies and national and regional institutions in Africa and innumerable changes in scenario, a bean research network encompassing the Great Lakes and eastern and southern Africa has now emerged.

THE REGIONAL PROGRAMMES

This commenced in 1983 with the establishment of the Great Lakes Project, funded by the Swiss Government with headquarters in Rwanda and working also with national programmes of Burundi and Zaire. The eastern Africa project was initiated in March 1986 with headquarters in Ethiopia and working also with Uganda, Somalia and subsequently, Kenya, and the southern Africa project in April 1987 in Tanzania for the SADCC group of countries.

The existing senior staff structure comprises: in the Great Lakes, a Breeder, Cropping Systems Agronomist, Pathologist and, presently a Postdoctoral Fellow, in Anthropology, all based at Rubona in Rwanda; in eastern Africa, a Cropping Systems Agronomist and Training officer at HQ at Debre Zeit in Ethiopia and Breeder, Cropping Systems Agronomist and Economist at Kawanda in Uganda; and in SADCC, a Pathologist, Cropping Systems Agronomist, Breeder and Entomologist in Arusha in Tanzania and a breeder in Malawi. One member of each HQ team functions as the Regional Coordinator.

Thereby, each region comprises a multi-disciplinary team with regional responsibilities supported, in some cases, by outposted staff in other countries in the region. Their activities are coordinated by steering committees composed of representatives of each national programme, the donors and the regional programme. The steering committees also control expenditure on training, equipment and research.

INFORMATION EXCHANGE

To facilitate exchange of information and technologies among regions and to stimulate collaboration and avoid duplication, one of the Regional Coordinators acts as overall coordinator of the three projects. Collaboration is also facilitated by frequent workshops and conferences in which regional, national and CIAT HQ staff participate. These include general workshops, like the annual (biennial in the case of southern Africa) workshops of the three regional projects for purposes of regional planning and specialist workshops for specific disciplines. The aims of the latter are to review the status of research in specific fields and to develop future strategies, allocating responsibilities for different aspects among regions and national programmes within regions to establish effective, coordinated research programmes.

Specialist workshops already held have covered beanfly, pathology, drought and soil fertility. This workshop is therefore the fifth in the series of specialist workshops.

The concept of a breeders workshop arose in steering committee meetings in 1987. Subsequently an announcement, programme and participants' list were developed and these were approved in meetings of the three projects in the first half of last year. They were then distributed and after minor revisions due to adjustments in participation and other circumstances, we have arrived at this final format

Lesotho is the venue, not because beans are more important here than in other SADCC countries, but because of the importance of rotating workshops of this kind among national programmes, to enable all of us to experience environments other than our own.

Its objectives are to:

1. exchange information among national programmes

2. determine requirements in terms of breeding materials and other services from CIAT HQ in Colombia.

3. discuss exchange of bean germplasm and breeding materials within and among regional programmes in Africa.

4. develop collaboration in bean breeding and evaluation within and among the regional programmes, and

5. establish a structure of regional and Africa-wide bean nurseries to facilitate exchange and evaluation of breeding materials among national programme.

PROGRAMME

Following the overview of the research services in Lesotho by Mr. Trower Namane, today we have descriptions of germplasm and breeding activities in CIAT HQ and in the U.S.A. These are followed by accounts of activities in Guatemala and Central America as a whole, as examples of the development of national and regional structures in another part of the world. We then consider recent development in breeding and evaluation in the three regional projects. Finally, today we have an account of participatory research activities in Rwanda.

Tomorrow, is devoted entirely to field tours - in the morning to the main research station for beans near Maseru and then to a recently developed sub-station at Machache in the foothills about 30 km from Maseru.

Wednesday and part of Thursday morning are occupied by country reports, which will review the status of breeding activities and varietal release in national programmes in the three regional projects followed by four discussion sessions on: genetic resources; segregating materials; regional nurseries; and varietal release and seed production during which we hope to arrive at recommendations for future strategy for approval by the steering committees of the three regional projects.

Finally, Dr. Matt Silbernagel will undertake the difficult task of summarising the recommendations and conclusions of the workshop.

LITERATURE CITED

CIAT (1980). **Regional Workshop on Potential for Beans in Eastern Africa, Lilongwe, Malawi, 1980.** Proceedings. Centro Internacional de Agricultura Tropical, Cali, Colombia (1981).

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SESSION II - AVAILABILITY OF GENETIC RESOURCES

EXISTING BEAN VARIABILITY AND BREEDING ACTIVITIES AT CIAT FOR NEW GENETIC COMBINATIONS

Joe Tohme

ABSTRACT

Assembled germplasm has provided breeders with valuable traits for the improvement of common beans. Molecular markers such as phaseolin and isozymes have facilitated understanding of the genus ***Phaseolus*** *thus enabling breeders to develop more effective strategies. However, there are still gaps in the collections that have been assembled and in available information. Strategies for conservation need to be coordinated among international and national programs to prevent further genetic erosion of collected germplasm. Duplication of germplasm collections is vital.*

New sources of genetic variability not present in existing cultivars have been identified and transferred to adapted backgrounds. Wild accessions of ***P. vulgaris*** *have provided genetic variability and sources of resistance not yet found in cultivated beans. At CIAT, the diversification of sources of resistance to several diseases and insects is well advanced. Broad and stable resistance is being sought. These new resistant sources are deployed through international nurseries which also serve to monitor pathogen variability.*

INTRODUCTION

Plant breeders have used available genetic variability to improve the yield and resistance of common beans to biotic and abiotic factors. Large collections of *Phaseolus* beans have been gathered and diversity seems to be wide. However, several characters of resistance to various adverse factors such as bruchids are either absent or poorly expressed. Studies are now in progress to understand the genetic structure of these collections, to develop strategies for collecting and conservation and to utilize existing variability to develop better adapted, heavier yielding cultivars. Reviews of various topics have been published or are being published. Readers should refer to these reviews for additional information. The talk will be confined to wild and cultivated common beans, *P. vulgaris*, and will address the issues of genetic variability and its uses by bean breeders.

EXISTING VARIABILITY

Bean germplasm banks

Major collections of bean germplasm are preserved in gene banks around the world. Banks, such as those at CIAT, the USDA, Pullman and the University of Cambridge in the UK have large international collections. Others, like national banks in Mexico, Peru and Malawi are more regional in scope. In 1975, IBPGR extended to CIAT the world mandate for *Phaseolus* collection. Currently CIAT has the largest collection of bean germplasm (about 40,000 accessions) with *P. vulgaris* accounting for some 27,000 of them (Table 1).

Table 1. Status of the *Phaseolus* collection held at CIAT (November, 88)

	Number of accessions	
Species	Introduced	Increased
P. vulgaris	35516	21326
P. vulgaris wild ancestral	434	372
P. lunatus	2847	904
P. lunatus wild ancestral	107	67
P. coccineus subsp. *coccineus*	936	490
P. coccineus subsp. *polyanthus*	461	271
P. coccineus wild ancestral	149	32
P. acutifolius	143	123
P. acutifolius wild ancestral	59	59

Initially the Genetic Resources Unit (GRU) at CIAT depended on acquisitions of bean germplasm from other collections. These included various established banks like those at Pullman, Cambridge, Chapingo, La Molina, Turrialba and Gembloux. CIAT also received germplasm from IBPGR-FAO sponsored collecting expeditions with national programs in Africa. A small subset of the Malawi Bean Cowpea CRSP-Bunda college collection was also sent to CIAT.

More recently, several collection trips were carried out by Dr. Daniel G. Debouck in collaboration with IBPGR and various national programs in Latin America. These trips were by far the most comprehensive attempts to collect valuable germplasm to address key questions related to bean evolution. The explorations were targeted at specific sites, to fill gaps in the genus *Phaseolus* (Debouck,1985; Debouck and Tohme, 1988). The populations collected have already provided a wealth of information with regard to gene pool formation for *P. vulgaris*, *P. acutifolius*, *P. coccineus*, *P. polyanthus* and *P. lunatus*.

Challenge facing the CIAT bank

The germplasm stored at CIAT is derived from most countries where beans originated or are being grown presently. However, gaps exist in the collection. In the case of the wild *P. vulgaris*, no collections are available from countries such as Honduras, Nicaragua and Panama, although herbarium specimens occur in various botanical museums. Colombia is also poorly represented in wild *P. vulgaris* germplasm. For cultivated common beans, undocumented accessions from the primary centers of origin make it difficult to assess where gaps exist.

Some problems facing CIAT trace back to the germplasm received through acquisition. With the exception of very few cases we do not know the extent of original variability within each accession; is the accession coming from very few seeds and thus quite uniform or was the sampling more extensive and variable? The strategy for screening will differ depending on whether an accession is a uniform or diverse population. In the latter case, care will have to be taken to consider individual selections whenever screening.

Another important problem is related to the information collected about accessions. The quality of the data on collections is rather variable. Some collections were received without passport data making it impossible to detect duplications and to identify major gaps in the collection of a specific country. Efforts are being made to recover information on the germplasm acquired from national programs and from other major banks.

Besides identifying gaps and duplications, the bean program at CIAT started recently to accumulate information for better utilization of variability. For example a large part of the Zambian collection has passport data pointing to gaps in the Copperbelt and North Western Province, two areas with interesting soils. Landraces from such areas may well provide sources of tolerance of poor soils for improvement of beans for soil stress conditions.

Loss of variability is another important problem. The danger of genetic erosion is very real. It is happening in poorly collected or uncollected areas due to urbanization, deforestation, soil degradation and introduction of improved cultivars. It is also happening within germplasm banks. Several programs have already lost national collections due to poor management and unexpected external factors. Thus it is crucial to duplicate collections, inside and/or outside countries. CIAT is currently involved in duplicating its collection in Costa Rica and Brazil.

The large number of accessions maintained at CIAT can create operational difficulties. Costs are proportional to the size of the collection. The size of the collection, about 40,000 accessions, is still manageable. However, CIAT, like other banks, faces the problems of seed borne diseases and seed viability. While seed health is monitored through careful seed increase, seed borne diseases such as bean common mosaic virus are difficult to handle without losing variability. It is not uncommon to find in certain groups, like the red mexican, a high percentage of BCMV infected seeds even after strict screening and repeated roguing. Serious attempts must be made to increase clean seed without causing genetic shift or losses of rare alleles in a population. In that respect, molecular markers such as isozymes may be helpful in monitoring allelic shift in populations subjected to strict roguing.

In large areas of the Andean region and certain countries in Africa, mixtures are still grown and preferred by farmers. Such mixtures are good reservoirs of genetic diversity. Their composition varies, ranging from two to 22 components per mixture. The challenge for germplasm banks is how to maintain the mixture and the integrity of a mixture without causing shift? Studies have shown repeatedly that good competitor lines in a mixture will eventually eliminate poor competitors and dominate. One alternative is to deliberately maintain the proportion of poor competitor lines and lines present at low frequencies in the original collection.

ORIGINS AND GENE POOLS

From archaeological records based on radiocarbon dating, we now know that beans were domesticated in the Americas 7,000 to 10,000 years ago. The oldest *P. vulgaris* beans excavated are from Jujuy in Argentina, Ancash in Peru and Puebla in Mexico. Beans from these and other archaeological sites appear to be fully domesticated and modern. Their seed sizes and seed colors are similar to beans presently grown in the same areas. Several good reviews have been recently published on the subject (Kaplan and Kaplan, 1988; Debouck and Tohme, 1989).

Wild *P. vulgaris*, the ancestor of the cultivated common bean, has been found in various places in tropical and subtropical America, from Chihuahua in Mexico to San Luis in Argentina (Gentry, 1969; Berglund-Brucher and Brucher, 1976; Debouck, 1986a; Debouck, 1986b; Debouck and Tohme, 1988). While gaps exist in countries like Honduras, Panama and Ecuador, distribution is near continuous and covers an area of some 7,000 km^2. Wild populations collected across the range of distribution differ in morphological traits such as seed size, bracteole size and shape and hypocotyl color.

Along with the archaeological information, morphological data provides evidence for two separate and independent domestication centers (Evans, 1976; Kaplan, 1981): one in Middle America giving rise to small- and medium-seeded cultivars (for example, navy, black, pinto, great northern, small red); and one in Andean regions giving rise to large-seeded cultivars (such as red kidney, cranberry, and large yellow).

The existence of two different main pools has been confirmed by biochemical studies. Phaseolin, a major seed storage protein, is also a useful evolutionary marker (Gepts, 1984; Gepts and Bliss, 1986; Gepts *et al*, 1986; Tohme *et al.*, 1989). Analysis of wild populations and cultivated landraces has provided additional evidence for separate domestication in Middle America and Andean regions. The principal conclusions arising from these studies are that:

- more phaseolin types exist in wild than cultivated forms;

- Middle American wild forms have 'M1' to 'M20' and 'S' phaseolin types whereas cultivated forms have only 'S' phaseolin;

- southern Andean wild forms have 'T', 'C', 'H', 'To', 'Ta', and 'J' phaseolin types, whereas the cultivated landraces have the 'T','C', 'H' and 'A' phaseolin types;

- wild and cultivated populations from Colombia have 'B' phaseolin.

The extent of variability is still under investigation. The data provided by biochemical analysis needs to be expanded to more accessions for a better resolution of the limits of the various pools. Studies are being conducted now at CIAT (Tohme et al., in preparation) on new wild populations collected recently by D.G. Debouck in the Andean zones. It is hoped that these will extend understanding of the Andean center of domestication.

Founder effect

Although wild bean populations are distributed over 7,000 km^2 in the Americas, they were apparently domesticated in only a few centers. Phaseolin types in wild populations are more numerous and variable in the Middle American and Andean centers. The importance of the founder effect in domestication and its implications for genetic variability are poorly understood in beans.

The founder effect is best illustrated by the case of bruchid resistance. So far no resistance has been found in some 14,000 accessions of cultivated beans (Schoonhoven and Cardona, 1982). However, very few populations of wild *P. vulgaris* beans from Mexico possess a high level of resistance. It was found that resistance to one of the bruchid species (*Zabrotes subfasciatus*) is linked to the presence of a protein called arcelin. The absence of bruchid resistance could be explained by populations carrying resistance remaining undomesticated.

Bean dissemination and distribution

After the discovery of the Americas in 1492, the cultivation of beans spread quickly in Europe. Within sixty years, beans were grown in various countries in the Old World. In general, they were large seeded and adapted to cooler conditions. Based on phaseolin analysis, Gepts and Bliss (1988) concluded that most of these European varieties originated from Andean regions.

The introduction of beans into Africa probably followed two distinct routes. One route was from Brazil carried by the Portuguese and Mozambique was most probably one of the sites of initial introduction (Martin and Adams 1987). The second route was from the southern Andes through Europe. Secondary centers in Africa may have preserved genotypes already lost in the Americas and could act as 'windows into the past' (Adams, pers. comm). In Malawi for example, genotypes with green colored seeds are widely grown for their sweetness and fast cooking characteristics. Such genotypes are extremely rare in American germplasm.

STUDY AND USE OF VARIABILITY

The value of collections is enhanced by the study of their genetic structure and their utilization. The characterization and evaluation of accessions for biotic and abiotic traits are crucial for the utilization of existing genetic variability. Along with other institutions, the bean program at CIAT has been involved in the study of bean germplasm.

Existing variability is becoming more and more valuable with the trends toward genetic uniformity. Local genetically variable landraces are being replaced by more homogeneous cultivars, often with narrow genetic bases. Till the early sixties it was not uncommon to find farmers in the Andean regions growing mixtures and highly variable landraces. Such practices have slowly disappeared as new improved cultivars have been released. Today in Colombia for example, mixtures are grown only on remote and more traditional farms. Mixtures are still important in some areas of Africa, notably in the Great Lakes and in Malawi/southern Tanzania/northern Zambia. However, the trend is towards more uniform cultivars.

Uniformity is demanded also by consumers and seed producers. Consumer taste is particularly demanding, each region having its own preferences. Such uniformity could lead to great losses if an epidemic occurs in an area growing genotypes uniformly susceptible to a disease such as rust.

Biochemical studies

Phaseolin and isozymes are being used at CIAT and other institutions to address key issues related to genetic diversity.

An extensive study was conducted recently at Michigan State University by Susan Sprecher on Malawian germplasm using isozymes. Six polymorphic enzymes were used on 373 lines collected from small farms in Malawi (Sprecher, 1988, pers. comm.). While genetic variation for morpho-physiological traits has been observed (Martin and Adams, 1987), the variability at the isozyme level was very limited. Only two groups were obtained, associated with the centers of origin (large-seeded Andean and small-seeded Middle American types). The data confirms the existence of two main pools and points to the rarity of recombination between them, at least for the biochemical markers used. Further analyses are being conducted to determine the reasons for this lack of recombination.

At CIAT, a study has been initiated using phaseolin to trace the dispersal of beans from their centers in the Americas to six countries of eastern Africa. The preliminary results showed most accessions had 'T' phaseolin (Malawian and Ugandan lines), some had the 'S' type, and a few were 'C' types, suggesting a southern Andean origin for most of the germplasm. Surprisingly, out of eighteen accessions from Tanzania, twelve small-seeded lines had 'S' phaseolin. Such small numbers, however, may not be truly representative of local germplasm.

Reactions to diseases and insects

The CIAT germplasm collection has been used to improve the potential of common beans and to broaden their genetic base. Till recently, in the case of some diseases, resistance could be traced to the same source. This situation developed because different sources were unavailable or uncharacterized.

Over the years, the disease reactions of large numbers of germplasm accessions have been evaluated at CIAT and other institutions to identify new sources of resistance. Stable and durable sources of resistance have been sought. The bean program of CIAT has systematically evaluated the germplasm for resistance to various pathogens and insects (Table 2). Several new sources of resistance to anthracnose, angular leaf spot, common bacterial blight, bean common mosaic virus, empoasca and bruchids have been identified.

These new sources of resistances have been incorporated into adapted and stable genotypes and made available through international nurseries distributed to national programs. International nurseries also serve to monitor pathogen variability, identify stable and durable resistances and detect susceptible cultivars before their release. A brief survey of some of the work on disease and insect resistance is presented in the following sections. For more detailed information readers should refer to CIAT annual reports and the recently published book on bean production in the tropics (Schwartz and Pastor-Corrales, 1989).

Anthracnose. Anthracnose, caused by *Colletotrichum lindemuthianum*, is probably the most widespread fungal bean disease. It is seed borne, has extensive pathogenic variation and may cause total crop loss under favorable environmental conditions (moderate to cool temperatures and ample moisture). Seed health, crop rotation and chemical control are common strategies to control anthracnose. However, the development and deployment of resistant varieties has most potential.

Numerous races of *C. lindemuthianum* have already been identified from Europe and North America. The races have been designated by Greek letters starting with alpha and beta. The race situation is now quite variable with several new races being described.

Table 2. Germplasm accessions of *P. vulgaris* evaluated for resistance to disease and insect pests*.

Disease/Insect	Testing location	Number of accessions Evaluated	Resistant
Cultivated			
Anthracnose	Popayan	13,000	400
Angular leaf spot	Quilichao	13,399	932
Common bacterial blight	Palmira	12,000	3
Bean common mosaic virus	Palmira	18,423	2,472
Empoasca	Palmira	16,216	485
Zabrotes subfasciatus	Palmira	10,000	0
Acanthoscelides obtectus	Palmira	6,000	0
Wild			
Zabrotes subfasciatus	Palmira	255	55
Acanthoscelides obtectus	Palmira	212	157

* Lines listed as resistant to anthracnose and angular leaf spot are being reevaluated to confirm resistance in Popayan.

The strategy followed by plant breeders relied upon race specific resistance. One of the most widely used source in Europe and North America was a black bean from Venezuela, Cornell 49-242. A single dominant gene designated the ARE gene was identified to confer resistance of Cornell 49-242 to all previously known races (alpha, beta, gamma, delta and epsilon). However, Cornell 49-242 was susceptible to new races of anthracnose such as kappa and alpha Brazil. Since then, several sources of resistance to the new races have been found, including Mexique 2, Mexique 3 and Kaboon.

Fourteen thousand accessions from the CIAT germplasm bank have been screened at Popayan, Colombia. Around 150 accessions with resistant and intermediate reactions were then screened against isolates from Colombia, Brazil, Mexico and Europe. About two dozen were identified to be resistant to all extant races. The accessions were of different growth habits and had small to medium seeds. Some of these accessions, such as G 2333, G 2338 G 9032 and AB 136, maintain their resistance across a broad range of conditions.

Work is now in progress to study the mechanisms of resistance. A breeding program has been initiated to incorporate the new sources into adapted lines by backcrossing, to confer more stable resistance. Two back crosses are used. Screening is in a glasshouse. Selection is emphasized for high yield with desirable grain characteristics.

Common bacterial blight. For common bacterial blight, very few sources of resistance have been identified in *P. vulgaris*. High levels of resistance have been found in *P. acutifolius* (the tepary bean). Some sources of resistance in common bean trace back to interspecific crosses. Within *P. vulgaris* intermediate levels of resistance were found in some 30 accessions after screening about 12,000 accessions. The large and small seeded pools have differing mechanisms of resistance. Germplasm screening has resulted in the identification for the first time of sources of intermediate level resistance in accessions (OJ-Santa Rita, G 18443) with medium sized seeds. These sources of resistance have already being incorporated into better adapted backgrounds (Table 3). A review of CBB has been presented (Beebe, 1989).

Table 3. Some lines resistant to common bacterial blight under field conditions.

Name	Pedigree
BAT 93	(Veranic 2 x PI 207262) x (Jamapa x Tara)
XAN 97	BAT 450 x (G 3130 x Jules)
XAN 91	BAT 445 x Tamaulipas 9B
XAN 112	(G 4454 x PI 207262) x (Porrillo Sintetico x Jules)
Xan 159	((Porrillo Sintetico x G10022)) x G40020) x G 4509

Bean common mosaic virus. BCMV, the most important virus of common beans, has been extensively characterized. The landmark work of Drijfhout (1978) along with other works dating back to the sixties have provided a framework for our understanding of the virus. The dominant I gene has been utilized extensively as a source of resistance. Numerous accessions carrying the I gene have been identified and the resistance has been incorporated in various high yielding cultivars.

However, BCMV strains capable of inducing a hypersensitive reaction have been reported on I gene materials. In the presence of the I gene, necrotic strains cause a systemic necrosis which can lead to the death of the infected plant. Such a reaction is known as black root. Necrotic strains have been found to be temperature dependent. Several recessive genes have been identified that, together with the I gene, prevent systemic necrosis. One recessive gene (bc3) found in a cultivated viny line has also been identified to confer resistance to all known BCMV strains. Drijfhout (1978) still provides the most complete description of plant:pathogen relations in BCMV.

So far, only very low frequencies of necrotic strains have been detected in Latin America, with the exception of Chile. The situation is quite different in Africa where the necrotic strains are prevalent. Their distribution is not yet fully-documented but their presence dictates a change of breeding strategy. If necrotic strains are in very high frequency, lines with the I gene, such as Carioca, should be avoided.

At CIAT, for several years, the main emphasis of the BCMV breeding work for Africa has been the combination of recessive genes such as bc2 with the I gene or the use of bc3 as a source of resistance. The breeding scheme utilized relies on backcrossing and has been described in the CIAT Bean Annual Report (1987). Several adapted lines with different seed colors have been developed (initially in collaboration with Dr. Drijfhout) with either the I gene protected by bc2 or bc3 or with bc3 alone.

Beanfly. Beanfly limits bean production in large areas of Africa. The insect does not occur in the Americas and no accession of African germplasm is known to be highly resistant. Thus there is need to screen new germplasm. A diverse set of germplasm of some 1200 accessions, introduced from CIAT, was screened in Ethiopia between 1986 and 1988. Preliminary results indicate that some 12 accessions have high levels of resistance, presumably to *Ophiomyia phaseoli* the only species of beanfly thought to occur in Ethiopia (Table 4). Most of the accessions belong to Central American upright, black-seeded germplasm. Such germplasm has not been widely distributed in the African continent. However, further studies must be carried out to confirm the resistance before starting any serious breeding effort.

Bruchids. Bruchids are the most important storage pests of beans in Latin America and Africa. Bruchid damage can result in heavy loss of both grain quality and quantity. No resistance was found in the cultivated, *P. vulgaris*. Sources of resistance were, however, detected in a very few wild *P. vulgaris* populations collected in various states of Mexico.

As mentioned in a previous section, resistance to *Zabrotes subfasciatus* is due to the presence of arcelin, a protein found only in the seeds of resistant wild populations. The presence of arcelin appears to be dependent on single dominant genes. Four alleles have so far been identified - ARC1, ARC2, ARC3 and ARC4. The variants, ARC1 and ACR4 are considered the best sources of resistance. The resistance has been shown to be due to antibiosis. Extensive tests have been conducted at CIAT and elsewhere to ensure that negative or toxic effects are not associated with arcelin. Results obtained so far indicate that arcelin is not toxic to man.

Since in simple crosses between wild and cultivated types, wild traits (for example pod dehisence, small seed size and viney growth habit) are dominants, a modified backcross breeding program has been implemented to transfer resistance to *Z.*

subfasciatus to cultivated beans. Serological tests are used to identify segregants with seed containing arcelin, thus reducing the numbers of lines and generations needed to obtain genotypes combining commercial characteristics with resistance to *Z. subfasciatus*. Commercially acceptable lines with high levels of resistance have already been developed. Their release will await the conclusion of the studies of nutritional effects of arcelin.

Table 4. Bean accessions found resistant to beanfly in Ethiopia.

CIAT number	Name	Origin	Seed characteristics: Color	Seed characteristics: Weight of 100 seeds (g)
G 1996	Gentry 20989	GTA	Black	21
G 2005	Gentry 21020	GTA	Black	23
G 2472	Guerroro 29-C	MEX	Black	16
G 3645	Jamapa	MEX	Black	20
G 3696	Coleccion 12-D	GTA	Black	22
G 3844	Cascade	USA	White (snap)	31
G 4456	Jamapa	MEX	Black	18
G 4958	Veranic 2	NCA	Cream	21
G 5059	H6 Mulatinho	BZL	Black	23
G 5773	ICA Pijao	CLB	Black	24
G 13176	Criolla Negra	DOM	Black	21

Resistance to the bruchid, *Acanthoscelides obtectus*, has also been found, in a wild population of *P. vulgaris* from Mexico. While backcross methods are also used, segregants have to be exposed to the insect because of the absence of a molecular marker. This has delayed the development of commercially acceptable materials with resistance to *A. obtectus*.

Empoasca. More than 22,000 accessions have been systematically evaluated under field conditions at CIAT-Palmira, Colombia. Only 3.5% of these accessions had moderate or greater resistance. Most of the resistant lines belong to the small-seeded black or cream gene pool. Tolerance is the predominant mechanism of resistance.

Detailed studies (Kornegay *et al.*, 1986) have shown that resistance is quantitatively inherited and that there are large genotype x environment interactions. Selection is directed against inferior crosses in F_2 and F_3 generations, thereby advancing only those populations with good specific combining ability. In F_4 and F_5 selection is practised within families to enhance additive genetic effects. Single seed descent is practised to advance as diverse a range of potentially favorable genotypes as possible. Genotype x environment interactions are minimized by repeated selection and yield testing of populations over time. For detailed descriptions of the procedures see CIAT

(1987, 1988). These strategies have produced improved lines with different seed colors (black, cream red, white) that consistently outyield the tolerant check ICA Pijao.

Interspecific crosses

Several important traits have not yet been identified in *P. vulgaris* despite intensive screening. However, some of these have been found in species belonging to the secondary gene pool. *P. acutifolius* is a good source of resistance to common bacterial blight; *P. lunatus* has good resistance to empoasca; and *P. coccineus* and *P. polyanthus* are good sources of resistance to ascochyta blight and bean fly. While crosses are not always possible (for example, *P. lunatus* x *P. vulgaris*), interspecific crosses are an option for some combinations (*P. polyanthus* x *P. vulgaris*).

Ascochyta blight. An important disease of cool, humid highlands of Latin America and Africa, ascochyta blight has received increasing attention in recent years. Good levels of resistance have not been identified so far in *P. vulgaris*, although intermediate resistance has been found in accessions such as G 6040, G 10747 and G 12582. Landrace germplasm from the highlands of Peru and Guatemala is being evaluated presently in Popayan, Colombia.

While good sources of resistance seem unavailable in *P. vulgaris* extremely high levels of resistance exist in *P. coccineus* and *P. polyanthus*. To date all accessions of *P. polyanthus* have proved to be highly resistant to ascochyta blight. Interspecific hybridization is in progress in collaboration with the University of Gembloux to transfer the resistance into *P. vulgaris*. While some level of tolerance has been transferred, conventional backcrossing or single plant selection has not achieved the success expected, as most truly resistant segregants remain strongly similar to *P. polyanthus* while *P. vulgaris*-like plants are more susceptible.

Currently, work is in progress to study the mechanisms of resistance in the *coccineus-polyanthus* complex in order to develop an effective strategy. Two new hybridization methods are also being implemented. One involves the use of congruity backcrossing to break linkages. The other uses wild *P. vulgaris* as a possible bridge between the two species. Pollen mutation is a further possibility.

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BEAN IMPROVEMENT IN THE UNITED STATES OF AMERICA. CONTRIBUTIONS TO NATIONAL PROGRAMS IN AFRICA

Dr. Matt J. Silbernagel

"The greatest service which can be rendered any country is to add a useful plant to its culture." Thomas Jefferson, 1743-1826, Third U.S. President, 1801-1809.

ABSTRACT

Many of the sources of disease resistance (bean common mosaic virus, anthracnose, rust, halo blight, common blight) that have been used in African national bean improvement programs were first described in the United States of America. Current Bean/CRSP-sponsored breeding activities at six U.S. Agricultural Universities are continuing to develop improved germplasm and new research information that are available to all bean researchers worldwide. Much of the Bean/CRSP related research at U.S. universities is being done by developing country graduate students; thus simultaneously providing trained scientists to accelerate achieving the objective of food crop self-sufficiency in developing countries.

The U.S. Dept. of Agriculture maintains a collection of over 9,000 bean accessions, most of which have been evaluated for a wide range of characteristics in the United States, and by CIAT-Cali; and are available to researchers worldwide. Sharing major collections insures against potential catastrophic loss at any one location. The rapid development of improved bean varieties in the next two decades by African national programs will displace many existing landraces. Strenuous immediate efforts must be made to prevent loss of the genetic diversity in African landraces. Most African nations do not have adequate long-term storage facilities or trained scientists to insure against loss of diversity present in bean landraces. The U.S. Plant Introduction Service stands ready to assist developing nations in the maintenance of bean collections.

EARLY BEAN IMPROVEMENT ACTIVITIES IN AFRICA

The common bean *(Phaseolus vulgaris* L.) is a new world species which has its centers of origin in Central and South America. According to a 1945 report by Greenway (in Leakey 1982), the crop found its way to Europe by the 16th century and was probably introduced to Africa by Portuguese traders soon after. During the past 200 to 300 years, beans have spread to many African countries and have been actively cultivated as a food crop in some areas. Beans were more successful in the higher, cooler areas of eastern Africa than in hotter, more arid environments, and have become a favored dietary protein staple. Unfortunately, most of the diseases and pests of beans were also introduced into Africa and these have become major production constraints wherever beans are grown. Although the yield potential of beans is over 3000 kg/ha, this level of production is seldom achieved. Adaptation refinement by natural selection, and over two centuries of selection by smallholder farmers, for cultural and culinary requirements have resulted in complex landraces (cv. mixtures) that are not easily defined by conventionally-trained, biologically-oriented scientists from temperate zones; because of the tremendous inter-relationships between socio-economic factors and highly dynamic (biologic) intercropping systems. Consequently, early scientific efforts at bean crop improvement over the past three decades in Africa have not been overwhelmingly successful.

Past lack of success in improving bean production in Africa may also have been due in some cases to a carryover from colonial times. Agricultural research during the colonial era was historically aimed at export crops. Likewise, some of the early bean improvement efforts like the haricot bean program (in the 1950s and 60s) in northern Tanzania (Karel *et al*, 1980) were trying to improve beans for export purposes in order to generate foreign exchange. After independence in the 1960s, most fledgling nations lacked the resources and trained scientists to do very much agricultural research, as most research programs in the 60s and early 70s were conducted by short-term expatriates, again mostly on non-food crops for export. By the mid to late 70s, most African governments had recognized the need for improvement of their domestic food crops, and initiated research programs often with the assistance of foreign aid programs using expatriates and the first generation of African scientists returning from training abroad with advanced degrees in the traditional biological sciences. The history of some of those earlier programs is reviewed by Leakey (1982) and in the Proceedings of a CIAT-sponsored workshop "Potential for Field Beans in Eastern Africa," which was held in Lilongwe, Malawi, in 1980 (1981).

From these reviews, it is clear that the initiation of national programs followed similar patterns in most cases. First, an assessment of production problems identified the major constraints (usually diseases and/or insect pests). Control procedures based on imported chemicals were demonstrated and regional landraces and germplasm materials from all over the world were assimilated and evaluated for response to the major diseases. Concurrently, agronomists conducted endless spacing, fertility, and time of planting studies with local favorites and imported lines. Eventually, sporadic breeding programs were initiated, supported in most cases by foreign aid projects which usually only lasted from three to seven years (not enough time to make much progress). Early foreign aid efforts also helped develop seed production and distribution systems, which provided seed of a few cultivars selected out of landrace mixtures. However, since smallholders could not afford fertilizers and pesticides, the cultivars provided were not really better than the mixtures from the smallholder point of view. They were not able to greatly improve bean production.

Another major contributing factor to lack of success in earlier programs was the simplistic view, often taken by biologically-oriented scientists like myself, that all that was needed were a few key genes for resistance to major diseases and/or insect pests. However, when resistant cultivars were introduced they were often not accepted. When sponsoring agencies like CIAT began to ask why, they brought in social scientists to provid. some of the answers. By examining a much broader range of factors, the sociologists working with biologists and economists provided us with a farming systems concept based on the perspective of the smallholder, subsistence farm family. Moreover, it was soon documented that most food crops in Africa are produced, stored, marketed, and cooked by women; whose point of view had rarely been considered in cultivar development programs, and at whom little agricultural training or extension efforts had been directed.

CURRENT BEAN IMPROVEMENT PROGRAMS

By the late 1970s and early 1980s some of the above considerations began to influence foreign aid sponsored programs and African national bean improvement programs. In 1980, CIAT was invited to establish bean improvement outreach teams in Africa, and at about the same time the US-AID-sponsored Bean/Cowpea Collaborative Research Support Program (CRSP) was initiated. The CRSPs grew out of a 1975 World Conference on Hunger, at which the United States made a commitment to help developing countries develop self-sufficiency in their domestic food crops. This was to be done through the involvement of our state agricultural universities, many of which have active crop improvement programs. In addition to the Bean/Cowpea CRSP, US-AID sponsored similar programs in groundnuts, small ruminants, tropical soils, aquaculture, marine stock assessment, and sorghum-millet. The CRSP concept was to: establish long-term (15-20 year) institutional linkages between collaborating scientists at the U.S. agricultural universities and developing country institutions and scientists to conduct research of value to both participating countries; provide training for host country research on the needs of the smallholder farm family; and to especially address the needs of women in the development process. Care was taken by US-AID to avoid duplication of what CIAT was doing (since US-AID also provides 25% of CIAT's core funding). The CRSP programs are intended to complement CIAT efforts by concentrating on providing basic research information, germplasm, and training opportunities for developing country scientists, while CIAT focuses more on applied production research and cultivar development working with host country scientists. Other speakers on this program will tell you what CIAT is doing in Africa, so I will concentrate on the CRSP bean programs and how they relate to bean improvement in Africa.

The B/C CRSP has what is called a global plan. During the formation of the Bean CRSP's, the 18 major production constraints that had been identified by consultation with developing country scientists were divided between different U.S. and HC teams, since no one institution has all of the resources and scientists necessary to address all of the major constraints simultaneously. Information and germplasm materials developed by any one team is made available to all other CRSP teams internationally, as well as any other researchers worldwide who have an interest in those materials. Extra copies of the 1988 B/C CRSP Annual Report are available and I invite anyone inerested to contact the Michigan State University B/C CRSP Management Office (200, Center for International Programs, East Lansing, MI 48824-1035) to get on the mailing lists.

Likewise, I would invite you all to consider personal membership in the Bean Improvement Cooperative. The BIC is an informal network of researchers, seedsmen, processors and others, who exchange information and germplasm materials through annual reports and biennial meetings. Anyone interested may contact the editor, Dr. Howard F. Schwartz (Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523 USA). The BIC Annual Reports are available for $20 U.S./year and will keep you in touch with who is doing what in bean research throughout most of the "bean world".

Originally there were twelve bean CRSP Projects; nine in Latin America and three in Africa (Kenya, Malawi, Tanzania). Due to various factors, only two bean CRSPs are still operating in Africa and seven in Latin America. The Washington State University/Sokoine University of Agriculture project has been operational since 1981, and concentrates on breeding beans for diseases and insect resistance, and assessing the nutritional and economic impact of improved cultivars on the smallholder farm family. We have been holding annual bean researchers workshops at Morogoro since 1982 and if any of you are interested in the Proceedings from those workshops, please contact the host country principal investigator Professor James Teri at SUA, or Dr. Susan Nchimbi, who is present at this meeting, for information on availability of copies of past workshops. Incidentally, our annual bean workshops are usually held near the end of September or early October and I want all of you to consider yourselves invited, and urge you to join us whenever possible. The 1988 Workshop was co-sponsord by the SADCC/CIAT (Arusha) outreach team and I hope they will be able to continue helping with this event at various intervals in the future.

The other Bean CRSPs in which you may be interested are:

Host Country/United States	**Primary Objectives**
Brazil/University of Wisconsin	Molecular biology of Bean Golden Mosaic Virus
Brazil/University of Wisconsin	Biological Nitrogen Fixation
Dominican Republic/University of Nebraska	Common blight
Guatemala/Cornell University	Genetics of temperature-photoperiod interactions on adaptation and yield.
Honduras/University of Puerto Rico	Rust
INCAP/Washington State University	Nutritional improvement
Mexico/Michigan State University	Drought
Malawi/Michigan State University	Genetic diversity

Professor Bliss (BNF-University of Wisconsin) has moved to UC-Davis, so the BNF work will be reassigned soon. Likewise, there may be some institutonal and personnel changes following Professor Adam's retirement (MSU-Mexico and Malawi).

For information on publications and/or germplasm, obtain the detailed B/C CRSP Annual Reports by contacting one of the PI's through the MSU Management Office.

In addition to the above B/C CRSPs many other public and/or private bean research programs are active in the USA. Since most B/C CRSP US PIs are in contact with various non-CRSP researchers, they are also utilizing information and germplasm from those programs. In time therefore these materials will also be found in the CRSPs and will be available worldwide.

Some specific characteristics that have been or are currently being widely used in U.S. bean improvement programs, that have real or potential value for improvement of beans in Africa include:

Resistance to BCMV - particularly the dominant I gene found by Ali (1950) and the several recessive genes described by Drijfhout (1978) which were found predominantly in U.S. cultivars.

Resistance to Curly Top Virus - available in a wide range of dry bean and snap bean cultivars developed by the USDA-ARS at Prosser, WA and the University of Idaho at Twin Falls, ID. Resistance due to two dominant factors. The disease is endemic around the Mediterranean desert regions (Silbernagel and Zaumeyer, 1973; Zaumeyer and Meiners, 1975).

Resistance to Anthracnose - particularly the ARE gene found in Cornell 49-242, as described by Mastenbroek (1960).

Resistance to white mold - as described by Dickson *et al* (1982).

Resistance to halo blight - described by Patel and Walker (1966) in P.I. 150414.

Resistance to common bacterial blight - as transferred from *Phaseolus acutifolius* by Honma (1956) to GN1-sel #27.

Resistance to bacterial wilt - as found by Coyne *et al* (1972) in P.I. 165078.

Resistance to rust - as described by Stavely in a series of USDA bean germplasm releases between 1984 and 1988, that carry multiple genes for strain specific resistance. And, for race non-specific resistance described by Steadman at the October 1988 Bean Workshop at SUA, based on pubescence length and density.

Resistance to bruchids - bean materials collected in western Mexico by USDA Botanist Dr. Howard Scott Gentry in 1966, were later shared by the USDA-Agricultural Research Service with CIAT after establishment of their germplasm bank. In the 1980s CIAT entomologists found bruchid resistance in some of those lines. Researchers at the University of Wisconsin discovered a unique protein named arcelin in the wild, bruchid-resistant beans. That resistance has been transferred successfully to cultivated types (CIAT, 1988).

For details on breeding beans for disease resistance see recent reviews by Silbernagel and Zaumeyer (1973), Zaumeyer and Meiners (1975), Schwartz and Galvez (1980), Allen (1983), and Silbernagel (1986).

U.S. NATIONAL BEAN GERMPLASM RESOURCES

The United States Department of Agriculture-Agricultural Research Service (USDA-ARS) maintains a collection of over 9000 *Phaseolus vulgaris* accessions, catalogued by Plant Introduction (P.I.) numbers. This collection is part of the U.S. National Plant Germplasm System (NPGS), which is responsible for the introduction, increase, evaluation, documentation, maintenance, and distribution of plant germplasm, and the advocation of the needs of researchers for introduced germplasm. These collections have always been shared freely with researchers worldwide as shown by the distribution lists published in 1988 issues of Diversity.

The major working components of the NPGS include:

1) the Plant Introduction Office, administered by the Plant Germplasm and Genetics Institute (PGGI), Beltsville, MD;

2) the four regional Plant Introduction Stations which maintain the "working" collections and special curator sites for major crops, as well as clonal repositories for the Genetic Stock Collections;

3) the long-term storage facility at the National Seed Storage Laboratory (NSSL), Fort Collins, CO;

4) the user community of public and private scientists, educators, and commercial concerns; and

5) the Germplasm Resources Information Network (GRIN), a national germplasm database, which is also administered by the PGGI.

The GRIN system was developed by USDA to provide a centralized national repository for information regarding plant germplasm introduction, maintenance, evaluation, and distribution by components of the NPGS. It is an operational, production database, accessible via a terminal or a modem-equipped computer to any bean researcher with a telephone in the United States. Eventually any nation with good satellite-telephone communications will be able to access the GRIN system via a "public" access code and "User's Manual" which can be obtained by contacting the GRIN Database Management Unit (USDA/ARS/PGGI, Bldg. 001, Rm 130, BARC-West, Beltsville, MD 20705; telephone 301/344-3318).

Until the above electronic hookup is available, however, Silbernagel and Hannan (1988) have listed over 300 literature citations relating to characters and/or traits investigated using USDA-ARS Plant Introduction *Phaseolus* Germplasm. That information is contained in a chapter in Gepts (1988). Every serious bean researcher should keep a copy of this book handy as a most useful reference

THE AFRICAN BEAN SCENE IN TRANSITION

The next two decades will witness tremendous improvements in African agriculture; as African governments place higher priority on domestic food production and more African scientists return from training abroad to take up the task. Many of you in this room will help provide the new bean cultivars and appropriate production technology that should at least double yields at the smallholder farm level within the time of your professional careers. Even if donor agencies do not greatly increase the present levels of support, and in spite of the many and tremendous difficulties you all face, the basic ingredients needed to implement these changes are already in place. And, I am confident this generation of young scientists will have the dedication and long-term determination to get the job done.

However, your success in providing enough food through the development of improved bean cultivars will also intensify some old problems and create some new ones. a series of increasingly better cultivar releases will tax the seed production, distribution, and marketing systems, as well as require a high level of close collaboration with your extension service and/or other agencies involved in the education of growers on the merits of each new cultivar, and/or the improved production practices.

By far the greatest challenges your successful new cultivars may present might be a reduction in the genetic diversity of the crops grown by the smallholders. This could increase the long-term food security risk of smallholder families and result in the national loss of many components of presently used landraces.

As farming systems-oriented scientists we should make every effort to develop cultivars and production techniques that complement and enhance the mixed cropping systems and bean cultivar mixtures that smallholders depend on for food security. These are matters of appropriate technology transfer within a developmental philosophy geared towards the needs of the subsistence farm family.

However, preserving the genetic diversity of existing landraces as new cultivars are released is a more difficult matter. The collection, characterization, storage, and maintenance of displaced landrace components is a difficult task which requires highly skilled scientists and expensive, hard to maintain facilities. Since most developing nations don't have those resources, and since the improved cultivars will most likely be available before the seed preservation systems are in place in each country, alternate procedures need to be considered now while there is yet time.

Many, or most, of you probably have made (or inherited) extensive collections of endemic bean landrace materials. These collections are usually evaluated carefully for a year or two, and then because the researchers want to focus more attention on a few outstanding lines, and don't have the time and/or space to grow out the others; they are usually lost in a few years to bruchids and hot humid storage conditions.

While the International Board for Plant Genetic Resources (IBPGR) and SADCC are aware of these problems, and making every effort to help developing countries obtain adequate seed storage facilities, there simply are not enough resources immediately on hand to meet all of the needs in the time we have left. Even those African countries that do have adequate national and/or regional resources and facilities for seed storage should strongly consider depositing duplicates of their bean landrace collections in major international seed repositories like CIAT in Cali, Colombia, to insure against accidental catastrophic loss.

The CIAT-African outreach teams are making an effort to transfer available African bean collections to their Cali seed storage facilities, but this also is a slow and expensive procedure. Materials from Africa must be passed through a cleanup protocol to free them of seedborne pathogens before they can qualify to enter Colombia.

The USDA Plant Inroduction Service as a collaborator with IBPGR is ready to share this task of helping to preserve and clean up these collections from seed borne pathogens before they are lost. After cleanup these materials will be distributed to Cali, Colombia, and any other research organization that has an interest (present or future) in them.

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SESSION III - AVAILABILITY OF GENETIC RESOURCES - DISCUSSION

Allen: From where in Tanzania have materials of Middle American origin been found?

Tohme: This is unclear, various white-seeded accessions might have been involved.

Massey: What is known about CBB resistance?

Tohme: My second paper will refer to this.

Allen: With regard to bruchid species in Africa, it is clear that both *Zabrotes* and *Acanthoscelides* are present. But it seems that other species, including *Callosobruchus chinensis* may also infest beans in Africa. The relative importance of these needs to be established.

Given that CIAT has found that only four out of 15 thousand accessions possess resistance to CBB, this suggests there may be danger in such a narrow base if utilized, particularly since you mentioned that resistance now appears to be based on one or two genes. Are we in danger of decreasing the level of CBB resistance?

Tohme: With respect to the inheritance of CBB resistance, the work of Drifjhout to which I referred relates to resistance in *P. acutifolius* not in beans *P. vulgaris* as such.

Dr. S. Beebe has recently done a review of the various reports related to inheritance.

Abebe: How stable is the anthracnose resistance possessed by G 2333 ?

Tohme: G 2333 has been extensively tested and has invariably been found resistant, so we conclude that its resistance is broadly based and stable.

Abebe: Are you characterizing the whole germplasm collection for drought reaction?

Tohme: There has been some work on drought resistance screening at CIAT. BAT 477 is among the promising lines. A complete list could be provided.

Camarada: If a national programme is not able to do its own crosses, to what extent can it benefit from introduced materials, for example with anthracnose resistance?

Tohme: This is the function of the disease nurseries, and the differential varieties that they contain, the latter helping to identify local races. We hope to better co-ordinate requests through regional programmes (RPs).

Musaana: What information is available on the N contribution of determinate plant types to the associated or succeeding crop?

Tohme: There is no relationship between growth habit and N fixing ability *per se*.

Kirkby: Another point is the extent to which N fixation by the legume can decrease competition with the associated crop.

Abebe: How can NPs obtain germplasm of unimproved types known to possess useful characters?

Tohme: Both from publications and from information held at CIAT and elsewhere.

Silbernagel: There is also a list in a recent chapter.

Mwandemele: Most NPs have problems in seed storage. What are the RPs doing to help?

Allen: The SADCC Nordic-supported Gene Bank planned for Lusaka will address long-term storage needs for the region.

Nchimbi: Are there sources of heat and drought tolerance combined.

Silbernagel: These are usually separate characters.

Tohme: We await interesting material from Mexico.

Sperling: Are you training social as well as biological scientists in CRSP?

Silbernagel: All the US PIs are urged to train social scientists, with varying success. Ours is the only one which has trained several economists. But money is confined to the specific project topics. No, non-economists have been trained.

Sperling: The point is that CIAT doesn't have the capacity to train at HQ. The greater flexibility of CRSP could meet this need.

Silbernagel: Yes, there is such a need.

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SESSION III - BEAN RESEARCH IN CENTRAL AMERICA

BEAN RESEARCH IN GUATEMALA

Dr. P. Masaya

ABSTRACT

Guatemala is a sub-tropical country of some 108 thousand square miles. Temperatures range from cool in the mountains to warm on the coast. Beans provide 19% of protein intake, at the per capita rate of 16 kg/year. The main producing areas are in the south east, north and the highlands. The seeds are mainly small blacks and growth habits II to IV, all from the Middle American gene pool. Constraints are economic (marketing and price levels and fluctuations) and agronomic (diseases, pests, drought, excess water, low and high temperatures). National agricultural priorities are listed and research strategies described. Genetic improvement receives the greatest emphasis. Two zones (low and high temperature) define adaptive requirements and producer and consumer preferences. General strategy is to incorporate desirable traits from local and introduced materials into adapted backgrounds by conventional and recurrent selection methods. On-farm tests are an important feature of the process. Linkages with CIAT include training and information and germplasm exchange. Research networks have developed in Central America. Several cultivars have ben released in Guatemala and others are in prospect. Since 1971, area and productivity have increased at the rates of 800 ha and 28.5 kg/ha per annum.

INTRODUCTION

Guatemala is a sub tropical country of 108,000 square kilometers, located in Central America between 14 and 18^{o}N and between 88 and 92^{o}W. The physiography is dominated by two coastal plains (Atlantic and Pacific), dense forested lowlands in the north and mountains in the center of the country. Natural resources in Guatemala are better suited for forestry than for agriculture.

Temperatures are cool in the mountains (15-24^{o}C mean temperature) and hot in the lowlands. At high altitudes, frosts occur any time from November through March. Rainfall occurs in most of the country from May through October, but on the Atlantic side also from November through March.

Bean production, as in most countries in Latin America, is socially important. They provide 19% of protein intake by the population (Gomez, 1970). Beans are consumed with maize, the two grains providing the everyday food for low income populations.

Beans and corn complement each other in protein efficiency. Bean is deficient in sulfur containing amino acids, especially methionine and tryptophane, but rich in lysine. Corn is deficient in lysine but adequate in sulfur amino acids. When consumed with corn, beans have a higher protein efficiency, the best ratio being 72:28 parts of corn and beans, respectively. The estimated *per capita* consumption of beans is currently about 16 kg/year having fallen from 21 kg/year in 1970 (see Table 1).

Table 1. Estimated *per capita* consumption of beans in Guatemala. 1970 to 1985.

YEAR	Consumption kg/year/person
1970 (a)	21.00
1975 (b)	7.69
1980 (b)	8.57
1981 (b)	13.52
1982 (b)	13.90
1983 (b)	11.88
1984 (b)	14.07
1985 (b)	14.74

a) Gomez (1970)
b) Anon. (1987)

Beans are grown almost everywhere in the country but the most important production areas are the south east, the north and the highlands (Table 2). The south east produces approximately 40% of the beans in the country. Jutiapa is the largest producer (17% of total production or 9,000 tonnes per annum) but production has increased to 13% and 7,000 tonnes per annum in the northern department El Peten, which is now the second largest producer.

Table 2. Bean production by region in Guatemala. 1979-80

Region	Production (1000 t)	Percent of total
Highlands	11700	22.5
South East	20313	39.0
North lowlands	14370	27.6
South lowlands	553	1.1
Central	5066	9.7

Source: Anon. (1979)

Small black seeded types predominate. Growth habits include types II, III and IV, all from the Middle American gene pool.

PRODUCTION CONSTRAINTS

The constraints to bean production in Guatemala are varied. In general, productivity is low despite some tendency for increase. Constraints can be grouped in two classes, economic and agronomic.

Economic constraints

The most important constraints in this class are related to marketing. Bean producers are not organized and marketing and distribution of beans from growers to consumers is via merchants who absorb a sizeable proportion of the final cost to the consumer. The combination of low prices for the farmer and the risks associated with traditional production systems make the crop a bad option for cash income for rural families. Conversely, urban families find beans an expensive food or at least subject to fluctuating prices.

Agronomic constraints

Disease and insect damage have long been recognized as the main production constraints for beans. Drought and excess water are also important limiting factors. Less documented are the reductions in yield due to poor architecture and low pod and seed set produced by extremes of low or high temperature or long days. As in other parts of the world, diseases, insects and climatic constraints are associated in complexes typical of specific regions where beans are grown. We show here the most important constraints (climatic or biotic) by region (Table 3).

Table 3. Environmental characteristics of bean producing areas of Guatemala.

	Cropping seasons		
	Irrigation (A)	First (B)	Second (C)
SOUTH EAST			
Duration	Jan-Apr	May-Jul	Aug-Nov
Main cropping system	monoculture	maize:beans	relay
Mean temp (^{o}C)	23.8	23.9	23.1
Rainfall (mm)	none	346	318
Daylength (hr)	11	13 1/2	11
Most important diseases	BGMV	BGMV, CBB, rust root rots	BGMV, rust root rots
Most important pests		Chrysomelids	*A. godmani* Chrysomelids
Stress	wind	drought excess water	drought

Table 3 (cont.)

	Cropping season
	Winter
NORTH	
Duration	Nov-Jan
Main cropping system	monoculture or relay
Mean temp. (^{o}C)	20.7
Rainfall (mm)	372
Daylength (hr)	11
Main diseases	web blight, rust, BGMV
Main pests	Chrysomelids
Stress	occasional drought, high aluminum

	Residual moisture	First	Second
HIGHLANDS (bush)			
Duration	Mar-Jun	May-Jun	Jul-Oct
Main cropping system	monoculture	maize:beans	relay
Mean temp. (^{o}C)	17.4	17.3	16.7
Rainfall (mm)	165	715	609
Daylength (hr)	12	13 1/2	12
Main diseases	rust	ascochyta, anthracnose, white mold	ascochyta, anthracnose, rust
Main pests		*A. godmani* *A. aurichalceum* Chrysomelids	*A. godmani* *A. aurichalceum* Chrysomelids
Stress	drought, frosts	low temps., frosts	

	Residual moisture	Second
HIGHLANDS (climbing)		
Duration	Mar-Nov	Jul-Dec
Main cropping system	maize:beans, maize:beans:*Vicia*	relay
Mean temperature (^{o}C)	16.7	16.2
Rainfall (mm)	1388	885
Daylength (hr)	12-13 1/2-12	12
Main diseases	ascochyta, anthracnose, rust	ascochyta, anthracnose,rust
Main pests	A. godmani, A. aurichalceum, Chrysomelids	A. godmani, A. aurichalceum, Chrysomelids
Stress	competition, frosts, maize lodging	low temps, frosts

Table 3 (cont.)

	Cropping seasons		
	Irrigation	First	Second
PACIFIC COASTAL PLAIN			
Duration	Dec-Feb	May-Jul	Aug-Oct
Main cropping system	monoculture		relay
Mean temp. (^{o}C)	26.9	28.3	27.3
Rainfall (mm)	none	793	996
Daylength (hr)	11	13 1/2	12
Main diseases	BGMV	web blight, CBB	BGMV, CBB web blight
Main pests		*Epinotia* sp. *Estigmene acrea*	
Stress		long days, high temps., excess moisture	drought

RESEARCH STRATEGIES

Agricultural research strategies of every country are determined by economic, social and political realities. Guatemala is no exception. We will consider: first, government priorities in agricultural policies; then, ICTA's research priorities to meet these agricultural policies; and, within these research priorities and objectives, the research objectives and strategies in bean research.

National agricultural priorities

The current agricultural priorities in Guatemala, are:

a) to achieve national food security - this refers to self sufficiency as a goal, avoiding the importation of any food. Food crops in this group are corn, beans, rice, sorghum and wheat;

b) to improve the living conditions of farmers, especially those in small landholdings - this point refers to the increase in productivity of farmers in small and medium size landholdings; and

c) to increase exports - this point refers to the improvement of the foreign trade balance, adding new crops to exports.

Research priorities and policies in ICTA

From the beginning, in 1973, ICTA was designed as a farming systems research institution. Research in ICTA is characterized by the participation of the farmer in the research process.

Taking into account the characteristics of the small farmer in the developing world, low income, low capital inputs and the high proportion of family labour in crop production, the research objectives in ICTA are:

a) to produce an easy to transfer technology; and

b) to generate stable, low cost production options.

Research in ICTA is performed using the following procedures:

a) socieconomic studies for diagnosing or updating the information on productivity constraints at the farm level;

b) constant interaction with international research centers, universities, foreign governments and private industry;

c) generation of new technology under controlled environment conditions at experimental stations;

d) testing of new options under small farmer conditions;

e) evaluation of promising technologies by farmers;

f) assessment of acceptance of new technologies by farmers; and,

g) transfer of new technology by extensionists with support from researchers - support to seed production.

In this scheme of research the scientific team is the evaluator of the new options a) to d). Farmer involvement starts with farm trials in d). In e) the farmer himself is the evaluator. In f), it is the scientific team.

Bean research strategies

Since the emphasis of research in ICTA is towards to cheap stable technology, it is necessary to develop production options that are low cost and easy to transfer. Production systems in the main bean-growing areas are now reasonably well understood. New varities have proved to be the easiest way to improve bean productivity, in Guatemala as well as in other Latin American countries. In addition, the development of new varieties has the following advantages:

a) the farmer will use seed as an input irrespective of his socioeconomic situation;

b) seed is the only agricultural input that can be totally produced in the country;

c) a resistant variety does not affect the environment;

d) a nutritious and productive variety is a way of directly improving the nutrition of the rural family; and,

e) a variety can be used to improve a whole production system.

The development of superior varieties has been the backbone of the generation of the new technology for bean production. Genetic improvement has been supported by studies of:

a) yield physiology and adaptation;

b) biology of the main pests;

c) integrated management of diseases with only quantitative resistance available;

d) management practices;

e) new technology adoption and impact studies;

f) updating of production constraints;

g) biological nitrogen fixation; and

h) design of new cropping systems.

SYSTEMATIC APPROACH TO THE GENERATION OF SUPERIOR VARIETIES

The development of new varieties and their deployment in growing areas follow patterns of adaptation and importance of diseases and pests. In turn, adaptation (and cropping systems) follow the basic biological responses of the bean plant.

Adaptation zones

Beans are grown in a variety of soil conditions, but extreme heavy or light soils are avoided. Soil conditions vary within each zone and adaptation of varieties or growth habits are predominantly defined by temperature regimes. Because of this, two zones of adaptation are recognized for beans: a low temperature zone with a mean temperature below 23°C corresponding to elevations above 1000 masl; and, a high temperature zone which includes areas where the mean temperature is above 23°C corresponding to elevations below 1000 masl.

Low temperature zone. The low temperature zone covers the central, western and eastern highlands.

The development of varieties for the zone proceeeds in the Chimaltenango and Labor Ovalle Experimental Stations with the following objectives:

a) development of types I and II with erect architecture, early maturity (85 days from planting to maturity), sensitivity to long days, lowermost pods located at least 10 cm above soil, resistance to ascochyta blight, rust, anthracnose and *Apion godmani*, and culinary qualities at least similar to those of the landraces; and

b) development of types IV with columnar architecture, uniform pod distribution, lowermost pods located well above the ground, less aggressiveness to maize, resistance to ascochyta blight, rust, anthracnose, *Apion godmani* and *Apion aurichalceum*, and culinary qualities at least similar to those of the landraces.

High Temperature Zone. THe high temperature zone covers the south east, the Pacific coast and the northern lowlands.

The development of varieties for this zone proceeds at the Jutiapa and Cuyuta Experimental Stations. The genetic improvement objectives are to develop types I, II and IV for monoculture, relay cropping, intercropping with maize or sorghum, monoculture with trellises and intercropping with papaya.

Improved varieties must have: erect architecture, even under warm temperature and long days for types I and II; columnar architecture and uniform pod distribution for types IV; low degree of sensitivity to long days for lowland adapted types and slight sensitivity for types adapted to the south east; uniform pod maturity; stable seed color; high yielding ability; resistance to BGMV; tolerance to *Empoasca* sp.; resistance or tolerance to common bacterial blight; maturity types suited to the farming system (early - 60 days - or intermediate - 68 days - for the south east: intermediate for the lowlands); resistance to *Apion godmani* (for the south east); and culinary qualities similar to those of the land races.

Genetic diversity

Local genetic diversity. One of the centers of diversity for *Phaseolus vulgaris* extends into Guatemala. Sixteen hundred local landraces are mantained in the Bean Program Bank at ICTA. The accessions are also mantained in the CIAT germplasm bank and elsewhere. This germplasm has now been screened for the most important traits for breeding.

Introduced genetic diversity. There are close working relationships with the CIAT Bean Program. The use of genetic diversity from CIAT includes: access to the germplasm bank and the use of breeding lines and segregating populations.

The first option has been used mostly for sources of traits that have proved difficult to identify. Examples of these are the screening of about 7,000 accessions in the search for tolerance to BGMV and the use of Mexican germplasm for resistance to *Apion godmani*.

The second option has been used variously, but mainly for the domestication of traits found in accessions of poor adaptation to

Central America and the combination or inclusion of traits in adapted germplasm that can be advanced to finished breeding lines for use in on farm trials.

For example, many crosses have been made using Mexican germplasm with resistance to *Apion godmani*. This germplasm shows poor architecture and adaptation to conditions in Central America, and cannot be used directly in crosses to derive breeding lines with suitable adaptation and yielding ability. This problem has been specially important in view of the use of recurrent selection and crossing for combining different traits in a single variety.

Segregating populations in early generations have been used extensively, mainly in crosses designed to combine specific traits. The varieties, ICTA-Quetzal, ICTA-Tamazulapa and ICTA-Jutiapan were derived from crosses made to increase the level of resistance to BGMV. The system is highly versatile and does not exclude the making of some crosses for specific purposes in ICTA. Breeding lines developed by CIAT have been used in many crosses in ICTA.

Simultaneous selection for several traits and recurrent selection and crossing.

Current improved varieties in use by farmers in Guatemala have accumulated, over the years, combinations of important traits that should be conserved in future varieties. Among them we can list:

For the high temperature zone. Resistance to BCMV and BGMV, tolerance to leafhoppers, intermediate resistance to *Apion godmani*, intermediate tolerance to web blight, some tolerance to drought, intermediate maturity, erect architecture and insensitivity to long days.

For the low temperature zone. Tolerance to ascochyta blight, resistance to the attack of several races of both *Uromyces phaseoli* and *Colletotrichum lindemuthianum*, good cooking quality and erect architecture.

Because of the need to assemble desirable traits, it is necessary to use a recurrent selection scheme in order to combine the already accumulated traits with greater yielding ability and higher levels of resistance to BGMV, web blight, common bacterial blight, ascochyta blight, and *Apion* sp. One of the current challenges is to introduce early maturity.

An example of one recurrent scheme is the recurrent combination of parents in the program at Jutiapa for five traits.

This recurrent scheme requires the use of simultaneous nurseries for specific objectives. Such nurseries are carried out in the Experimental Station when phytosanitary measures require this. Otherwise we use satellite fields, where proper conditions can be met.

A total of 69 crosses is required and, from F_2, selection is practised in five separate nurseries: earliness, *Apion* resistance and yield in Jutiapa; BGMV in Cuyuta; and rust in Monjas.

Individual plant selections are made in F_2 and their progenies are evaluated in F_3 and F_4. The best progenies are intercrossed or advanced by other breeding methods to derive advanced breeding lines..

On farm testing of advanced lines

In each cycle of recurrent selection, a varied number of advanced lines can be produced, then advanced to later generations, usually by pedigree methods. The best lines are compared in replicated yield trials in several representative environments. Once the number of advanced lines has been reduced to 10 to 20, they are tested under farm conditions by teams that work with several crops simultaneously. The crops to be included depend on the region of the country. In the south east, maize and sorghum are as important as beans. The experimental designs used are randomized complete blocks, lattices and split plots. The agreement with the farmer includes the use of his or her land, and the payment by the farmer of all inputs used in the trial. At harvest, the produce belongs to the farmer.

If any of the lines tested is promising, showing some advantage over previous varieties or land races, the following stage, usually the following year, is to run a test by farmers with little involvement from the researcher. The test should be as simple as possible, comparing for example, the new line with the farmer's variety, using exactly the same management practice the farmer usually follows. It is customary to combine the test of a new promising line in the farmer's test plot with some effort to increase seed of the new variety. Recently, a procedure was established by which the line to be tested is named before it is taken to the farmer's test plot. Either the seed unit in ICTA or the farmers themselves are at the same time increasing seed of the new line.
The statistical comparison of the new line is by using each site as an experimental unit, computing the mean and standard error for the whole set of test plots used in a region in a cropping season or year.

LINKAGES WITH CIAT

The linkages of the Bean Program in ICTA with CIAT are varied. In previous years, cooperative linkages were restricted to research. Now, working relations have evolved to include on farm research groups and extension services in DIGESA.

Training

Training has been one of the most important ways of cooperation between ICTA and CIAT. By 1988, five researchers of the ICTA Bean Research Program have completed M.S. studies under the program. Academic work has been conducted in universities in Brazil, Mexico and Colombia and at the CIAT main headquarters in Cali. These graduate studies have included, plant breeding, plant pathology, and agronomy.

Interdisciplinary bean production courses and in service training have included more than 50 persons from ICTA and the extension service in Guatemala. Over the years, this effort has upgraded capability for research and technology transfer in Guatemala. Interdisciplinary courses have included those offered each year in Colombia, and increasingly, jointly organized courses in Guatémala and other Central American countries.

Specially important are the annual or bi-annual workshops covering specific problems. Web blight, BGMV, bean pod weevil and seed production have been covered in these workshops. Breeders workshops covering uniform screening methods and adaptation comparisons and methodology for nurseries and selection have been completed or are being planned. These workshops are complementary to the workshops in the main headquarters.

Information interchange

Information interchange includes: visits by CIAT staff members for discussion of specific topics or problems; the distribution of bibliographic summaries; and the opportunity to discuss in detail specific problems at the annual meeting of the PCCMCA, the Central American Cooperative Program for Food Crops, which is held during March to April of each year in Central America. Topic covered have included breeding for higher yield, nutritional quality and resistance to web blight and diseases produced by viruses.

Germplasm interchange

One of the most important and active means of cooperation between CIAT and the national program in ICTA is the use of germplasm from CIAT and other national programs. The kind of germplasm and the uses for it have been described above. Because the uses of germplasm depend on the objectives of the breeding program and Central American countries face similar production problems, the best way to cooperate is through networks. The mode of operation is described below.

Networking and specific projects

There is a long history of cooperation in Central America and the Caribbean, including also Mexico. The Central American Bean Project evolved to become a research network. In past years we have cooperated in research and breeding for control of web blight and BGMV. Consumer preferences have hindered this effort to some extent. There are very specific types of seed that are preferred in each country. There are also differences in adaptive and plant type requirements among countries.

Nevertheless, cooperation is very active in common bacterial blight, early maturity, bean pod weevil and web blight.

Their complete modes of operation will not be described here but the four projects were chosen to combat the most important production constraints across participating countries, Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Haiti, Cuba and the Dominican Republic. Networking makes use of the relative advantages of each country in terms of physical environment or trained personnel. CIAT backstops these networks with expertise in breeding, physiology, entomology, agronomy and pathology. Also, CIAT has the advantage of first hand use of genetic resources and established capacity for crossing of the most relevant germplasm. Breeding and selection methodologies are also areas where CIAT support is crucial.

The ICTA bean breeding program is formally involved in two projects (early maturity and bean pod weevil) and interacts with the common bacterial blight and web blight projects.

FINAL REMARKS AND COMMENTS

Research and breeding achievements

The cooperation of the ICTA Bean Research and Breeding Program with CIAT on the one hand, and with extensionists and farmers on the other hand has produced important pay offs. Several bean varieties have been released, which have been instrumental in the improvement of bean production in the country. Some of the varieties have also been adopted in other coutries. A list of the varieties released by the ICTA program is in Table 4.

Table 4. Bean varieties released by ICTA.

Variety	Year of release
ICTA-San Martin	1976
ICTA-Tamazulapa	1980
ICTA-Jutiapan	1980
ICTA-Quetzal	1980
ICTA-Ostua	1986
ICTA-Quinak-Che.	1985
ICTA-Parramos	1985
ICTA-Valle	1989
ICTA-Teshel	1989
ICTA-Valle	1989

Eleven experimental lines are in on farm trials in 1989. They are: JU-89-1 to -4 and Precoz-1 to -7.

In the south east, the recommended variety now is ICTA-Ostua, which had an average yield of 1300 kg/ha during the 1987 season, outyielding ICTA-Quetzal by 30%. Line JU-89-3 has outyielded ICTA-Ostua by 24% in 1987 and 9% in 1988.

Table 5 presents the mean yields of the best lines in replicated trials during 1987 and 1988 in the Jutiapa area.

Table 5. Seed yields (kg/ha) and percent improvements relative to ICTA-Ostua of best lines in replicated yield trials at four locations during 1987 and 1988.

	1987		1988	
Line	Yield	% of ICTA-Ostua	Yield	% of ICTA-Ostua
JU-89-3	1874	124	1780	109
12362-39-1-cm-cm	1715	113	1741	107
12362-24-3-cm-cm	1780	117	1710	105
12362-24-1-cm-cm	1857	122	1696	104
ICTA-Ostua	1515	100	1631	100
12362-19-1-cm-cm	1715	113	1562	96
12362-61-2-cm-cm	1721	114	1543	95
12362-55-1-cm-cm	1773	117	1532	94
ICTA-Tamazulapa	1351	89	1442	88
12362-20-2-cm-cm	1775	117	1441	88
ICTA-Quetzal	1303	87	1355	83
12362-47-3-cm-cm	1791	118	1352	83
Rabia de Gato	1014	67	1332	82
12362-55-2-cm-cm	1683	111	1317	81
Pata de Zope	1126	74	1222	75

Adoption of new varieties

ICTA-Ostua was released in 1986 and immediately promoted by the extension service. The promotion starts with on-farm testing and continues through test and transference plots. To date, 90% of farmers serviced by extension have adopted the new variety on 20% of their land area. Also, previously released varieties, ICTA-Quetzal, ICTA-Tamazulapa, still occupy significant proportions of the bean area in the south east, being adopted by 75% of farmers on 45% of their land area (Viana, 1989).

In the eastern highlands, ICTA-San Martin, a type III variety adapted to cool temperatures occupies nearly all the area planted with beans. This variety is very popular in the western and central highlands and the main constraint these days is the availability of seed.

Changes in bean production

The population of Guatemala is increasing at an average rate of 2.5% per year. To cope with the corresponding increases in bean demand and consumption, from 1971 to 1985 there was an increase in area planted with beans of 800 ha/year (Figure 1). In the same period, there was also an increase in productivity of 28.5 kg/ha/year (Figure 2).

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Figure 1. Guatemala - bean area 1971 to 1985.

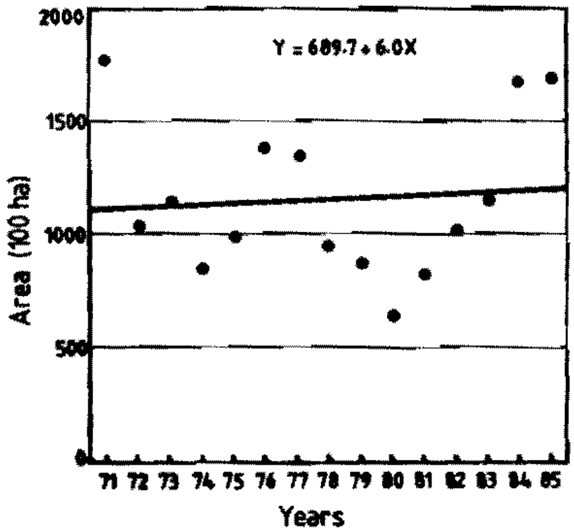
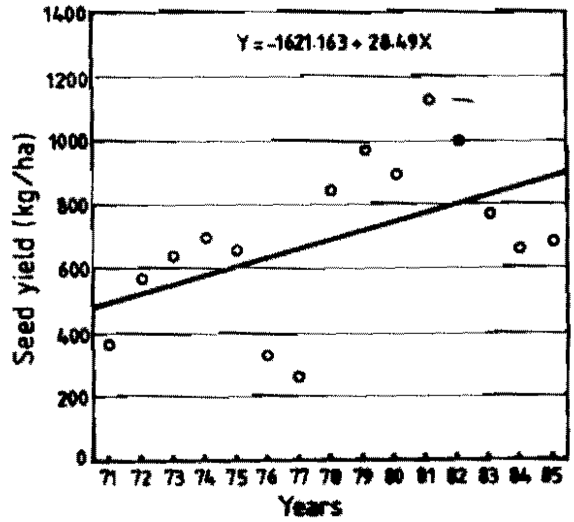


Figure 2. Guatemala - bean yields 1971 to 1985.



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THE EVOLUTION OF REGIONAL TRIALS AND COLLABORATION IN CENTRAL AMERICA, 1955 TO 1988

J. Michael Dessert

ABSTRACT

The paper describes the development of collaborative research on beans in Central America, Mexico, Colombia and Venezuala, since the 1950s. National bean research programs were established in all countries by the 1960s. The PPCMCA was formed in 1955 and extended to beans (PPCMF) in 1962, when the first regional trial was composed. IICA assumed responsibility for the management of regional trials in 1965, now numbering three for different seed types and purposes. In 1969, it was proposed that regional collaboration be extended to other disciplines but, for various reasons, this was not accomplished. Similarly, the regional trials system was abandoned. Bean research began at CIAT in 1971 and, following a workshop in 1975, the first IBYAN was formulated, replacing the former regional trials of the PCCMF. Collaboration was further strengthened by the development of the CIAT regional Programme in Central America. In 1977, the VEF and the EP trial series and various international disease nurseries were initiated and, with the IBYANs, remained the chief sources of new materials until the early 80s, when truly regional trials again emerged. The present structure of the system is described.

INTRODUCTION

This presentation will consider the evolution of regional collaboration of bean research in Central America since the 1950s when regional collaboration emerged. Though centered in Central America, regional collaboration has extended and has included at times, Mexico, the Caribean, and the southern neighbors, Colombia and Venezuela. The presentation will focus on the key trials and nurseries that have formed the basis of regional collaboration in bean research and their evolution relative to the various factors affecting regional collaboration throughout the period.

PERIOD 1962 TO 1971

Initiation

Through the 1960s, the national bean research programs of Central America were for the most part in an initiation phase. Bean research programs in these coutries were formed during the 1950s and 60s. The national bean research programs of Mexico and Brazil were initiated earlier (in the 1930s) and that of Peru in the 1940s, when the Rockefeller Foundation initiated research support to Mexico and Colombia.

In 1955, the **Programa Cooperativo Centroamericano para el Mejóramiento de Cultivos Alimenticios (PCCMCA)** (Figure 1) was created which formed an important basis for intra-regional cooperation of agricultural research in Central America, also establishing a network of maize trials in Central America for the first time. Through the PCCMCA, information was exchanged via rotating annual meetings, organized and financed by the host country. The annual meetings were organized into sections such as maize, horticultural crops, beans, seed production, and other subjects. They considered technical reports, updates on national and regional variety trials and reports on other regional meetings and made resolutions and recommendations.

In 1962, the **Programa Cooperativo Centroamericano para el Mejoramiento de Frijol (PCCMF)** was initiated and met for the first time in San Jose, Costa Rica, location of that year's PCCMCA meeting. The first regional bëan yield trial was organized during the meeting. The regional yield trial was to be coordinated from Costa Rica, and included materials from Mexico, Guatemala, Costa Rica, and El Salvador. The single trial included 15 bean varieties, both red and black seed colors, and was planted at several sites throughout the region. Nicaragua, Panama, and Honduras had not yet established bean research programs.

In 1963, the **Instituto Interamericano de Ciencias Agricolas (IICA)** initiated a food crops program (unidad de cultivos alimenticios) which strengthened bean research in Central America and the Caribbean. In 1965, IICA accepted coordination responsibility for the PCCMF regional trials. The PCCMCA continued to be the forum for trial planning and presentation of results.

The 1965 trial included ten improved varieties among the total of nineteen. By 1966/67 the trial network was expanded to three groupings:

1. Black seeded yield trial (nine varieties)
2. Red seeded yield trial (five varieties)
3. Adaptation and resistance nursery

IICA prepared the seed, field plans and field books, distributed the trials and adaptation nursery and analyzed results. The trials were planted in Honduras, Nicaragua, Panama, Costa Rica, El Salvador, Guatemala, and Venezuela. CATIE (Centro de Ensenanza e Investigacion) took responsibility for disease evaluation of the three plantings. The plot size of the yield trials was 6 m by 4 rows by 70 cm row spacing, planted in five replications. The adaptation nursery included two replications of one or two row plots. All materials in the three trials came from national varietal development programs.

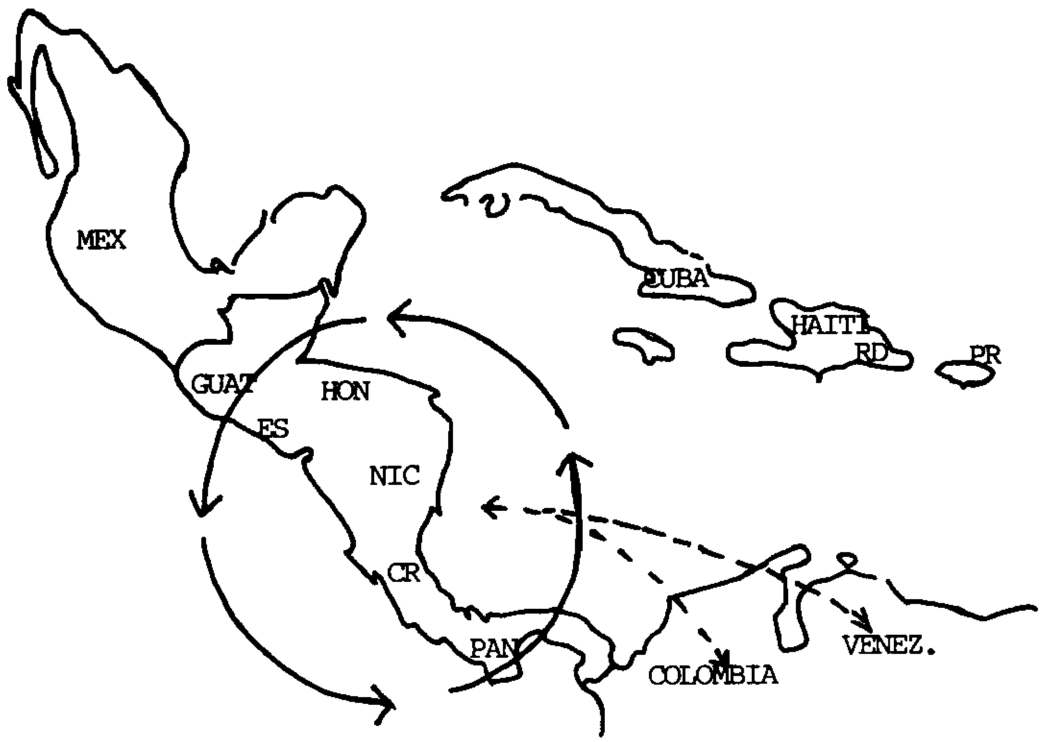
By 1969/70, the black seeded trial included 16 varieties and was planted at 22 sites (8 returned data). The red seeded trial included 14 varieties, also at 22 sites with 8 reporting data.

Figure 1. Regional trials - Central America - 1962-1972.

- Intra-regional germplasm exchange - PCCMF regional trials

- Varietal development - CIAT - NPs

- Initiation of NPs



The adaptation nursery included 60 entries planted at 25 sites, seven returning data. Soil analysis of the trial field plots and nutritional value screening of the entries were also carried out. An observation nursery of 17 other legume species was initiated that year also. At that time EPA (Escuela Panamericana Agricola) collaborated in the management of a regional germsplasm bank of about 1950 entries.

A PCCMF technical meeting was held in 1969. Participants included representatives from the national bean programs and IICA, INCAP, Rockefeller, ROCAP, and SIECA. The objective of the meeting was to develop a regional project for investigation and extension in beans. The outcome of the meeting was a recommendation for the initiation of regional subprojects to coordinate research among national bean research programs. The recommended subprojects were:

1. Varietal improvement
2. Agronomic practices
3. Pathology
4. Training
5. Seed production

The recommendation was not followed up, primarily because funds for such a project were ultimately not made available.

Additionally, collaborative agricultural research at the time became more difficult because of the overall tense political climate in Central America as expressed by an earlier war between Honduras and El Salvador.

The 1970 PCCMF meeting recommended that climbing beans be included in the regional trials for the first time in 1971/72, but interest in the trials diminished and the regional trial system was soon discontinued. One reason for the diminishing interest and discontinuation of the regional trial network was the lack of availability of new, more promising materials from the national bean varietal programs. The national research programs by 1972 were still weak in the area of varietal development and few new varieties that showed advantages over materials such as Jamapa, that had been in the trials since their inception, were emerging. Likewise, seed production and extension services within the region were also weak and varieties, if identified as promising for yield and disease resistance, very often did not advance beyond research programs to the region's farmers. Table 1 indicates the distribution of trials for the 1970/71 season. Table 2 presents a list of varieties evaluated in the trial network from 1962-1971.

Centro Internacional de Agricultura Tropical (CIAT)

Soon after the initiation of the bean breeding program at CIAT (1971/72), a meeting on yield potential of grain legumes was held at CIAT headquarters during 1973. The meeting, in which 150 scientists participated, discussed the possible development of a

Latin American network for bean research. A follow up workshop on bean germplasm exchange took place in 1975, also at CIAT headquarters, where the idea of the IBYAN (International Bean Yield and Adaptation Nursery) evolved.

Table 1. Distribution of PCCMF regional trials 1970/71.

	Adapt-ation nursery	Black-seeded		Red-seeded	
		Climbers	Bush	Climbers	Bush
Guatemala					
DGIEA	1	1	1	1	1
El Salvador					
DGIEA	6	2	6	2	6
Honduras					
Desarrural	4	4	4	4	4
EAP	1	1	1	1	1
Nicaragua					
Santa Cruz	2	-	2	-	2
Costa Rica					
Universidad	1	1	1	1	1
CEI (un juego)	1	1	1	1	1
Panama					
Universidad	1	-	-	-	2
Min. (Boquete)	2	-	-	-	3

PERIOD 1976 TO 1980

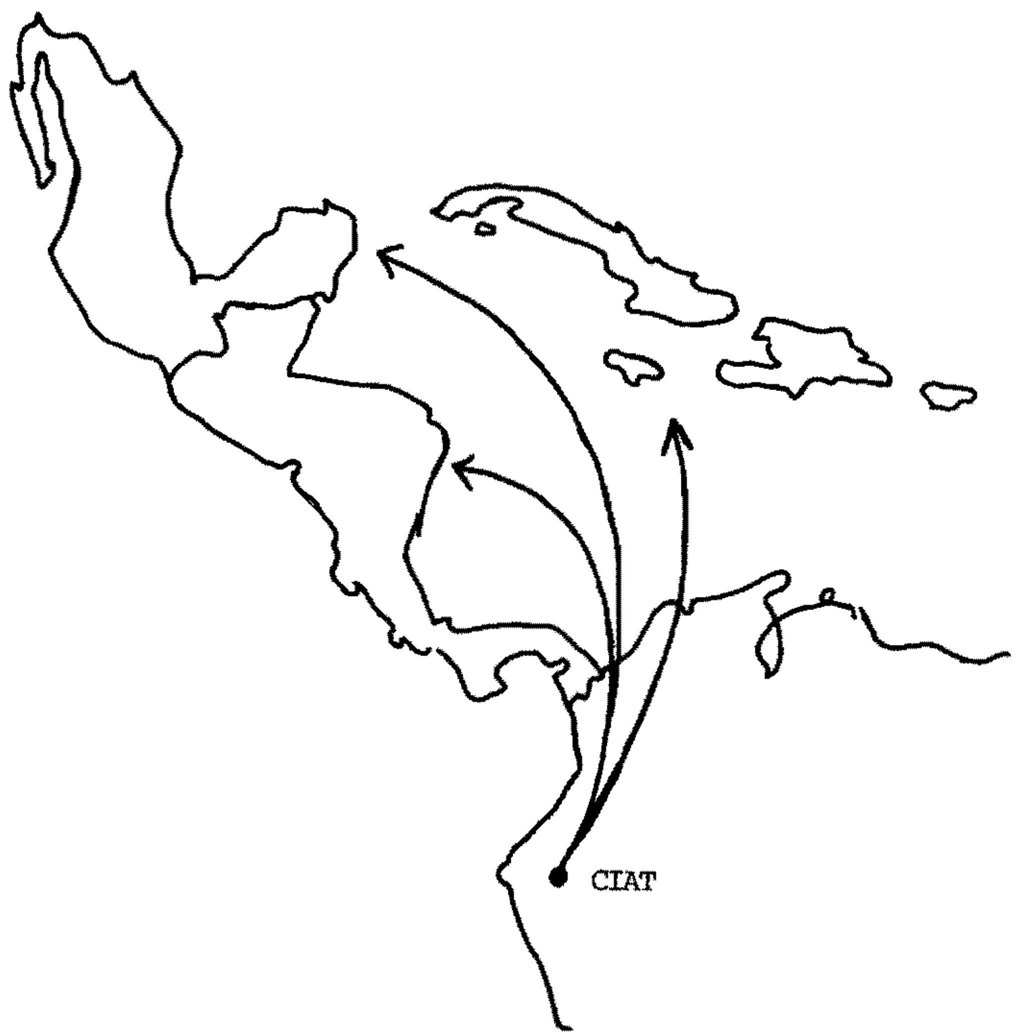
International Bean Yield Adaptation Nursery (IBYAN)

The IBYAN was first distributed in 1976. That year only one trial, of diverse grain types, was made available. The IBYAN was distributed throughout Central America and other countries of Latin America (Figure 2). In 1978, three IBYANS were made available to national programs: black bush; other bush; and climbing beans. By 1980, eleven different IBYANS were available for distribution.

In 1976, after a period of five years of very little regional collaboration in bean research, the IBYAN became the principal substitute for the PCCMF regional trial and brought much new germplasm to the region's research programs. Activities were further strengthened during 1976/77, with the placement of international staff (plant breeder and agronomist) in Guatemala by CIAT through an AID contract with ICTA, the national agricultural research program of Guatemala, and a

Figure 2. Regional and international trials - Central America - 1976-1980.

- Inflow of germplasm - CIAT to NPs - IBYANs
  VEFs
  EPs
  Pest nurseries
- Varietal development - CIAT - NPs
- Strengthening NPs



coordinator/pathologist in Costa Rica, financed by UNDP. The initiation of the CIAT regional Central American and Caribbean bean project in 1981, financed by the Swiss government, secured the foundation for continuing regional collaboration.

Table 2. Entries tested in PCCMF regional yield trials 1962-1971.

Entry	Country	Years							
		62/63	63/64	65/66	66/67	67/68	68/69	69/70	70/71
Black-seeded									
Jamapa	Mexico	x	x		x	x	x	x	x
Mecentral	Mexico	x							
Negro 150	Mexico	x	x						
Negro 170	Mexico	x	x						
Compuesto Chimalteco No. 1	Guatemala	x							
Guateian 6662	Guatemala	x							
Rico	Nicaragua	x	x						
S 29 N	El Salvador	x							
Porrillo No. 1	El Salvador	x	x		x	x	x	x	x
S 67	El Salvador	x	x						
Mex 27 N	Costa Rica	x	x						
S 182 N	Costa Rica	x	x		x	x	x		
Compuesto Cotaxtla	Mexico		x						
G 70	Mexico		x						
CH-60-1112	Mexico		x						
M-22-1	El Salvador		x						
Mex 24 N	Costa Rica		x						
Mex 29 N	Costa Rica		x						
Rico	Hondurus		x		x	x	x		
IAN 2829-1-g	Guatemala			x					
IAN 2829-36	Guatemala			x					
IAN 2465-29-6	Guatemala			x					
IAN 2843-4m	Guatemala			x					
IAN 2465-29-6N	Guatemala			x					
Oaxaca 8	Guatemala			x					
Ideal Market	Guatemala			x					
San Andres No.1	El Salvador			x	x	x	x		
Black Valentine	El Salvador			x					
S 19 N	Costa Rica			x					
S 443	Costa Rica			x					
Veranic 2	Nicaragua			x	x	x	x		
Turrialba 1	Costa Rica				x	x	x		
Turrialba 2	Costa Rica				x	x	x		
Mex 29	Honduras				x	x	x		
Guatemala 5	Guatemala					x			
Guatemala 33	Guatemala					x			
Guatemala 174	Guatemala					x			
Sant.del Norte 3	Colombia					x			

Table 2 (cont.).

Entry	Country	Years							
		62/ 63	63/ 64	65/ 66	66/ 67	67/ 68	68/ 69	69/ 70	70/ 71
Ecuador 208	Colombia					x	x	x	
Honduras 35	Honduras						x	x	x
Florida Copan	Honduras						x	x	x
S 219·N	Costa Rica						x	x	
I-61	Venezuela						x	x	x
I-117	Venezuela						x	x	
I-65	Venezuela							x	x
Ven 63	Colombia							x	x
Mex 498	Colombia							x	x
Ecuador 132	Colombia							x	
Guat 526	USA (Gentry)							x	
Guat 401	Guatemala							x	x
Preto Uberabinha	Brasil							x	x
Ven 36	Colombia								x
51051	Costa Rica								x
51052	Costa Rica								x
Red-seeded									
Mex 80 R	Costa Rica	x	x						
S 382 R	Costa Rica	x	x						
S 18-1	El Salvador	x							
Mex 81 R	Costa Rica		x						
S 402 R	Costa Rica		x						
Zamorano	Honduras		x						
Poroto Bayo (crema)	Panama		x						
Poroto Chauises (blanco)	Panama		x						
Poroto Rosado (rosado)	Panama		x						
Michelite (blanco)	El Salvador			x					
S 167 R	El Salvador			x					
S 230 R	El Salvador			x					
37 R	Costa Rica			x					
S 64 P	Costa Rica			x					
S 856 B	Costa Rica			x					
S 452 BI	Costa Rica			x					
Turrialba 3	Costa Rica				x	x	x		
27 B	El Salvador				x	x			x
COL 1-63-A	Honduras				x	x	x	x	x
COL 1-63 B	Honduras				x	x			
Zamorano L-274	Honduras					x	x	x	
Guatemala 97	Guatemala					x			
Chile 23	Colombia					x			
Italia 3	Colombia					x	x	x	

Table 2 (cont.).

Entry	Country	62/63	63/64	65/66	66/67	67/68	68/69	69/70	70/71
Guajira 1	Colombia					x	x	x	
Boyaca 1	Colombia					x	x	x	
Congo Belga 9	Colombia					x	x	x	
Honduras 18	Honduras						x	x	x
Honduras 24	Honduras						x	x	x
Honduras 46	Honduras						x	x	x
66 Retinto DNC	Honduras						x	x	x
Mezcla roja Sel. 16	Honduras						x	x	x
50613	Costa Rica								x
Rico rojo	Guatemala								x
Ecuador 299	Colombia								x
Mex 193	Colombia								x
Mex 235	Colombia								x

Source: Voyset (1983).

Vivero de Equipo de Frijol (VEF) and Ensayo Preliminar (EP)

In 1977/78, the IBYAN was complemented by two other trials, completing the CIAT varietal testing scheme.

These are the VEF, for disease and insect resistance screening, and the EP, a preliminary yield trial. Though these were designed as CIAT internal trials, they were readily distributed to national programs and have acted as principal sources of breeding lines for national programs.

International disease and pest nurseries

From 1977 onwards, a series of international pest/pathogen resistance nurseries was initiated at CIAT, providing selected collections of germplasm to national bean research programs. These nurseries have been used by national programs principally for the identification of donor parents with resistance to specific limiting factors for their and CIAT's bean hybridization programs.

PERIOD 1981 TO 1986

With the strengthening of national programs, and new varieties available for regional testing, the regional trials network (Figure 3) was reestablished in 1981 with the initiation of the Vivero Centroamericano de Adaptacion y Rendimiento (VICAR). This regional yield trial included commercial varieties and promising breeding lines from the national varietal programs of Central America. The objective was to stimulate horizontal transfer of

Figure 3. Regional and international nurseries - Central America - 1981-86.

- Intra-regional exchange - VICAR
- Inflow of germplasm - VAs
  IBYANs, VEFs, EPs,
  Pest nurseries
  US university programs
- Varietal development - CIAT - NPs
- Initiation of CIAT program in Central America
- Continued strengthening of NPs

varieties among national progams and evaluate these on a regional basis, providing this information to national programs in order to increase the efficiency of their varietal selection. It was initially coordinated by the country hosting the annual PCCMCA meeting and subsequently by the CIAT agronomist. There are two trials, of 12-16 red and black-seeded bush types with two control varieties, sown as randomized complete blocks, with 4 reps and plot sizes of 4 rows, 5 m long and 50 cm apart. Fertilizer and disease and pest control are according to local recommendations. The data requested are: number of plants harvested; seed yields corrected to 14% moisture; and disease reactions. Individual location and combined analyses are conducted and culinary aspects are assessed by INCAP.

With increasingly better-trained staff, national breeding programs began to place greater emphasis on selection in segregating populations as a source of new breeding lines. The VEF-EP-IBYAN trial sequence, however, remained through 1981 the most important source of new varieties for the region's programs.

During 1981/82, with the regional project established, the CIAT breeding program for Central America started to decentralize, placing a regional bean breeder in Central America and also establishing the **"VA" nursery (Vivero de Adaptacion)**. The VA consisted of breeding lines (F_4-F_6 generation) sent to Central American national programs from the CIAT breeding program. They were evaluated for adaptation and disease resistance, with performance in Central America for the first time becoming the principal criterion for entry into the VEF. The choice of parents for breeding lines destined for Central America was also based on performance in Central America. This decentralization considerably increased the efficiency of CIAT's breeding program for Central America.

From 1981, other regional nurseries and informal varietal exchanges became increasingly common, with the objective of exchange of germplasm and wide evaluation.

The Costa Rica national Mustia nursery became a regional nursery in 1981, with distribution to several sites throughout Central America. The nursery became the VIM (Vivero Internacional de Mustia Hilachosa del Frijol). Data from such nurseries are typically collected and distributed in the form of a report after at least two seasons of testing.

The VA was successfully evaluated throughout Central America for several years. In parallel to the VA, national programs developed breeding lines directly from segregating populations from crosses made by the national program itself or from populations received from CIAT. By 1986/7 many breeding lines developed by the national programs were at an advanced stage of testing and available for regional trials.

1987 TO PRESENT

Vivero de Adaptacion America Central (VIDAC)

To accommodate these, the VIDAC was initiated in 1987 and replaced the VA (Figure 4). The VIDAC was managed similarly to the VA but included breeding lines from various national programs in addition to those from CIAT. There are separate nurseries for red- and black-seeded beans, which are coordinated by CIAT staff, through an annual meeting of national program breeders. Entries number a maximum of 200 and those selected progress to national programs, 'the VICAR and the VEF.

The VA and the VIDAC were initially restricted to evaluations of adaptation and to reactions to diseases that happened by chance to present heavy and uniform pressure in occasional plantings of the nursery. The VIDAC has now evolved into a nursery which is planted purposely under specific conditions (site and planting date) or inoculated to obtain high and uniform pressure of specific individual diseases or insects to allow precise evaluations for specific characters. The principal objective of the nursery is becoming that of character evaluation for resistance to the diseases and pests of the region. This is advantageous to national programs because though many diseases and pests are a threat to every country's bean production, none of the national research programs have the capacity to screen for all potential limiting factors. Besides diseases and pests, other factors such as heat tolerance and cooking time are being included in the evaluation scheme of the nursery. Each institute participating in the regional program takes responsibility for the evaluation of one or more characters, planting and managing the nursery flexibly to collect accurate data (Table 3). Data is compiled each year by the regional program breeder-agronomist and presented to national programs for use in selecting breeding lines for advanced yield testing.

Table 3. National program responsibilities for evaluation of VIDAC.

National programs	Characteristics
Panama	*Mustia*
Costa Rica	*Mustia*, anthracnose
Nicaragua	*Xanthomonas*, cooking time
El Salvador	Heat tolerance
Honduras	*Apion*, angular leaf spot
EPA/Honduras	Anthracnose, rust
Guatemala	BGMV
Cuba	Rust, *Xanthomonas*
Mexico	*Apion*, BCMV

Figure 4. Regional and international trials - Central America - 1987 to present.

- Intra-regional exchange - VICARs, VIDACs, VAs Caribe
  Pest nurseries
- Inflow of germplasm - VIDACs, F_2/F_4 populations, IBYANs, VEFs, EPs, Pest nurseries
- Varietal development - CIAT - NPs
- Strengthening of some NPs - stagnation of others
- Increasing focus on specific characters - BGMV, Mustia, Apion

The regional trials and nurseries interact in a complementary fashion with the national trial system of each of the region's national varietal development programs. Materials advancing into each country's preliminary trial are included in the VIDAC for the various additional evaluations the nursery offers. Materials then selected for testing in national advanced yield trials, or those entering multiple site testing within each country, are entered into the VICAR to collect region-wide yield data.

The national-regional trial interaction is illustrated below:

NATIONAL TRIAL SYSTEM

Pópulations/ introductions	Preliminary trials	Multi-location trials	On-Farm/ extension
REGIONAL TRIALS	VIDAC	VICAR	

Consolidation of regional network

Additionally in 1987, national programs began taking a greater role in the management of the regional program with the formation of a steering committee (Asembea de Coordinacion) and the initiation of regional collaborative research projects. Individual institutes took responsibility for research in specific areas. The four initial research projects were: *Mustia hilachosa*, earliness, *Xanthomonas*, and *Apion*. Each project is led by one institute with support research carried out by one or more other institutes. The research projects often include an aspect of varietal improvement. Breeding lines originating from the projects are distributed to interested national programs often in the form of a regional nursery. The multiplication and distribution of these materials may be by the lead institution or by CIAT regional staff.

SUMMARY

In summary, four periods may be distinguished in the evaluation of Central American regional collaboration and regional trials (Figures 1-4):

1) **1962 to 1971**, characterized by young or initiating national programs and covered by the PCCMF intra-regional trials in Central America, with minor links with Colombia and Venezuela.

2) **1976 to 1980**, after a period of very little collaboration, large amounts of germplasm are introduced to Central America, Mexico and the Caribbean from CIAT through the new series of CIAT trials including the IBYAN, VEF, and the EP.

3) **1981 TO 1986**, reinitiation of the regional trial system with the VICAR, strengthening of national programs and continued

inflow of germplasm into the region.

4) **1987 to present**, maturing of the regional program, varietal and information exchange, region wide testing of locally developed varieties in the VIDAC and the initiation of regional research projects.
The long term tradition of regional meetings as part of the PCCMCA has been an important foundation for regional collaboration in bean research. This collaboration in bean research and the regional trials network has gradually expanded and fluctuated in importance responding to the needs and interests of the national programs.

Regional collaboration has been most active and effective when international staff and funding have been available to support and coordinate the regional collaborative activities, though the long term continuation of the PCCMCA meetings has partially been due to host country financing of the annual meeting.

The trials network evolved twice a system of two key trials: 1. an advanced regional yield trial, and 2. a regional adaptation and character evaluation nursery. Additional germplasm exchanges both informal and formal have also taken place in parallel to these. The regional trials complement eachother and national program trials. The trials increase the efficiency of breeding line evalution for specific characters, allow region wide testing and ensure a dynamic exchange of germplasm among the region's programs. The regional trials depend on the national programs as a source of germplasm, and should be understood as a support mechanism, rather than a substitute for varietal development by national programs. To be effective such a trial network requires easy access and movement of germplasm among participating countries, and is most useful when the trials link countries with similar varietal requirements, and production limitations due to similar soils and climate.

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SESSION III - BEAN RESEARCH IN CENTRAL AMERICA - DISCUSSION

Amane: Do you use any other criteria aside from temperature to delimit agricultural ecological zones in Guatemala ?

Masaya: We do use other criteria but temperature is the most useful relevant character.

Abebe: How often have you released new varieties in Guatemala?

Masaya: A new variety is released when we feel there is sufficient data to clearly indicate that we have a superior variety. However, before release, acceptability by the farmers is checked through questionnaires and every new release is followed up as a new variety may appear to be acceptable (from questionnaires) but it is later found that it has not been adopted by the farmers. This sometimes has reflected lack of seed for distribution and we try to encourage farmers to produce seed.

Nchimbi: Is there any irrigated bean production in Guatemala ?

Masaya: In certain areas there is irrigated production.

Musaana: What criteria do you use for selection in segregating populations from CIAT in Guatemala ?

Masaya: We try and put the segregating populations in disease hot spot locations but may use multilocation testing to cover a number of important diseases. Pedigree selection is usually imposed.

Musaana: It would appear in Guatemala that, over the years, a decrease in average farmer's yield has been accompanied by an increase in area planted and vice-versa.

Masaya: The yield data is not very accurate but I think that the decrease in yield with an increase in area reflects an increase in more marginal land being brought into cultivation.

Sperling: How do you undertake cooking quality evaluation in Guatemala ?

Masaya: Seed samples of all advanced lines are routinely sent to the Central American Institute for Nutrition for quality screening.

Allen: I would like to congratulate you on the very successful programme you have run in Guatemala and wondered what advice you could give to national coordinators to achieve the same.

Masaya: I would suggest the following :

a) access to training;
b) constructive interaction with farmers;
c) constructive interaction with other programmes in the region;
d) links with universities and international institutes to help address important and specific problems identified in your programme; and,
e) a set of clear objectives.

Camacho: Do you have data on the impact of the regional programme in Central America?

Dessert: Data is available for specific countries for increases in productivity and adoption (cf new varieties in Nicaragua and Honduras)

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SESSION IV - BEAN BREEDING AND EVALUATION IN AFRICA

UTILIZATION OF EXISTING GENETIC VARIABILITY

Dr. J. B. Smithson

ABSTRACT

The diversity of bean producing areas in Africa in terms of environments and cropping systems and the nature of existing cultivars are briefly described. The lengths of growing seasons and rainfall, temperature and photoperiod during the growing seasons of bean producing areas are being characterized. These have been combined into an index to map the distributions of areas of similar growing conditions in Latin America and Africa. Research stations may be classified in a similar manner. Such classifications require refining but are important in directing flows of germplasm and breeding materials between Latin America and Africa and within African national programmes.

Knowledge of genotypic responses to environments is necessary to support such classifications. Evaluation of common sets of genotypes across locations and seasons, for example the African Bean Yield Adaptation Nursery (AFBYAN), is one means of obtaining such knowledge. Recent introductions have exhibited dramatic improvements in performance over existing cultivars. Possible strategies for the evaluation of local and introduced germplasm and breeding materials are discussed.

INTRODUCTION

In this presentation, what I want to try to do, is to briefly describe the area with which we are all concerned - its cropping systems and environments and the origins and nature of its current bean cultivars - and consider possible ways of deploying the enormous genetic resources now available, both inside and outside the Continent, in the most efficient manner.

THE AREA

The projects

First, a reminder of the project areas. There are three regional projects with which CIAT is involved. The first is in the Great Lakes area of central Africa, based in Rwanda and working also with the national programmes of Burundi and Zaire. The second is in eastern Africa, with headquarters in Ethiopia and working also with Uganda and Somalia: and the third is in southern Africa, based in Tanzania and acting as the bean research component of the Grain Legume Improvement Programme of the SADCC group of countries (Tanzania, Angola, Zambia, Malawi, Mozambique, Botswana, Zimbabwe, Swaziland and Lesotho).

The production

Bean areas range from 700 thousand ha in Kenya to 1000 ha in Botswana. Based on a preliminary analysis of production patterns, the main concentrations of beans are found: in the Rift Valley of Ethiopia; west of Lake Victoria in Rwanda, Burundi, Zaire, Uganda and Tanzania; east of Lake Victoria, in Kenya, Uganda and Tanzania; and in the area around the southern tip of Lake Tanganyika and Lake Malawi in Tanzania, Zambia, Malawi and Mozambique. Beans are grown elsewhere but are much less important.

There are detailed data on distribution for some countries, like Ethiopia but more work is needed to assemble data - for example in Tanzania, where village extension officers assess area and production annually - these data are available but lie in district, regional and national headquarters and need to be collated. One of the first tasks of the economist recently appointed to Uganda will be to assemble available data in order to construct accurate maps of bean distibution, where they do not already exist.

The cropping systems

The full area extends from 18°N to 28°S and 12° to 48°E with altitudes from sea level to 6000 masl.

Over this vast area, there are widely varied environments and cropping systems. In the Rift Valley of Ethiopia, where rainfall is unimodal, beans are grown commonly in pure stands between June and September.

Southwards, the rains become bimodal, making possible two bean crops per year. In the Great Lakes region, and extending into southern Uganda and western Tanzania, beans are grown in both rainy seasons but the second (October/November to January/February) is the most important. A third crop is commonly taken on marshes during the dry season, sole or in association with sweet potatoes. Beans are found in all manner of cropping systems: in pure stands; under bananas or coffee; and associated with maize (as an intercrop or relayed) and many other crops, including sorghum, sweet potatoes, peas, taro and cassava.

Eastwards, beans are more important in the first season (March/April to June/July), when they are grown in pure stand or intercropped with mainly maize and, rarely, sown under coffee or bananas. Except at higher altitudes, the second rains are too short for a second crop of beans without supplementary irrigation, which is practised in some areas.

Further south, rainfall again becomes unimodal, but the season is sufficiently long in some highland areas for two bean crops. In these situations (southern Tanzania, northern Zambia, northern and southern Malawi) beans are most important in the second season (January/February to April/May). They are grown in the first season (October/November to January/February), usually in association with maize, but principally as seed multiplication for the second season, when they are commonly relayed into maize or grown throughout in pure stands.

East and south, the rains are too short for more than a single crop and beans are grown from December/January to March/April - in pure stands or associated with maize and other crops.

The existing cultivars

The only situations we know where the products of organized breeding programmes are cultivated on large scales are in Ethiopia, northern Tanzania, Kenya and the commercial lands of Zimbabwe. All rely on introduced cultivars for production of canning, snap and other types of beans for export to Europe. In northern Tanzania, the multiplication of bean seeds for export to Europe is an important industry.

Elsewhere the cultivars being cultivated are the descendents of successive introductions directly or indirectly from the Americas from the sixteenth century onwards. They are almost exclusively indeterminate, usually bush or semi-climbers. Climbing types are cultivated on a large scale only in the highlands of the Great Lakes, though they are found everywhere in compounds scrambling over fences or cereals. Nevertheless, provided suitable support is available, the replacement of bush types by climbers, would provide a means of producing quantum leaps in yields in many situations.

These local cultivars are sometimes cultivated as mixtures of seed types that vary in complexity from area to area. In the Great Lakes, southern Uganda and Malawi they are exceedingly complex, averaging ten or more components ranging in colour from white, through yellow and green to red brown and purple and of varying colour pattern, size and shape. In northern Zambia and adjoining areas, mixtures are less complex, being based mainly on yellow and white seeds.

More or less pure seed lots are the rule in other areas. This results partly from the export industries that have become established, but not entirely, as even beans for food are grown in unmixed lots. A notable example is western Tanzania, where seeds are sown unmixed when, across the border in southern Uganda and the Great Lakes, mixtures are the rule.

The reasons for the use of mixtures are not properly understood. Theoretically, mixtures should confer greater stability of yield and, in the Great Lakes, mixtures are deliberately composed for specific situations. In many areas, mixtures command reduced prices in local markets and their components are sorted into colour categories for sale. Whether reconstitution is deliberate or because of seed shortage is not always clear. Whatever the reason, mixtures appear to be a fact of life in Africa and we can't neglect them.

RECENT ADVANCES IN VARIETAL IMPROVEMENT

Information on the current status of varietal improvement is available for all the countries covered by the projects and will be described in the country reports on Wednesday and Thursday. Suffice to emphasize here the dramatic advances over existing cultivars that have been achieved from recent introductions, mainly from the U.S.A. and Latin America and it seems likely that, at this stage, further advances can be derived from introduction.

The central problem is the very large germplasm resources that are available both inside and outside the Continent. CIAT alone now has nearly 40,000 accessions in its germplasm collection and four breeders at HQ continually creating new genetic combinations. In addition, there are collections in Africa, notably in Malawi, which are not fully represented at CIAT and breeding programmes being initiated by national programmes in Africa. With the wide diversity of environments and requirements that has to be considered, it is clearly impossible to evaluate this volume of material in every situation. So, what strategies can be devised, that are both feasible and have minimum risk of missing genetic combinations that are valuable in different situations?

THE ENVIRONMENTS

Characterization

One important step is characterization of the environments in which beans are produced in Africa. The agroecological unit of CIAT has made a start on this in terms of length of growing season and rainfall, mean temperature and photoperiod during the growing season (Figures 1 to 3).

These parameters have been combined into a similarity index, that enables us to identify areas of similar growing conditions for beans both within Africa and in Latin America.

For example, Darien, a location near CIAT headquarters in Cali being used to evaluate bean materials, is environmentally similar to extensive bean-producing areas in northern and western Tanzania, the Great Lakes and parts of Ethiopia (Figure 4). Popayan, another, higher altitude, location in Colombia is environmentally similar to a more restricted area in the Great Lakes region (Figure 5). Obviously, refinements are needed - for example soil characteristics need to be included - but this kind of classification should help to evolve strategies for development, evaluation and movement of bean materials for Africa.

Figure 1. Africa - length of main growing season.

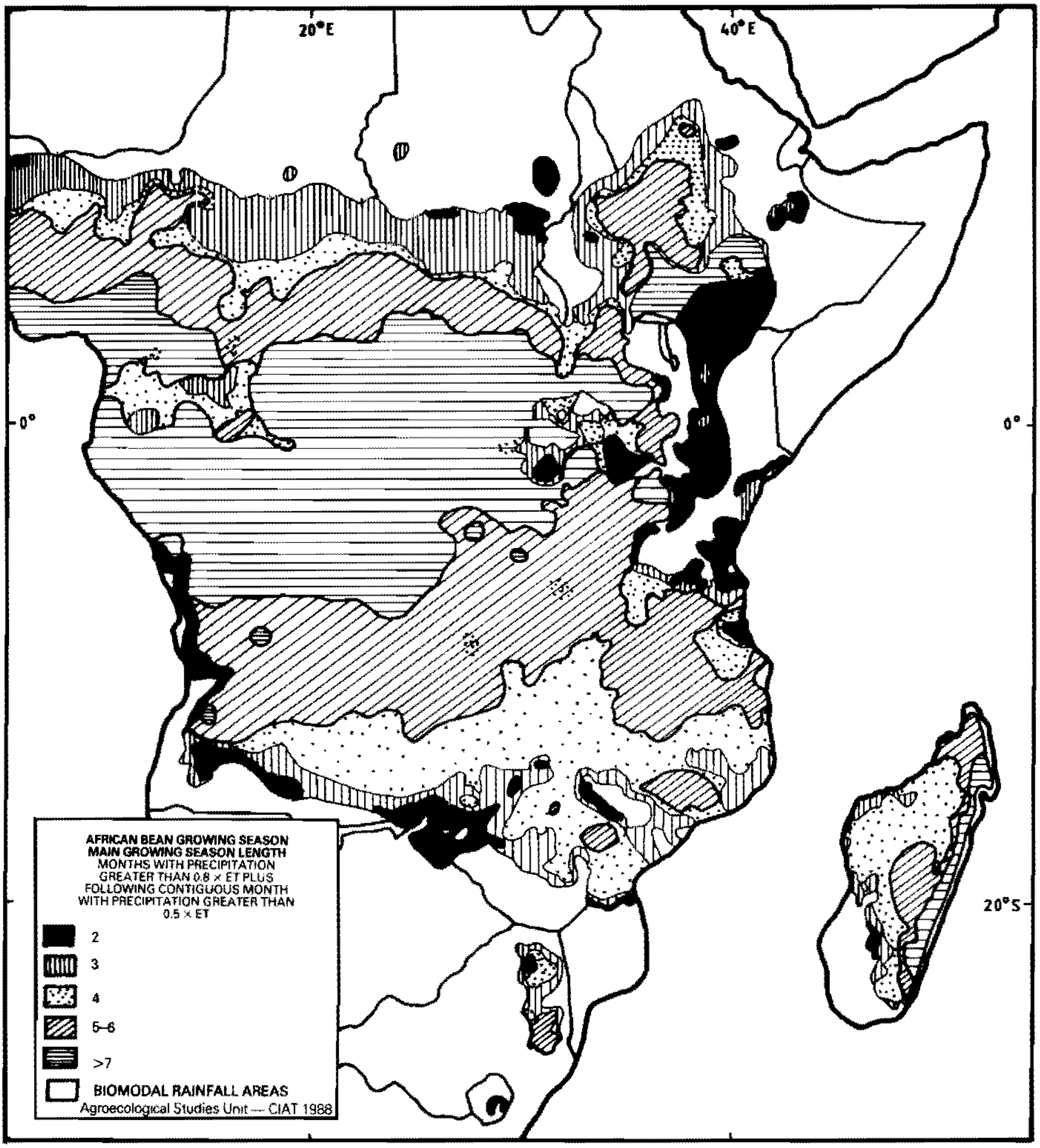


Figure 2. Africa - rainfall during main growing season.

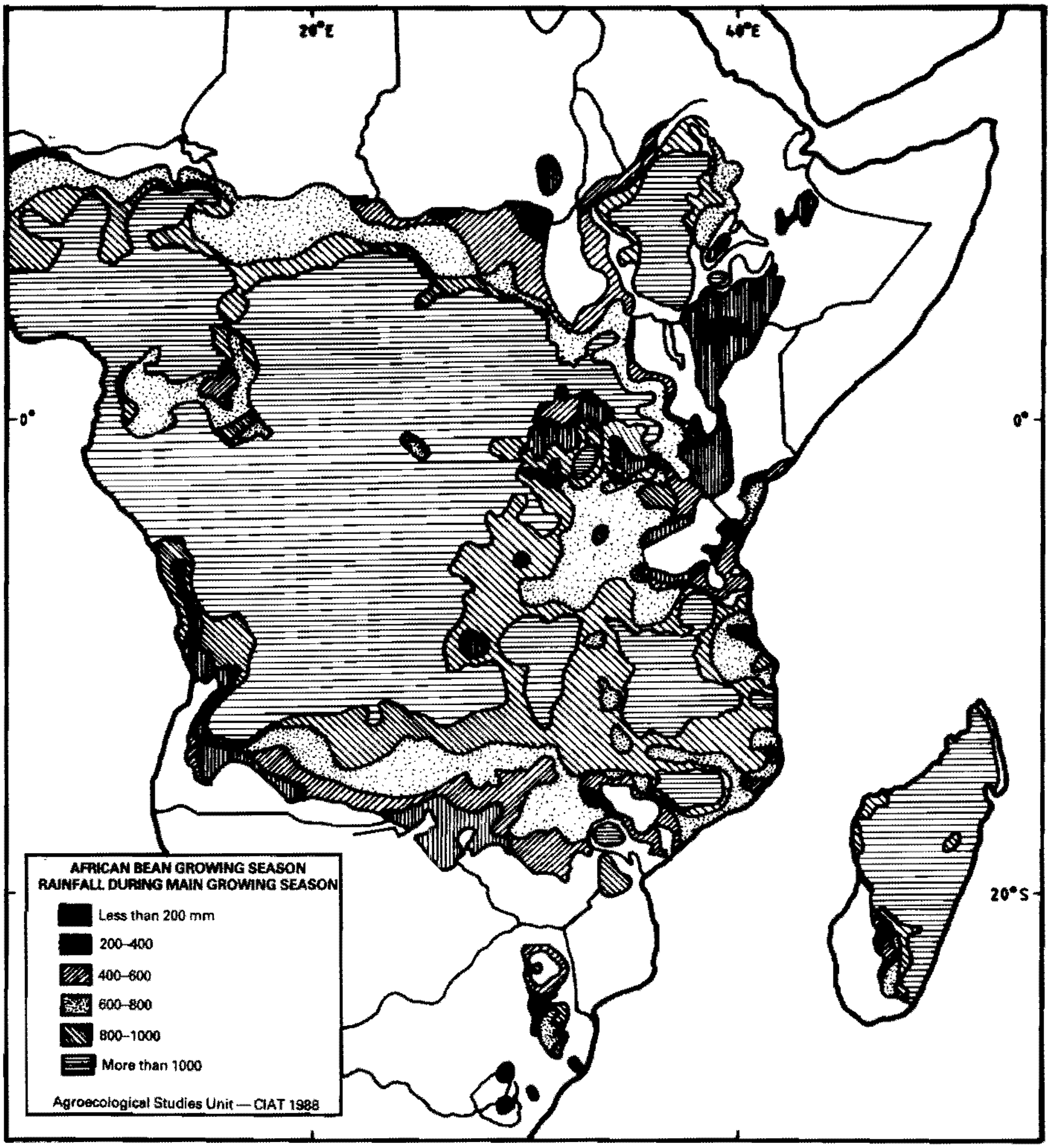


Figure 3. Africa - mean temperature during growing season.

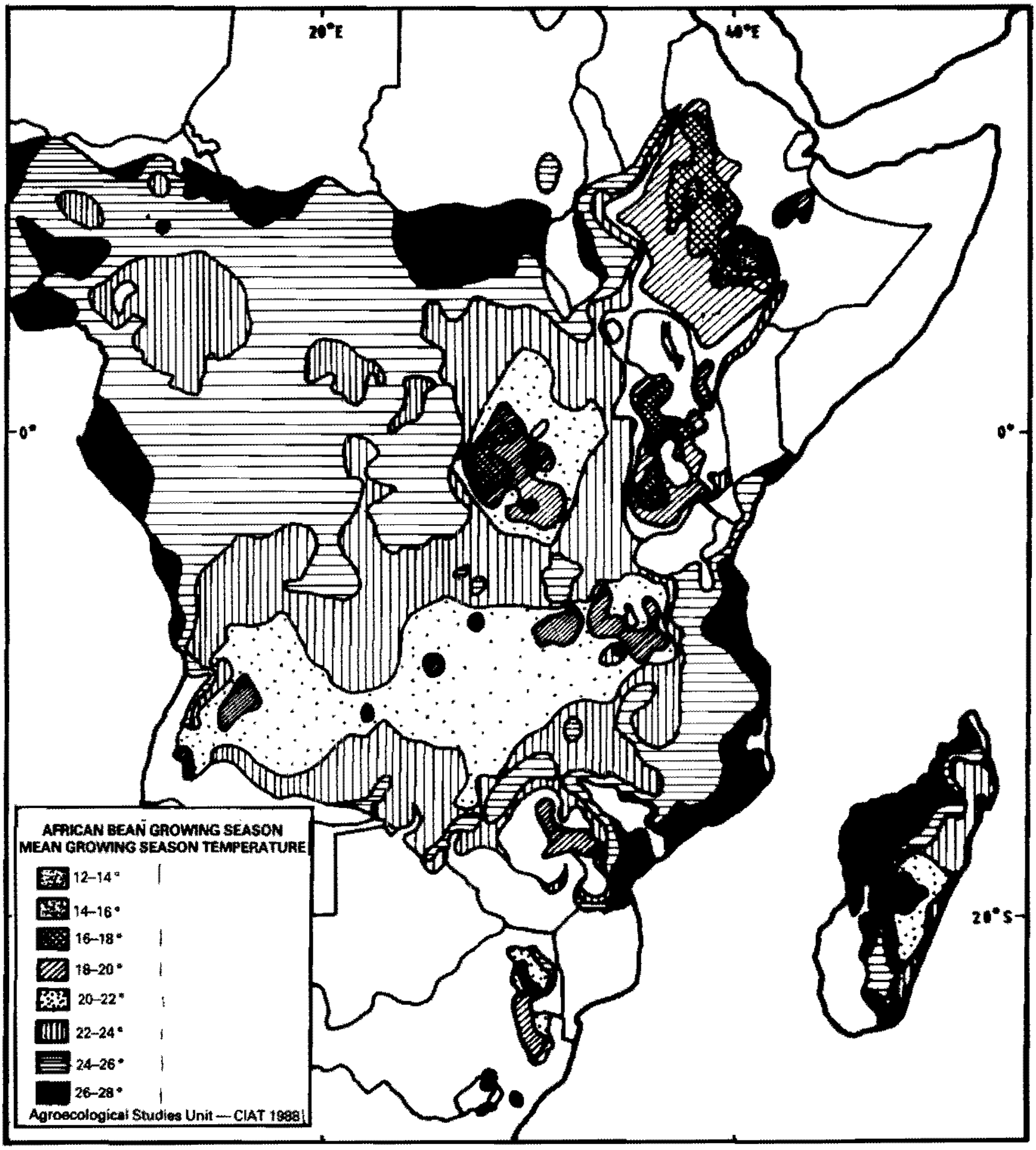


Figure 4. Africa - climatic similarities with Darien, Colombia.

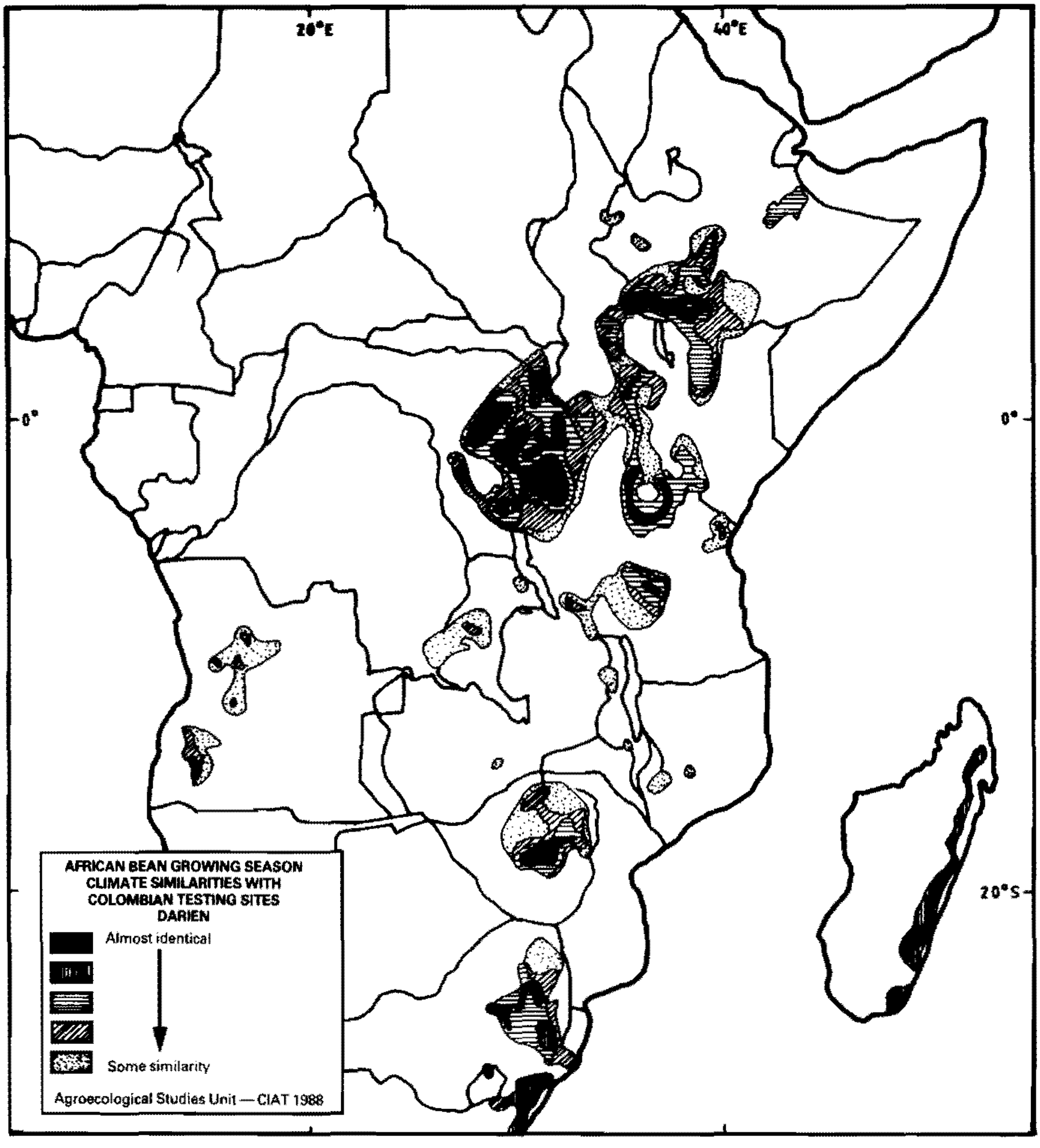
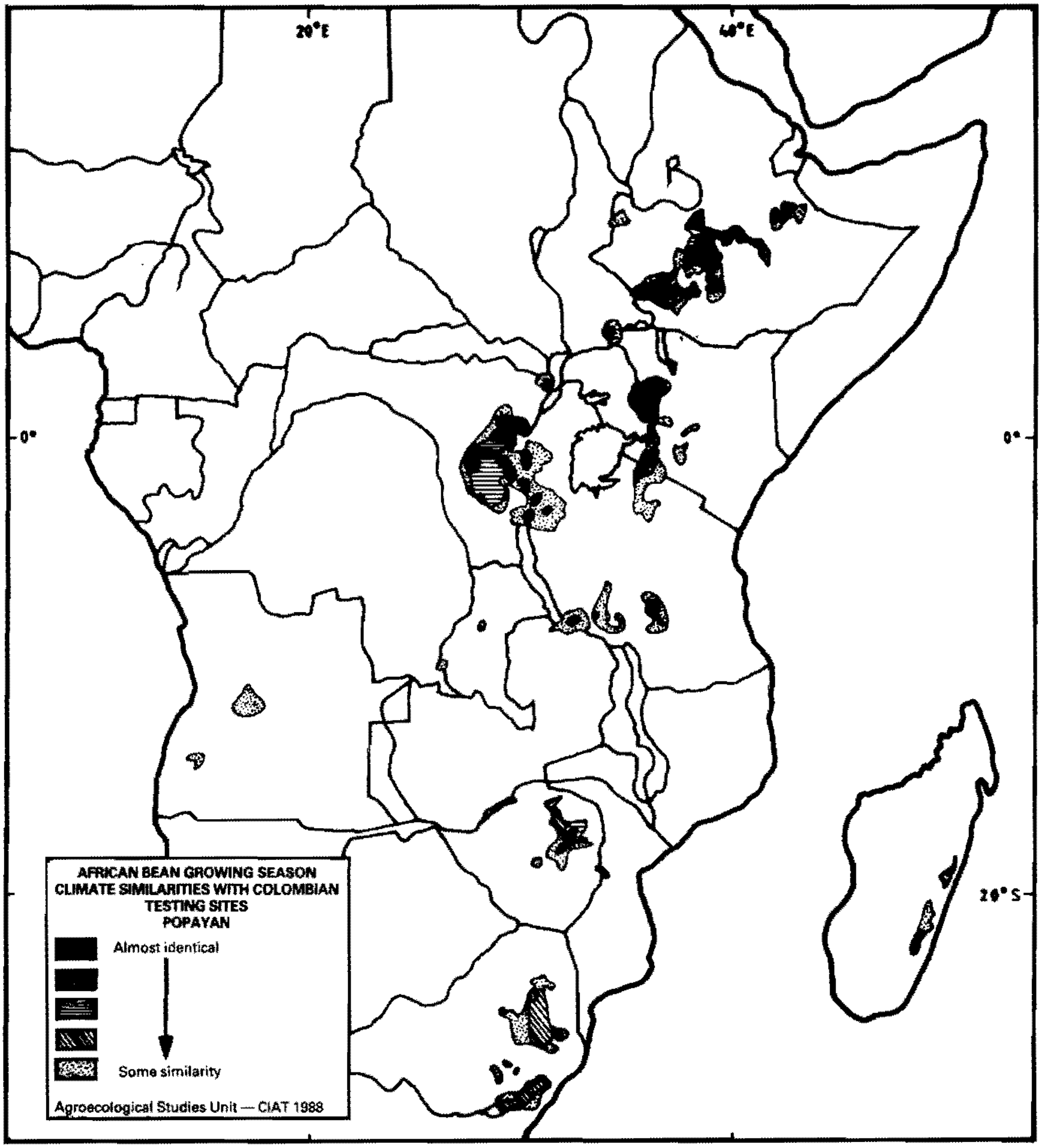


Figure 5. Africa - climatic similarities with Popaya, Colombia.



The research stations

Bean research needs are served by national research centres and sub-centres with varying capacities for research on beans. These stations can be classified according to: latitude; altitude; rainfall and mean maximum and minimum temperatures during the growing season; and capacity. Capacity is assessed in terms of a score based on numbers of resource staff involved in research on beans (Table 1).

Table 1. Classification of research stations according to capacity for research.

Score	Description
1	Full national team and regional staff
2	More than one scientist year plus technical support
3	One scientist year plus technical support
4	Less than one scientist year plus technical support
5	Technical support only

For example, in Tanzania (Table 2), there are teams of national scientists working on beans at the regional headquarters in Arusha (TARO); at the University of Sokoine in Morogoro; and Uyole Agricultural Center in Mbeya. The three centres are conveniently situated in different altitude zones and each operates through substations at similar latitudes - for example Lambo, Bukoba and Lyamungu for Arusha. This structure provides a useful basis for stratifying breeding efforts in Tanzania. There is similar information on locations in other countries being served by the regional projects.

Table 2. Research centres and sub-centres in Tanzania - environmental data/research capacity

Location	Season	Latitude	Altitude (masl)	Rainfall (mm)	Temperature (°C) Max	Temperature (°C) Min	Capacity
Arusha	Feb-Jun	3°20'	1402	600	24.2	14.8	1
Morogoro	Jan-May	6°50'	579	670	30.3	20.3	1
Lambo	Feb-Jun	3°16'	1067	786	27.2	17.2	2
Bukoba	Aug-Dec	1°19'	1137	701	26.1	16.1	4
	Feb-Jun			1246	26.0	16.4	
Lyamungu	Feb-Jun	3°13'	1250	1256	23.9	14.9	2
Mbeya	Jan-May	8°55'	1736	662	22.4	12.9	1

Based on this classification it is possible to identify research centres representing different environmental situations and with the capacity to properly evaluate large numbers of breeding materials - termed "primary" for want of a better word. These are complemented by other "secondary" locations which widen the spread of environments but with the capacity for more limited evaluation.

Possible primary locations are (Table 3): Rubona in the Great Lakes, Melkassa and Kawanda in eastern Africa; and Arusha, Bunda and Mbala in southern Africa. All of these have full teams of national and, in some cases, regional scientists with the capacity to handle substantial volumes of germplasm and breeding materials.

Table 3. Possible primary locations.

Location	Country	Altitude (masl)	Rainfall (mm)
GREAT LAKES			
Rubona	Rwanda	1276	425/728
EASTERN AFRICA			
Melkassa	Ethiopia	1550	545
Kawanda	Uganda	1198	553/500
SOUTHERN AFRICA			
Arusha	Tanzania	1402	600
Bunda	Malawi	1134	785
Mbala	Zambia	1673	786/816

Possible secondary locations are, in southern Africa (Table 4): Morogoro, Lambo, Bukoba, Lyamungu and Mbeya, in Tanzania; and Msekera in Zambia. Others lie in the Great Lakes and eastern Africa. Secondary locations could serve to evaluate sub-sets of materials from the primary locations.

Table 4. Possible secondary locations - southern Africa.

Location	Country	Altitude (masl)	Rainfall (mm)
Morogoro	Tanzania	579	670
Lambo	Tanzania	1067	786
Bukoba	Tanzania	1137	1246/702
Lyamungu	Tanzania	1250	1253
Mbeya	Tanzania	1736	662
Msekera	Zambia	1032	958

Together, the primary and secondary locations give good coverage of the major bean-producing areas. For example, there are centres in all altitude and rainfall zones except altitudes above 1500 m with rainfall greater than 1000 mm (Figure 6).

Other points to emerge are that, where there are two growing seasons, they are remarkably alike in terms of rainfall and temperature, suggesting that selection could be practised in either season. For example, the three locations that are being developed in Uganda as testing centres that represent the main bean growing areas (Table 5).

Table 5. Similarities between seasons at locations in Uganda.

Location	Season	Latitude (° ')	Altitude masl	Rainfall (mm)	Temperature (°C) Max	Min	Capacity
Kawanda	Feb-Jun	0°34'	1196	553	27.0	16.4	1
	Sep-Jan			500	27.7	15.9	
Serere	Mar-Jul	1°30'	1097	717	29.9	18.5	2
	Aug-Dec			592	28.8	17.5	
Kachwekano	Jan-May	1°14'	2123	505	23.1	11.1	3
	Aug-Dec			429	23.2	10.3	

There are also similarities among locations. For example, Awassa in Ethiopia, Lichinga in Mozambique and both seasons at Mbala are very similar in character (Table 6). Bunda in Malawi and Msekera in Zambia are also very similar (Table 7). It should be possible to exploit these similarities to develop effective and efficient testing strategies.

Table 6. Similarities in environments among locations.

Location	Season	Latitude (° ')	Altitude (masl)	Rainfall (mm)	Temperature (°C) Max	Min	Capacity
ETHIOPIA							
Awassa	May-Sep	7°05'	1700	710	24.8	13.5	3
MOZAMBIQUE							
Lichinga	Nov-Mar	13°17'	1364	938	25.0	15.7	4
ZAMBIA							
Mbala	Sep-Jan	8°15'	1673	786	24.8	15.0	2
	Jan-May			816	24.1	14.1	

Table 7. Similarities in environments among locations.

Location	Season	Latitude (° ')	Altitude (masl)	Rainfall (mm)	Temperature (°C) Max	Min	Capacity
MALAWI							
Bunda	Dec-Apr	13°58'	1134	785	27.0	17.2	1
ZAMBIA							
Msekera	Dec-Apr	13°33'	1032	958	27.4	18.0	1
TANZANIA							
Lambo	Feb-Jun	3°16'	1067	786	27.2	17.2	2

Similar classifications have been done for the locations in Colombia where selection is being carried out (Table 8).

Table 8. Environments of centres in Colombia where evaluation and selection is being practised.

Location	Season	Latitude (° ')	Altitude (masl)	Rainfall (mm)	Temperature (°C) Max	Min
Cali	Feb-Jun	3°30'	965	477	29.1	19.4
	Sep-Jan			390	28.9	19.0
Darien	Feb-Jun	3°49'	1360	464	24.7	14.7
	Sep-Jan			457	24.4	14.4
Popayan	Feb-Jun	2°25'	1760	697	23.0	13.0
	Sep-Jan			1088	22.6	12.6
La Selva	Sep-Feb	6°20'	2200	826	21.9	11.2
Obonuco	Sep-Mar	1°12'	2700	530	17.4	8.3

These indicate that Serere resembles Cali in climate during the growing season; Darien is similar to Awassa, Arusha and Mbala; and Popayan and La Selva resemble Kachwekano, Lyamungu and Mbeya.

As with the mapping, this is a very simple classification and will need to be refined as we assemble more detailed information on the countries in which we work, for example on soils and on cultivar performance in different environments, but it serves as an illustration of the sorts of analyses required to develop flows of materials from headquarters to Africa and within Africa as a basis for effective and efficient breeding and testing strategy.

This environmental analysis is only of use if it enables us to interpret and perhaps predict genotypic behaviour. Some information is available from earlier work but this tends to be incomplete and inconsistent. One approach is to relate the behaviour of the same set of genotypes to environmental changes across a range of locations and seasons. This is one of the objectives of the African Bean Yield Adaptation Nursery (AFBYAN), established in 1980. The AFBYAN comprises a set of 25 entries contributed by national programmes involved in the regional projects. Its purposes are: to initiate a regional nursery network; to make the best materials more available; to assist in the classification of environments for beans in Africa; and to interpret variations in performance across environments in terms of physical and biotic environmental factors.

So far the AFBYAN has been grown at 10 locations in the three project areas and preliminary analyses of data from five of them have been conducted. Combined analyses of variance indicate that G x E interactions account for substantial proportions of the total variation and are the same as or greater than genotype effects for several important plant characters, for example, plant height and ground cover , that reflect vigour, and pod numbers and seed yield (Table 9).

Table 9. Partitioning of total sums of squares of various plant characters in the AFBYAN grown in 4 environments in 1986-87.

	Plant height (cm)	Ground cover	DFF	Pods/ m^2	Seeds/ pod	Weight of 100 seeds	Seed yield (kg/ha)
Environments (E)	19.3	27.0	53.2	25.3	2.6	8.0	49.9
	*	***	***	***	**	***	**
Varieties (V)	10.9	19.3	27.4	24.9	57.3	66.3	5.8
	NS	***	NS	***	***	***	NS
V x E	38.1	21.7	16.7	23.4	13.7	9.5	27.6
	***	***	***	***	NS	NS	***

For seed yields this is reflected in dramatic changes in ranking of genotypes among environments (Table 10). For example, K 20 was bottom in two seasons at Kawanda, in the area where it was developed, and at Mulungu, and top and second at Rwanda and Zambia. Similarly, Nain de Kiyondo ranked second in Mulungu but was among the poorest yielders at all other locations. Stability analyses show differences among entries in regressions on environment mean yields and deviations from the regression both contribute to these interactions (Table 11). We have environmental as well as plant character data and now that data are available from more trials it is hoped to begin clustering environments according to genotype behaviour in an attempt to interpret observed variations in performance.

Table 10. Ranks of entries in AFBYAN for seed yields in 5 environments in 1986-87.

Entry	Kawanda 86	Kawanda 87	Msekera 87	Rubona 87	Mulungu 87	Mean
Black Dessie	9	2	13	25	10	7
G 13671	1	11	23	20	14	10
G 2816	7	9	14	9	1	1
K 20	25	25	2	1	25	16
Carioca	6	1	7	21	4	3
Urubonobono	2	10	24	8	15	6
Nain de Kiyondo	20	21	18	23	2	10
G 12470	17	20	25	2	6	14
Xan 76	3	4	1	17	9	2

Table 11. Stability analysis of seed yields (kg/ha) of some entries in the AFBYAN 1986-87.

Entry	Mean	b	SE	R^2%
Black Dessie	1058	0.70	0.296	58
G 13671	1039	1.20	0.771	67
G 2816	1387	0.20	0.771	2
K 20	970	1.39	0.566	60
Carioca	1271	0.58	0.559	22
Urubonobono	1116	1.35	0.356	78
Nain de Kiyondo	1034	0.38	0.480	14
PVA 563	916	1.14	0.098	97
G 12470	968	1.16	0.346	74
XAN 76	1344	0.90	0.409	55

THE CROP

Turning now to the crop - one obvious source of new diversity is the CIAT germplasm collection. Since evaluation of the entire collection in the necessary range of environments is clearly untenable, a set of about 1200 accessions has been selected to represent the total range of variation in the collection. This set can be evaluated initially at the primary and some secondary locations.

In addition to CIAT germplasm, local collections exist within Africa. Those in Malawi (around 3000) and the Great Lakes are most extensive, but there are smaller ones (between 100 and 200) in other countries. Representative sets from each of them can be used to compose a local base set to handle in the same way as the CIAT collection. New germplasm, both locally collected and from CIAT can be evaluated in the same way as it becomes available.

Some evaluation of the germplasm set has already been started in eastern and southern Africa. In Ethiopia, in the first evaluation, at Melkassa in medium altitude, dry conditions in 1986, the germplasm sustained heavy damage due to bean fly and leafhoppers. Accessions with reduced damage were selected and were grown last season at Melkassa and two other locations for further evaluation by the entomologists.

In addition the whole of the original set was grown again in 1987 at Melkassa and at Pawe (low altitude/humid) and Awassa (high altitude/humid). At Melkassa, the set was extremely drought stressed and sustained heavy damage from root rots and bacterial blight; at Pawe, web blight was a major problem; at Awassa, the main problem was bacterial blight. At all locations, disease damage, time to flowering, growth and podding were evaluated and seed yields estimated. The most promising entries were evaluated in the first stage of national variety tests last season.

The same set was grown in 1986 at Kawanda (medium altitude, dry) in Uganda, where bacterial blight, angular leaf spot and floury leaf spot were the principal problems. The best were selected for more detailed examination and the full set grown at Kachwekano (high altitude, dry). It was also grown in 1987-88 at Mbala in Zambia (high altitude, moderately dry, very acid soils).

The data from these intial evaluations are being processed at CIAT for cluster analysis to form sub-sets adapted to particular environments for tests at additional locations. From the first evaluation, it should be possible to identify materials of direct value for particular situations and subsequently to examine additional accessions of similar origin and/or character in these situations.

Advanced breeding lines

There are two main sources of advanced breeding lines from CIAT. They include:

The Bean Team Nursery or VEF, which constitutes annually around 2000 of the newest breeding materials emerging from the CIAT programmes. Each year the new VEF can be evaluated at the primary locations and handled in a similar way to the base sets of germplasm. Since seed is available usually in July, the first tests can be at one or more of the southern Africa locations (December/January sowing - Bunda, Mbala) and in Uganda and Rwanda (September sowing - Kawanda and Rubona). One set also for dry season multiplication in Ethiopia - December sowing.

The 1985 VEF set was grown at Melkassa in Ethiopia in 1986 and in 1987 the best entries were promoted to the second stage of national variety trials, in which one produced 70% more yield than local materials. The 1986 VEF was grown also at Melkassa - it was received late due to quarantine delays but was repeated at Melkassa again in 1988. VEF sets have also gone annually to the Great Lakes, Uganda, to Zambia and, for the first time to

Lesotho.

In addition to the VEF, there is also a series of special nurseries that represent the best of specific groups identified by CIAT to date. They can handled in the same way as the base sets of germplasm. Since, most of the future lines of these types will be included in the VEF, it appears necessary to test only those that do not reach that stage. Since seed of these usually becomes available in February, the first tests can be in Arusha; Kawanda and Rubona (March/April sowing); and Melkassa (June/July).

Locally and CIAT generated segregating materials are a further source of diversity. Locally generated segregating populations are unlikely to be many initially, and will probably be confined to crosses among local and improved breeding lines and for purposes specifically African (eg bean fly).

Crossing at CIAT can then concentrate on specific crosses for preliminary selection at CIAT (eg to incorporate BCMV, anthracnose and early nodulation into local materials). Back crossing will be very useful for the latter purpose - with 3 to 4 generations a year and the need for relatively small populations, it should be quick and easy to develop local materials with new characters; in addition, materials at intermediate stages can be evaluated in Africa to check progress. Such projects will be ideal for training - African staff can participate in the work at CIAT and can handle the materials they generate on their return to their national programmes. For general crosses, it is undesirable to go beyond the F_3 stage at CIAT, because of the importance of local adaptation.

It is expected that crossing will be limited initially, but will receive more emphasis as we become more familiar with the problems and the genetic combinations required to combat them.

African Regional Cultivar Trials and Nurseries. From secondary locations selected materials can proceed to regional nurseries throughout the region. In the Great Lakes, regional nurseries are already established. They will be described elsewhere but form an example of the type of structure that may develop in eastern and southern Africa. From regional nurseries, selected entries can proceed directly into the first stages of national testing systems and into regional trials.

We have already mentioned the AFBYAN in relation to environmental analysis. This was initially a single set of mainly bush types but a trial of climbing types has recently been assembled. The AFBYAN should probably diverge further into sets of materials for different ecological situations and purposes and serve as the main vehicle for dissemination of elite materials among African national programmes.

CONCLUSIONS

The foregoing is intended to offer ideas of the strategy that may develop for the flow of bean materials from outside and among African national programmes. Some elements have already begun since a start had to be made, but a system has by no means yet been established. It is hoped that one outcome of this meeting will be to establish such a system. To decide on: the types of materials that are required from CIAT and other sources; the locations where the materials should be evaluated and the types of designs to be used; and the structure for a testing system enabling movements of germplasm and breeding materials among and within the regional bean programmes in Africa.

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BREEDING ACTIVITIES IN AFRICA

Jeremy Davis

ABSTRACT

Bean breeding activities in the Great Lakes area (Rwanda, Burundi, Zaire) are described. An integrated scheme of variety evaluation has been established. The nucleus of the scheme is the Pepiniere Regionale pour l'Evaluation des Lignees Avances de l'Afrique Centrale (PRELAAC), which was initiated in 1987 to evaluate entries contributed by the three national programmes for resistance to diseases and pests.

Promising entries from the PRELAAC proceed to the Essais Regioneaux des Grands Lacs (ERGL) and thence to the African Bean Yield Adaptation Nursery (AFBYAN). There are separate nurseries or trials for bush and climbing types at each stage. PRELAAC entries that are agronomically unsuitable but with resistance to diseases are included in the Pepiniere Regionale pour l'Evaluation de la Resistance (PRER). Promising lines identified by the system are listed. Seed multiplication and distribution are organized from the regional HQ at Rubona.

Emphasis is now moving towards breeding for specific traits such as: resistance to BCMV (mosaic and black root), halo blight, angular leaf spot, anthracnose, beanfly and ascochyta blight. Regionally funded sub-projects are important for these activities. Other sub-projects are concerned with improved nodulation and artesenal seed production. Farmer involvement is emphasised in all phases of research.

INTRODUCTION

The last workshop for bean breeders in Eastern Africa was held at CIAT, Cali, Colombia in November 1983, in collaboration with the Title XII bean/cowpea Collaborative Research and Support (CRSP) Programme. Since that time considerable progress has been achieved in developing regional collaboration in bean breeding in eastern and southern Africa. This workshop provides an opportunity to evaluate progress and further develop strategies for bean improvement.

In this paper I am going to concentrate on the Great Lakes Regional Programme, as the oldest bean network since CIAT began working in Africa.

Beans are a major food crop in the Great Lakes Region. In Rwanda the production of beans has increased in the twenty years since 1965 from 70,000 tons to 310,000 in 1985, due mainly to area increases, but also to intensification. In Burundi, production amounts to approximately 200,000 t and in the Kivu region of Zaire, production is about 150,000 t.

REGIONAL TRIALS AND NURSERIES

Collaboration in bean improvement among the three countries has resulted in an integrated scheme of variety evaluation. The nucleus of this scheme is the PRELAAC (Pepiniere Regionale pour l'Evaluation des Lignees Avancees de l'Afrique Centrale) nursery, which brings together the varieties entering the comparative yield trials (Essais Comparatifs) in each country. The first PRELAAC was distributed in 1987. The purpose of the nursery is to evaluate specific traits, such as resistance to diseases or pests, in a range of suitable locations.

A meeting was held in August 1988 to review the results of the 1988 PRELAAC before the planting season. Rapid compiling of the data is critical, since it allows the information to be used by national programmes for selecting the varieties which go into multilocational yield trials. At the same time, the meeting allows participating scientists to select the varieties for the regional yield trials (ERGL = Essais Regionaux de Grands Lacs). These normally consist of 14 varieties and 2 controls in a 4 x 4 triple lattice design. There are separate trials for bush and climbing types.

Varieties which show exceptional disease resistance, but which may not meet other requirements for entering the ERGL, can enter the PRER (Pepiniere Regionale pour l'Evaluation de la Resistance) which provides pathologists with the opportunity to evaluate the stability of the resistance and its suitability for use in the crossing programme. The PRER is, therefore, the nursery which provides sources of resistance for use in the breeding programmes of each national programme. The ERGL, on the other hand, provides national programmes with yield data over a wide range of environments to complement data from their own multilocational yield trials and ensure that only the best varieties are selected for on-farm trials and variety release.

The varieties selected from the ERGL at the same time enter the AFBYAN (African Bean Yield and Adaptation Nursery), which allows them to be tested over a still wider range of environments, and ensures interchange of the best varieties among regional programmes.

Seed multiplications under protected conditions are carried out by the Regional Programme at Rubona, Rwanda, to ensure that only seed of the highest quality is distributed.

In the PRELAAC for 1988, a bush variety, A 321, showed combined resistance to BCMV, anthracnose, halo blight and ascochyta. XAN 68 was resistant to ascochyta, halo blight and angular leaf spot. Excellent resistance to anthracnose was found in AND 303 and RWR 45. In climbers, ZAV 83052 was resistant to BCMV, anthracnose and halo blight. Resistance to BCMV and halo blight was found in ACV

83031, and promising resistance to anthracnose was found in AFR 229 and VAMY-127-310-S5.

In the ERGL for 1988, the best bush varieties for yield were: PVA 15, PVA 1432, PVA 1438 and AND 303. The best climbers were AFR 13 and ZAV 83052. These varieties will pass to the AFBYAN, and should be candidates for variety release.

REGIONAL RESEARCH SUB-PROJECTS

As improved varieties are selected, so breeding needs to concentrate on specific traits in order to deal with problems as they arise with new varieties. Regional sub-projects are being initiated for this purpose, so that expertise and facilities are developed in the region to screen and breed for specific traits. I will give several examples of this approach.

Bean Common Mosaic Virus

BCMV is a virus attacking beans, which causes mosaic symptoms in susceptible varieties. The strains which have been identified in many countries of Africa, including Rwanda and Burundi, are often necrotic strains of the types known as NL-3 and NL-5. These are virulent strains which can cause black root symptoms in varieties carrying the dominant I gene. Hence, breeding at ISAR, Rwanda, is concentrating on developing varieties which combine resistance to mosaic with resistance to black root. For example, GLB 1 is a new resistant line from a backcross with C 10, a high yielding but susceptible climber from Rwanda; GLB 6 is from a backcross with G 2333, a high yielding and anthracnose resistant climber recently released in Rwanda. The source of BCMV resistance in both cases was ACV 83034.

Halo blight

Halo blight is a bacterial disease which has caused problems especially with seed multiplication of susceptible varieties. Races 3 and 1 (in order of importance) predominate in the Great Lakes Region. Resistance to these races is controlled by independent dominant genes. Selection at ISABU, Burundi, has resulted in the development of resistant lines, for example, GLH 9, which is from a backcross with Kilyumukwe, a high yielding but susceptible bush variety. The source of resistance was G 76 (Redkloud).

Other sub-projects

Similar programmes are in progress for angular leaf spot (PNL, Zaire), anthracnose (ISAR, Rwanda), bean fly (ISABU, Burundi), ascochyta (ISAR, Rwanda). Other sub-projects include screening for improved nodulation for more efficient nitrogen fixation (ISAR, Rwanda), and farmer participation and artesanal seed production (ISAR, Rwanda and CEDERU, Zaire).

FARMER PARTICIPATION

Emphasis is being given to involving farmers at an earlier stage in the variety selection process, and it is hoped this will lead to improved variety adoption, especially when combined with appropriate methods of seed production at a local level. This topic - Participatory Research - will be discussed in greater detail in the following presentation.

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BREEDING TO MEET FARMERS' NEEDS

Dr. Louise Sperling

ABSTRACT

This paper describes two techniques used in Rwanda for integrating farmer expertise into bean varietal development. Standard farmer evaluation of on-farm trials can help: 1) indicate how varieties perform under farmer conditions; 2) better identify criteria critical to farmers; 3) target varieties to agronomic regions; 4) target varieties to socio-economic groups of farmers; and 5) lead to the improvement or fine-tuning of varieties. A sceond, novel evaluation procedure, farmer evaluation of on-station trials, has the following further advantages: 1) integration of farmer criteria into the breeding process at an earlier stage; 2) promotion of a close breeder/farmer collaboration; and 3) enhancement of farmer influence in technology/varietal development. Both techniques are described in detail: the evaluation formats, the process, specific findings and future implications. Such methods for melding farmer and breeding expertise are neither arduous nor time-consuming; they can be integrated, at little monetary cost, into an on-going farmer-oriented research program.

INTRODUCTION

Breeders select improved varieties to meet farmers' needs. Perhaps they aim to increase yields and hence land productivity where such a resource is scarce. Perhaps they strive to give farmers a more saleable product, and thus to raise farmer income. In some cases, breeders may work to increase the nutritional level, by crossing grains with improved protein contents. In all instances, farmers are breeder clients and farmers should be breeder collaborators. Station research is worth little if station-developed technologies are either unsuitable for farm use or are simply not adopted by farmers.

Today, I would like to pose several basic questions relating to the breeder and farmer relationship - questions which, I hope, will remain as themes throughout this meeting. Are breeders meeting farmers' needs? Why or why not, and what kinds of evidence do we have? And how, in general, can breeders better work with and serve small-scale farmers? Most of the case material will be drawn from the Great Lakes Region, with particular reference to Rwanda, but I suspect that the issues raised are applicable throughout the African continent.

ARE BREEDERS MEETING FARMERS' NEEDS?

The fairest answer could be that in most cases we don't know: we can document some instances of "yes", some of "no". Studies, however, of specific varietal adoption and diffusion, or general studies of "what happens to improved varieties once they are tested on farm" are few. How many countries here have regular research programs which follow the progress of varieties in rural areas? In Rwanda, we have recently set up a program to monitor the course of our varieties. Among the more than fifty lines tested on-farm in the last ten years, we find that about 10 % still exist in quantity in farmers' bean mixtures, although use of many of these seems to be on the decline. Ten percent is not a bad record, but it is one we would like to improve. Through varietal follow-up, we have been able to identify the primary reason for varietal rejection - lack of disease resistance - and also have been able to identify problems of seed distribution and seed multiplication.

Beyond, studies of varietal adoption, researchers working within agricultural institutes, are also increasingly documenting how farmers' breeding goals (in addition to specific varietal preferences) often diverge from those of breeders. For example, work by the International Potato Center (CIP) in Rwanda, identified a farmer preference for short-cycle and often short dormancy potato cultivars - helping to shift a national breeding program which had been largely screening for later maturing, long dormancy varieties (Haugerud, 1987) (see also Prain, n.d.; CIAT, 1988, for comparable examples). We will explore the case of beans in Rwanda, in some depth, shortly.

So, the answer to whether breeders are generally meeting farmers' needs is unfortunately vague. All too often, we don't even know, as national African institutes have few monitoring programs. However, accumulating evidence suggests many instances where farmers' goals are not necessarily breeders' goals.

WHY BREEDERS' AND FARMERS' VARIETAL CRITERIA MAY NOT COMPLETELY COINCIDE

There are very good reasons why breeders and farmers may not always share the same viewpoint. To mention a few:

The conditions of varietal testing on-station differ markedly from those on-farm. Station soils are usually more fertile than those on many farmers' fields, planting densities are lower, and bean associations with other crops, on station, if any, are few. Hence station testing conditions do not begin to resemble farmer circumstances.

Station testing can only take account of an impartial set of varietal criteria. Certainly yield and disease resistance figure prominently within national breeding schemes. However, such important factors as plant architecture, which affect weeding ease (among other characteristics), taste, or cooking time are given scant attention in on-station or even on-farm researcher managed trials. Figure 1 lists central varietal criteria which prove important for Rwandan farmers. It is not an exhaustive list, but it certainly gives an idea of the comprehensiveness of farmer concerns.

Figure 1. Farmer bean varietal selection

POSITIVE CRITERIA	NEGATIVE CRITERIA
1. Good yield (many flowers) (many pods) (pods well-filled)	15. Bad yield (few flowers) (few pods) (pods not well-filled)
2. resists rain	16. does not resist rain
3. resists sun (i.e. drought)	17. does not resist sun
4. good architecture (upright)	18. poor architecture
5. grows well under banana grove	19. does not grow well under banana grove
6. resists less fertile soil	20. does not resist less fertile soil
7. leaves in good health (vigorous, numerous)	21. leaves in poor health
8. pods in good health	22. pods in poor health
9. early maturing	23. late maturing
10. pleasing color	24. unpleasing color
11. size of grains (positive)	25. size of grains (negative)
12. other: specify	26. susceptible to disease
	27. other: specify

Farmers' ultimate goals may simply diverge from breeders'. The latter, breeders, aim for high-yielding disease resistant varieties. Farmers, of course, yearn for large harvests, but perhaps, even more important, is their need for stability over the long-term. The majority want good varieties which produce good yields throughout varying kinds of stress: e.g poor soil fertility or drought.

Breeding for farmers is made all the more complex when one realizes that farmers themselves may differ in their needs. Some are more or less market-oriented. Some can afford to take risks, other not at all.

All of the above suggests that it is not easy to select for farmers, either for farmers in general, or for specific groups of farmers. Breeders have considerable expertise, given their particular conditions of research. Farmers, however, obviously know more of their own personal preferences and are more familiar with conditions on-farm; they understand agronomic variability at one point in time, and many can adjust for variability throughout time, that is, through conditions of stress.

So the third question might now be posed again, but in a different form. Not how can breeders better serve small-scale farmers? But rather as breeders, themselves, cannot be expected to anticipate all farmer needs, how can breeders complement their own strengths to create more farmer-acceptable varieties? The obvious answer seems to lie in some sort of breeder/farmer collaboration. Farmers may have difficulty in comparing dispersed, replicate trials, but they can compensate with decades of accumulated observation and with broad and direct experience.

Today, I would like to discuss two methods by which breeder and farmer expertise can be merged more completely. Both have been tried in Rwanda over the course of several seasons.

METHODS FOR MELDING BREEDER AND FARMER VARIETAL EXPERTISE

There are both formal (structured) and informal (less structured) means for trying to bringing breeder and farmer expertise within the same arena. Here, I present several of the formal techniques, those which lead to more rigorous analysis. The value of informal dialogue, however, should never been underrated. A good conversation with farmers, either singly or in groups, may be worth a score of evaluations. Before embarking on the two methods described - **farmer evaluation of on-farm variety trials** and **farmer evaluation of on-station trials** - I would urge all of you to organize several open-ended discussion groups with farmers. Talk about their general varietal criteria, perhaps using samples of your own varieties as reference points. Talk to farmers about their most pressing varietal concerns. Group discussions can also prove a particularly informative (and cost-effective) means for starting to understand differences among farmers.

I. Farmer evaluation of on-farm variety trials

This technique is in an abbreviated form both because a) most of you are probably familiar with it, and b) it represents an indirect method for feeding farmer varietal criteria back to on-station breeders.

As you know, varietal trials on farmers' fields most fundamentally help us understand how varieties will perform under actual conditions of use. If done sensitively, they can serve numerous other goals, elaborated below. To gain maximum information, varietal trials should not only be installed within a range of agronomic conditions (e.g. of altitude, soil fertility, rainfall) but also among a range of farmers (e.g. differentiated by wealth, market-orientation, or by key socio-economic variables relevant to your areas of testing).

On-farm varietal trials in Rwanda : general information. Within Rwanda, we now install about 100 varietal on-farm varietal trials during both the main bean season (September to January) and secondary period (March-June), though we are trying to reduce this number and target our testing. Trials are installed in most of the major agronomic regions, at altitudes ranging from 1400 to 2100 m. As the Institut des Sciences Agronomiques du Rwanda (ISAR) itself lacks sufficient personnel and logistical resources to follow such trials, we heavily rely on collaborating development projects to carry out such experiments. Five to seven varieties are planted in each trial, including the local check, which in Rwanda consists of the farmer's mixture containing 6-20 varieties. The varieties being tested are planted pure as farmers themselves plant pure when trying out a new seed, whether local or imported in origin (Voss, n.d.).

The evaluation format. Our evaluation form for on-farm varietal evaluations was refined over several seasons (Graf *et al*, 1987; Voss, n.d.; Voss and Graf, in press) always moving towards a simpler and more open format - one which can accommodate the heavy workload of collaborating project personnel. In the latest version (Figure 2), farmers are asked two questions: 1) which varieties tested do you like better than your own mixture, and why? and 2) which of the varieties do you like less, and why? They are then asked to rank the varieties they have mentioned in order of preference and non-preference.

This simple format allows farmers to cite only the negative and positive characteristics they feel are most important or are key to characterizing the variety (Voss, n.d.). Note, however, that most efficient use of this format is facilitated by a prior understanding of the varietal criteria which are important to farmers; these criteria are coded at the bottom of the evaluation sheet.

Further, our formats are in constant revision; the more we learn from farmers, the more accurate our evaluating capabilities become. For instance, through other investigations, we recently noted that "better or worse than your mixture" does not always give an assessment which is sufficiently precise to allow one evaluation to be compared with another; we are now considering adding an overall rating (perhaps 1 to 5, "very bad" to "excellent") which will permit cross-region or cross-wealth comparisons to be made - with little added research costs.

Evaluation findings. Evaluations of on-farm trials (using a range of formats, some quite detailed) have helped us to identify relevant farmer varietal criteria and the weight given to these various characteristics. To illustrate some of our findings, and simplify discussion, I would like to focus on the evaluation of a single variety, a small-black seeded, type 3 plant, known as "Ikinimba", and bring in other examples when necessary.

Figure 2. Farmer evaluation of on-farm trials

NAME ....COMMUNE ....SECTEUR ....

SEASON .... SEX ...... FARMER INSTALLED TRIAL?......

INTERVIEWER ....

VARIETIES 1) 2) 3) 4) 5) 6)

1. Which varieties do you judge as better than your mixture and why? (State in order of preference).

Variety	Why? (list codes)	Commentary
A.	....	....
B.	....	....
C.	....	....

2. Which varieties do you judge as worse than your mixture and why? (Start with the least liked)

Variety	Why ? (list codes)	Commentary
A.	....	....
B.	....	....
C.	....	....

BETTER because :	WORSE because :
1) good yield	1) poor yield
2) resists rain	2) sensitive to rain
3) erect	3) bad taste
4) early	4) late
5) big seeds	5) poor color
6) good taste	6) long cooking
7) color	7) poor plant type
8) rapid cooking	8) poor seed type
9) resists less fertile soil	9) needs stakes
10) many pods	10) poorly-filled pods
11) vigorous	11) misshapen pods
12) swells well	12) difficult to weed
13) good broth color	13) sensitive to sun
	14) resists sun

Evaluations carried out in the 1985 (March-June season) showed that yield is not a direct predictor of varietal appreciation or depreciation. In the central regions of Rwanda (Mayaga and Granitic Spur), Ikinimba was the least preferred variety, although it was the highest yielding (Table 1). The variety was downgraded due to its sprawling plant type, black seed color, poor broth quality and cooking time - among other features. Further, analysis of all the rejected of varieties, or "least liked", showed that yield (in this case "low yield", in general played a secondary role, with disease susceptibility (expressed as "sensitivity to rain") being the main determinant for a negative evaluation. In terms of the characteristics important for a positive evaluation of a variety, yield, resistance to rain, and earliness figured prominently (Voss and Graf, in press).

Assessments of Ikinimba in diffferent regions further indicated how useful farmer evaluations can be in helping us in targeting varieties to different agronomic circumstances. During 1986, the variety was tested on-farm in diverse regions in Rwanda, and after harvest, farmers were asked whether they were intending to replant the variety (a good indication of varietal preference). While, in the high-altitude, acidic soil region of the Zaire-Nil Crest, 90% of the farmers responded positively (given that they are having increasing difficulty in growing beans); in the medium altitude, high rainfall area of Nyabisindu, (with a range of soil fertilities), farmers were somewhat less positive, with 67.4% replying affirmatively; and in the low-altitude, relatively fertile areas of the Mayaga, where farmers have good leeway to productively plant a range of seeds, farmers were split, 50/50.

Finally, analysis of the Ikinimba evaluations serve to show how socio-economic differences can influence varietal appreciation. Follow-up studies were recently carried out in the prefecture of Butare, an area with about 1700 mm of rainfall. Poorer farmers categorically rejected the variety as its sensitivity to rain rendered it a particularly poor-yielder - and its poor color and poor cooking qualities did little to add to its popularity. Wealthier farmers, however, asked if we might sell the seed in local stores, to make it available on a constant basis. It appears that the green beans of Ikinimba are particularly delicious; their use fresh avoids both problems with rain and aesthetic dislike for its black color. Of course, it is particularly the wealthy who can afford to grow a green bean for home consumption.

Evaluation vs. "improvement diagnosis". It is important to note that farmer evaluations do more than simply critique varieties. They can serve as a tool for improving seed, if indeed, 1) the evaluations are precise enough and 2) scientists assess the variety has sufficient positive potential to warrant efforts to ameliorate negative aspects. Thus, farmer evaluations have recently shown that a well-liked variety, A 197, has developed extreme anthracnose susceptibility in the regions of low, but

Table 1. A comparison of on-farm trial farmer evaluations in the central plateau of Rwanda, 1985.

		Farmer evaluation[1]		Yield[2]	
Variety	No. of trials	Score	Rank	Kg/ha	Rank
Ikinimba	41	67	7	1650	1
A 197	48	88	4	1220	2
ISAR Mix	41	81	6	1215	3
Kirundo	40	92	3	1073	4
Kilyumukwe	41	96	1	1053	5
Local mix	41	92	3	1048	6
Rubona 5	41	83	5	1039	7
Umutikili	18	95	2	1021	8

[1]The farmer evaluation score is the result of evaluation questions asking farmers how they feel about continuing to grow the variety as they see it in on-farm trials. The score is based on a five-point scale where: Excellent = 100, Good = 75, Average = 50, Fair = 25, Poor = 0.

[2]Based on mean yield data of on-farm trials in Nyabisindu, Ruhashya, and Mayaga.

Source : Voss (n.d.)

particularly medium altitude. The variety is going "back to the drawing board", and breeders have started a crossing program to build in such resistance. Further, farmer evaluations can serve as an important tool for improving agronomic management. For example, during initial seasons of testing, the variety G 13671 was generally not liked for its sensitivity to rain and its low yield. Evaluations identified lodging as probably the major reason for the rain problem. The CIAT agronomist suggested that farmers try the variety with short stakes; farmer evaluation, hence appreciation, immediately shot up. The variety is now also doing well in association with maize, the latter serving as staking material (Voss n.d.).

Summary. Why are farmer on-farm varietal evaluations important for on-station breeders? They can help:

1. indicate how varieties perform under farmer conditions
2. better identify farmer varietal criteria
3. target varieties to regions
4. target varieties to socio-economic groups of farmers
5. lead to the improvement or fine-tuning of varieties (both in terms of breeding and agronomic management)

II. Farmer evaluation of on-station trials.

The second approach to capturing farmer expertise complements the first and represents an extension of the on-farm evaluation process. As before, researchers visit farmers' fields, and researchers elicit farmer evaluation of on-farm trials. In addition, however, farmer seed experts (in Rwanda, women) are now being invited on to the station to evaluate research-managed regional trials. This farmer evaluation on-station differs from farmer-evalution on-farm in at least three important respects: 1) farmers are able to critique varieties at an earlier stage of the selection process; 2) they are able to share expertise directly with station scientists; and 3) farmers themselves select varieties to test in their own fields. While this program of what we call "participatory research" is relatively new, initiated at ISAR in March 1988, it is already starting to yield significant results.

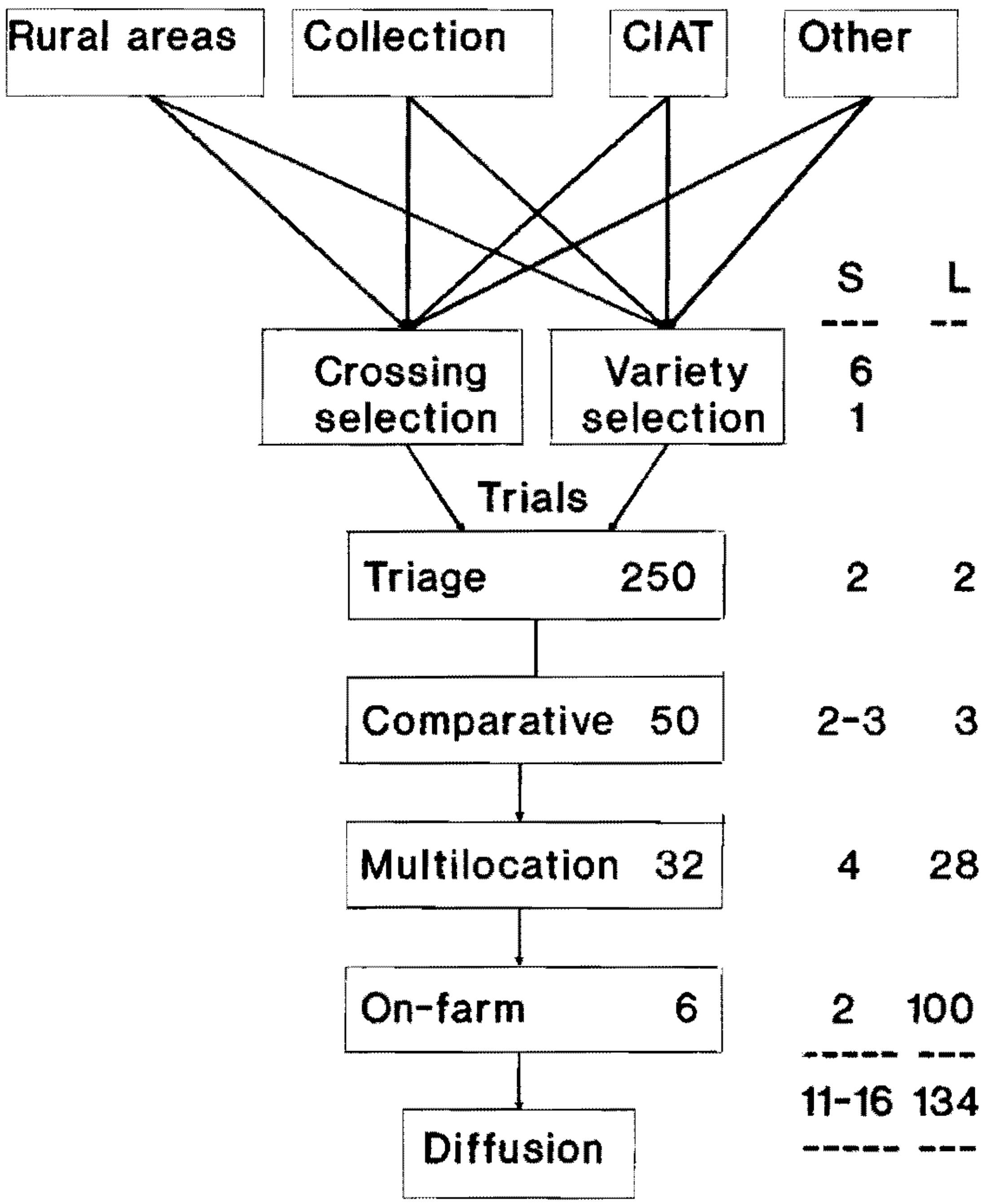
The current structure of bean breeding at ISAR, Rwanda. To put in perspective the two approaches being discussed today, **farmer evaluation on-farm** and **farmer evaluation on-station**, let us refer to the general scheme of breeding at ISAR (Figure 3).

At all stages of on-station testing, beans are selected primarily for yield; disease resistance is an important but secondary consideration. Beans are grown at various station sites for nine to fourteen seasons (five to seven years) before they enter the phase of on-farm testing. Farmer evaluations have traditionally been incorporated only at this last stage of selection, directly before diffusion. Hence the process of on-station testing remains time-consuming and station-focused; and farmers simply react to breeders' choices of varieties the latter predict will do well in rural areas. With our newer approach, bringing farmers on to what are called "multilocational sites", we hope to incorporate farmer expertise some four seasons earlier and use that expertise to help us select which varieties should even be tested on-farm. Question: can this approach help us more efficiently identify productive varieties? If so, eventually, we would like farmer expertise to affect decisions made at the stage of crossing and selection.

The evaluation format. To date, Rwandan farmers have been involved in six sets of on-station varietal evaluations: at high, medium, and low altitude sites. To provide an idea of the scale of the program, we have completed 114 evaluations with 47 farmers, and 25 interviewers (breeders, agronomists, sociologists and technicians) are becoming well-versed in this participatory technique.

Women make two kinds of evaluations: they first closely critique varieties as they grow on-station. They then select "the three best" and "the three worst" varieties and explain the rationale of their choice. As a third step, women predict which varieties will grow best in their own fields. The wisdom of their evaluations is put to the test as participants have been

Figure 1. Bean selection scheme at ISAR



S = seasons; L = locations Source: Nyabyenda (1986) permitted to select several varieties for home growing. Women who chose varieties in May 1988, grew them this season in their own fields; the crops were recently harvested.

Note that the format used (Figure 4) is more geared for obtaining specific information for breeders than that used for general on-farm use. It allows for the evaluation of each variety separately, both the negative and positive characteristics, and then calls for overall comparisons among varieties. The format also contains several means of cross-checking the accuracy of information.

Table 2 presents an example of one of our on-station evaluations last season, September-January 1989. Yield again emerges as an important, but not determinate factor in farmers' selection of varieties. The ease with which a variety can be associated, its ability to withstand stress (particularly less fertile soils, and its early maturity (hence minimising risk) all emerge as essential concerns.

The evaluation process. We should note that it is not easy for a researcher to identify farmer seed experts: that is, those who have had considerable success in growing beans, who consciously experiment with varieties, and who are able to extrapolate beyond the conditions of their own farms. In addition, representativeness is quite important, that is, choosing farmers with varying wealth and varying agronomic conditions. In our initial trials, we have sometimes relied on the community's own assessment of their local experts before interviewing a range of candidates. We additionally look for women who are reflective, speak clearly, and who are not intimidated by the presence of men (certainly a major concern when station scientists are overwhelmingly male). If the candidate expresses a strong interest in helping us evaluate varieties, we then take the final step - getting the permission of her husband.

Further, the process differs markedly from farmer on-farm evaluations as women experts have not nurtured the variety from seed, being able to note its habits at the various stages. The women seed experts themselves thus suggested visits at two or three critical points in bean growth (R6/R7, the beginning of R9, and shortly before harvest). While some felt they could make one-shot assessments, at the peak of maturation, they suggest that the workers who had planted and weeded the varieties might be on hand to answer their questions.

Several trends have emerged quite clearly, through the six sets of evaluations:

a. When evaluating a variety, farmers consider as primary not only its apparent yield. Although the bean trials are always laid as a sole crop and generally under favorable conditions, farmers judge varieties on such factors as their expected ability to associate with other crops, especially bananas, and their tolerance of stresses likely to be

Figure 4. Evaluation of multilocational trials.

SITE.............

Name .... Commune .... Sector ....

Stage .... Date .... Interviewer ....

1. How do you generally rate each variety: (circle the letter)

a) excellent b) good c) average d) fair
e) poor

VARIETY	EVALUATION	REASONS (use codes Figure 1)
1.	a b c d e	....
2.	a b c d e	....
3.	a b c d e	....
4.	a b c d e	....
5.	a b c d e	....
6.	a b c d e	....
7.	a b c d e	....
8.	a b c d e	....
9.	a b c d e	....
10	a b c d e	....
11	a b c d e	....
12	a b c d e	....
13	a b c d e	....
14	a b c d e	....
15	a b c d e	....
16	a b c d e	....

Which are the 3 best varieties ?	The 3 worst ?	The 3 to test at your home ?
1.	1.	1. ....
2.	2.	2. ....
3.	3.	3. ....

Table 2. Farmer evaluation at mid-altitude multilocational site. Bush Bean Trial 1988/89.

Variety	Seed yield (kg/rep)	Among 3 best (%) farmers	Among 3 worst (%) farmers	Mean* score	Comment
PVA 15	3.264	32	a	4.16	Late-maturing, poor on less fertile soil.
PVA 46	2.950	47	a	4.42	Good yields, fine pods, late maturing
K-20	2.436	58	a	4.74	Good yield, resists disease, associates with bananas.
G 11525	2.346	a	57	2.95	Vulnerable to wind, hard to associate.
PVA 705	2.323	42	a	4.47	Associates with bananas.
Nain de Kyondo	2.106	a	63	3.32	Good yield, late-maturing, poor under bananas.
RWR 52	2.035	a	a	4.15	
HATVEY 23	1.949	37	a	4.32	
RWR 45	1.927	26	a	4.21	
Kabanima	1.574	a	a	3.84	
PVA 782	1.524	a	a	4.00	
PVA 774	1.517	a	a	3.39	
Kilyumukwe	1.397	a	a	4.00	
ZAA 840/86	1.304	a	a	3.44	
RWR 14	.972	a	79	2.80	Poor yield on less fertile soil, early-maturing.

*Farmers scored varieties from "excellent" = 5 to "poor" = 1

encountered off-station.

b. Farmers assessments do not strictly follow the actual yields of station trials. Varieties selected had among the better yields and those rejected among the lower. But the relationship was not always clear. For example, at the mid-altitude locational site, the correlation between the mean of the farmers' scores and realized yields was positive but just short of significance (r=0.51, P> .05) (Table 2). As explained above, farmers were considering other characteristics as well.

c. Farmers are in considerable agreement as to which varieties do well on-station. Accord is often greater, however, on which varieties perform poorly - and why.

d. Some farmers select different varieties according to season. Crop associations and especially intensity of rainfall vary across the year. During times of greater stress, the choice of varieties becomes more conservative: farmers choose the sturdier varieties, not necessarily the earliest-maturing or those with greatest yield potential.

e. The evaluations clearly highlight regional differences. For example, in an area of little rain, farmers consider highly a variety which they believe resists drought, despite its very long cycle. In an area of more abundant rainfall, the same variety is categorically rejected - because of its late maturity.

f. Farmers are eager to try a wide range of varieties on their fields. However, in all regions some varieties are rejected categorically. Results suggests that the proportion of varieties rejected is greater in the harsher than in the more permissive environments.

Some implications of the process. Beyond such specific findings, the process of such evaluation also seems to be making an important contribution to our goal of conducting farmer-oriented research. The various research actors have all gained in different, but important ways :

Farmers: Women seed experts have been unanimously pleased by the station visit. They have new bean varieties and are particularly grateful that, this time, they were given an idea of varietal growth habits before being expected to plant seeds in their own plots. Further, the bean trials have been interesting but so have the on-station plots of sorghum and sweet potato - while these farmers have lived within 10-20 km of a research station for all their lives, they have had no idea what went on there. Now, the women worry that the varieties they have chosen to test on their home plots might not perform maximally. That is, they feel responsible for and committed to their own on-farm trials, which have thus far been installed and managed with great care.

Station scientists: At all of the evaluation sites, this was the first time that station breeders had directly spoken with farmer seed specialists. One breeder was surprised that farmers select varieties according to season and filled several pages with notes. Another learned of important new varietal criteria, e.g. resistance to wind. Certainly each of the groups of experts (on and off station) still has much to prove to the other. However, useful information has been exchanged, information which had never emerged during years of on-farm varietal evaluations.

Station administrators: Higher level administrators are enjoying the publicity effects. At little cost, the research center appears to be taking account of its rural population.

Summary of objectives. In returning to the objectives of these farmer on-station evaluations, we see how they complement, although differ from on-farm evaluations. In terms of verifying how varieties will perform in farmers' fields, hence fine-tuning them to actual conditions of use, there is no substitute for on-farm evaluations. The on-station program, however, meets several research needs which are not met by more conventional on-farm testing.

First, it integrates farmers' criteria into varietal development at an earlier stage of the selection process (i.e not after ten seasons of on-station testing). If done well, it can help increase the efficiency of varietal dissemination, eliminating farmer-unacceptable varieties from the breeding sequence quickly.

Second, and perhaps even more important, the process promotes a closer collaboration between on-station researchers and surrounding farming communities by initiating a direct dialogue between breeders, pathologists and other station personnel on one side and local expert farmers on the other. If scientists can better internalize farmer criteria from the very first stages of crossing and selection, they have a good chance of developing progressively more productive and accepted varieties.

Third, the participatory exercise, both on-station and the subsequent testing on-farm, should give farmers a stronger voice in technology/varietal development, as well as a greater responsibility for selecting the varieties they feel will perform best on-farm. Through such a program, we find that farmers, themselves, can take the lead in managing on-farm trials - hence cutting both supervising costs and increasing the quality of on-farm research results.

CONCLUSIONS

The methods described above for melding farmer and breeder expertise are neither arduous, nor particularly time-consuming. They can be integrated, at little monetary cost, into an on-going farmer-oriented research program. Such programs, however, do demand a certain will on the part of each collaborator to listen and try to understand the other's goals, and a faith that each, breeder and farmer, has something important to offer to the partnership.

Realistically, much of the initiative of the breeder/farmer collaboration rests on breeders; such scientists continue to decide which varieties to develop, which varieties to diffuse, and whether or not to integrate the results of farmer evaluations into future breeding strategies. In terms of varietal development, breeders do hold the key to better meeting farmers' needs.

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SESSION IV - BEAN BREEDING AND EVALUATION IN AFRICA - DISCUSSION

Massey: From the agronomy point of view yield is the number one criterion whereas the pathologist would not consider yield highly. Are you overstressing resistance at the expense of yield?

Davis: It may seem that way; we are trying to redress imbalance.

With regard to acceptability, yield *per se* is not the major criterion.

Silbernagel: In the AFBYAN, does stability analysis relate to disease resistance?

Smithson: As more data becomes available, we shall look more thoroughly at the reasons for instability.

Pali-Shikhulu: I doubt that a variety should be rejected on the basis of disease alone. Diseases often can be controlled by cultural means.

Baert: There are some diseases that we believe should be taken into account. e.g. in Burundi, we do not release varieties with halo blight susceptibility for highlands.

Bokosi: The older varieties released in Malawi were chosen on the basis of agronomic-performance alone, so they are all disease susceptible. In future, we shall seek to combine agronomic performance with resistance.

Abebe: Davis showed a slide of two cultivars contrasting in degree of nodulation. Do you evaluate all your lines ?

Davis: The method in use at ISAR is accurate but labour intensive, so we cannot yet evaluate all varieties with better techniques, larger numbers of lines could be screened.

There is little interaction between strains and beans/cultivars. A good nodulator will always nodulate well.

Silbernagel: The slide I showed was of a line found nodulated on a deliberately low N field.

Amare: Do you find flower abortion at sites at about 500 masl (for example, Morogoro) as we do at Gambela in Ethiopia ?

Smithson: Gambela is probably much hotter than Morogoro, because of latitude differences.

Pali-Shikhulu: Why are all your primary sites confined to the more northerly latitudes, with the most southern being Bunda in Malawi?

Smithson: The choice or classification of primary sites was based on there being sufficient scientific manpower to undertake large scale research programmes, and it is imperative not to overload a national programme with additional trials.

Dessert: How do you choose your farmers and for how many years do you use these farmer's aid, do you have an estimate of the cost involved?

Sperling: The local community is asked to choose the farmers and when they come to observe the plots their interest and ability to express themselves is assessed. The same farmers may be used for a number of years. The only cost involved is transport and this is not very expensive.

Mushi: Very interesting work. How did you choose the farmers? Are the questionnaires too complex?

Sperling: The farmers often complain that the interviewers are not sufficiently interested! We choose farmers on bases of: interest and knowledge of beans; ability to communicate; that they have their husband's permission; and that they have no timidity in speaking to men. Both well-to-do and poor farmers are included.

Mushi: A breeder uses many selection criteria but how much weight do you give to the farmer's judgements?

Sperling: Breeders need to harness farmers' expertise and appraise it along with the breeders' own expertise. I don't believe farmers have all the answers.

Amane: On-station evaluation by farmers is presumably during vegetative stage, and yet they need to evaluate seed. How do you manage this?

Sperling: A good question. We seek farmer participation at least twice each season.

Nchimbi: Can farmers really evaluate sixteen varieties all at once?

Sperling: In our experience, farmers can easily evaluate sixteen simultaneously.

Masaya: How long should you use the same farmers over seasons? I would expect that after 2-3 years those farmers would no longer be representative.

Sperling: There is obviously a danger in 'professionalizing' farmers. But this needs to be balanced with the value of their experience.

Baert: I think you would need to be very careful in analyzing farmers' answers to questionnaires. Our experience in Burundi suggests farmers often confuse improved cultivars with previously known ones.

Sperling: The methodology is not easy. Notes are available on ways of explaining it to farmers.

Bokosi: In some communities, it is the man that is the decision maker? Shouldn't men's opinion be sought too?

Sperling: In Rwanda, we seek husband's permission but the expertise lies with the wife. It all depends on your situation as to whether the women or men are the key decision-makers.

Pali-Shikhulu: How do you choose your farmers when multilocational testing is involved?

Sperling: Individual groups of farmers are chosen for each location as they know the local agronomic/ ecological conditions.

Masaya/Massey: Both questioned the cost effectiveness of utilizing farmers in the selection process.

Sperling: The use of farmers in the selection process considerably reduces the chances of the rejection of a variety at an advanced stage of testing, with all the costs that this has already involved. With the relatively low cost of farmer involvement I feel it is fully justified.

Abebe: Aren't two visits expensive?

Sperling: Two hours twice a season is not expensive to some, but it may seem so to others. In our experience, farmers have expressed concern over costs to the researcher, rather than vice versa.

I would like to add that participatory research could prove extremely useful not only for varietal evaluation, but also of more complex technology, including cropping systems and agroforestry experiments.

Dessert: Are your on-station trials specially designed for farmer evaluations, or are they part of trials for another purpose.

Sperling: Davis's breeding trials were used, making slight adjustments as appropriate.

Nchimbi: Farmers preferences can change very rapidly. How do you accommodate this?

Sperling: Farmers preferences for the beans they actually consume do not seem to change much or rapidly. However, it is true the preferences of farmers who are commercially oriented can change rapidly reflecting market demands.

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SESSION V - COUNTRY REPORTS - EASTERN AFRICA

ETHIOPIA

Amare Abebe and Haile Kefene

ABSTRACT

Ethiopia is environmentally diverse, enabling production of a wide range of crops. Haricot bean ranks among the five major pulses. Between 1980 and 1985, production of beans increased by 50 % and has since doubled, probably in response to drought situations and expansion of cropping into lowland areas.

The structure of the breeding programme is described. Breeding materials are stratified according to seed type: White Pea Beans; Medium-Sized Colored Beans; and Large-Seeded Beans. Between 1984 and 1987, 2,723 germplam accessions and breeding materials were introduced from CIAT. These have progressed through preliminary and advanced adaptation nurseries into Pre-National and National Variety Trials. Pathologists, entomologists, food scientists, agronomists and socio-economists all collaborate in the selection process.

Among the White Pea Beans, Ex-Rico 23 and BAT 338-1C have been submitted for approval for release; in the Medium-Sized Coloured group, A 176 has been approved; A 410 and A 267 (Large-Seeded) are likely to enter Verification Trials this year. Materials have been identified with very good levels of resistance to beanfly.

INTRODUCTION

Ethiopia lies between latitude 3° and 18°N, and longitudes 33° and 48°E, entirely within the tropics (Westphal, 1974). The total land area is about 1.2 million km^2 (Ermias, 1987). The country is believed to have about 86 million ha of arable land, out of which only 7 million ha is cultivated annually (MAO, 1979). It is in a favoured geographic position to grow different species of food crops. Few countries in the tropical world possess as good a natural environment for agricultural development, as Ethiopia. The favourable climate is mainly influenced by altitude which ranges from sea level to more than 3500 masl.

IMPORTANCE AND PRODUCTION OF HARICOT BEAN

A large number of crops are grown in the country but six cereal and five food legume crops are very important (Table 1).

Table 1. Estimates of area and yield of major crops in Ethiopia (1985).

Crops	Area (000 ha)	Yield (kg/ha)
Cereal		
Teff	1,204.7	750
Barley	872.5	1,000
Wheat	772.0	1,010
Maize	840.5	1,200
Sorghum	725.9	1,080
Pulses		
Horse bean (*Vicia faba*)	268.0	830.0
Field pea (*Pisum* spp)	123.9	520.0
Chick pea (*Cicer arietinum*)	109.9	690.0
Lentils (*Lens esculentum*)	39.9	550.0
Haricot bean (*Phaseolus vulgaris*)	45.0	510.0

Source: Central Statistics Office, Addis Ababa, Ethiopia

Haricot bean (Phaseolus vulgaris L.) is among the five most important food legumes of Ethiopia (Table 2). It is mainly grown at intermediate altitudes (1400-1800 masl). In haricot beans, seed color, shape, size and cooking quality are important features for producers and local consumers. In central Ethiopia (Shoa) (Figure 1) farmers grow the white pea bean, for export, as their cash crop. In these areas, the rainy season is short (about three months) and early maturing varieties are needed. In the south (Sidamo and Gamo Gofa), haricot beans (red and other colors except black) are grown mainly for local use. Unlike central Ethiopia, the southern region has a rainfall period of more than six months and the intercropping of beans with maize and other cereals is very common. In Welega (western Ethiopia), climbing bean types are grown in many farmers' gardens and used as green beans for local food preparation.

The area of beans produced increased by more than 50 % from 1980 to 1985 (Table 2). Though the information for 1988 is not available, it is believed to be double that of 1985. One of the main reasons for the expansion of bean area has been the prevalence of drought during recent years, particularly in the intermediate altitude areas. This is because beans mature within three months and are able to give reasonable yields when rains are poor. Also, crop production is expanding in low altitude areas, where other traditional pulses perform poorly due to diseases and pests. In these areas, beans perform very well and are being produced as a source of protein.

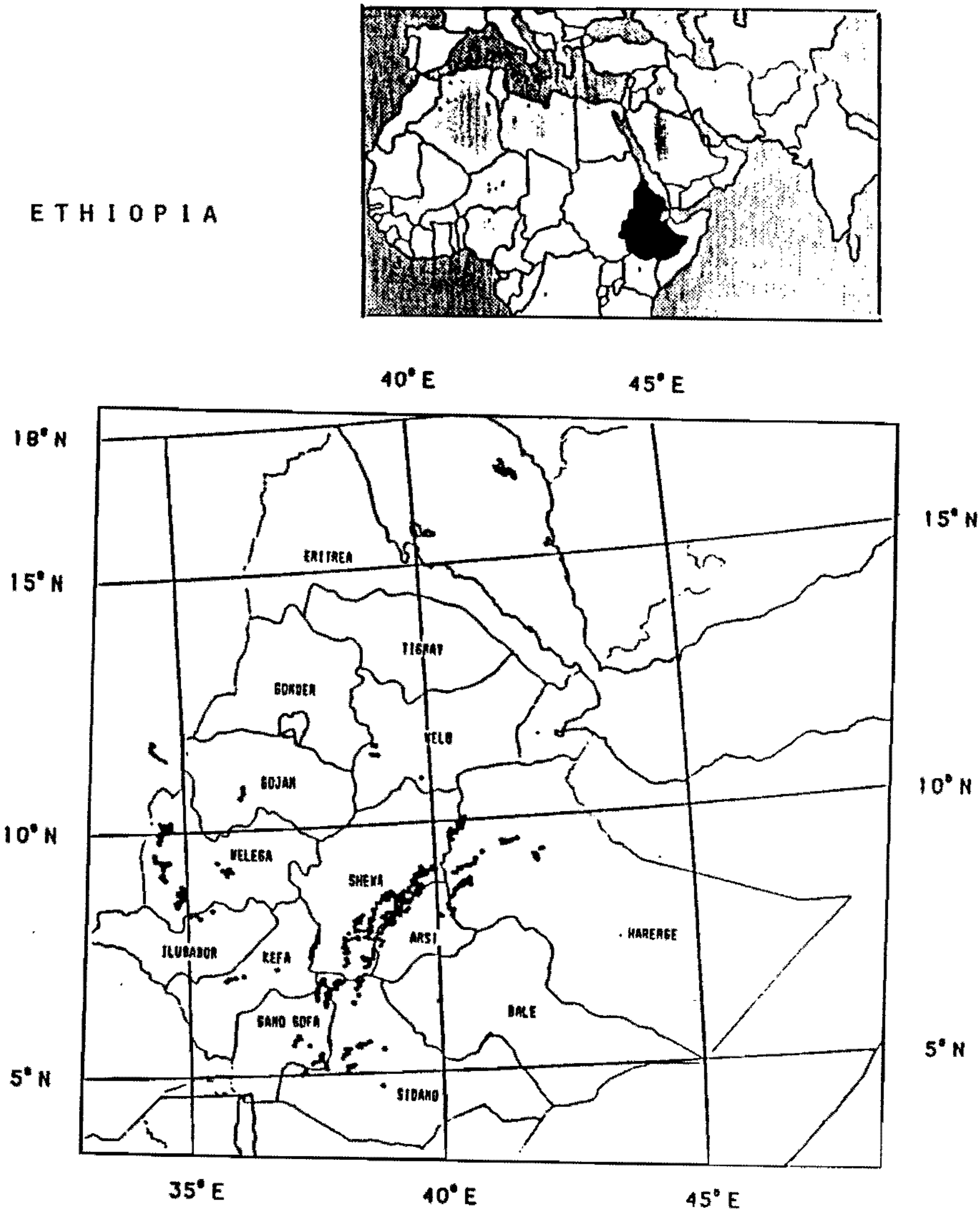


Figure 1. Bean growing areas in Ethiopia

Table 2. Estimates of area, production, and yield of important food legumes in Ethiopia (1980-1985).

Pulse	Years					
	1980	1981	1982	1983	1984	1985
Area '000 ha						
Horse bean	306.5	350.0	380.6	350.4	341.6	268.0
Field pea	169.1	175.9	151.1	123.1	128.1	123.9
Chickpea	149.0	135.2	134.8	172.8	157.3	109.9
Lentils	53.4	69.7	55.3	40.2	32.6	39.9
Haricot bean	20.7	24.4	43.4	46.9	43.4	45.0
Production '000 t						
Horse bean	469.0	472.5	600.4	388.9	191.9	222.4
Field pea	150.7	165.3	133.0	119.4	79.4	64.4
Chickpea	117.7	101.4	118.6	108.9	78.7	75.8
Lentils	59.8	50.2	42.0	25.3	15.0	22.0
Haricot bean	23.2	11.7	35.3	46.0	35.2	23.0
Yield kg/ha						
Horse bean	1,530	1,350	1,580	1,110	610	830
Field pea	890	940	880	970	620	520
Chickpea	790	750	880	630	500	690
Lentils	1,120	720	760	650	460	550
Haricot bean	950	480	840	980	810	510

Source: Central Statistics Office, Addis Ababa, Ethiopia.

HARICOT BEAN RESEARCH (1984-1987)

At national level, bean yields range from 500 to 1,000 kg/ha (Table 2). Diseases, drought, pests and poor cultural practices are the main causes of poor bean yields in farming communities. To alleviate the problems, the Bean Research Program conducts research activities in several disciplines, notably: breeding, pathology, entomology, agronomy, food science and socio-economics, the latter being mainly concerned with on-farm trials.

Breeding

During 1984-1987, the main activities of the breeding program were evaluating introduced and locally collected bean germplasm for yield in preliminary and advanced adaptation trials and further evaluating the adaptation of selected materials in Pre-National and National Variety trials in different agro-ecological zones. The incorporation of specific traits into commercial varieties by crossing was also practised to some extent.

During this period, a total of 2,723 germphasm and advanced lines from CIAT (Table 3) were introduced and evaluated for adaptation. Promising materials were promoted to the next stage of testing for further evaluation. At all stages, selection has been in collaboration with food scientists, pathologists and entomologists.

The bean breeding program is conducting trials of three different seed types. The groupings, based on market requirements, are: White Pea Beans (for export); and Medium-sized Colored Beans and Large Seeded Beans, both for for local use.

White pea beans. Top yielding varieties were selected from trials received from CIAT, and included in preliminary adaptation trials in 1984. The selected materials were evaluated in advanced adaptation trials in 1985 at four locations. In 1986 and 1987, the performances of the best materials in different environments were evaluated further in Pre-National Variety Trials (five locations) and National Variety Trials (13 locations) (Figure 2).

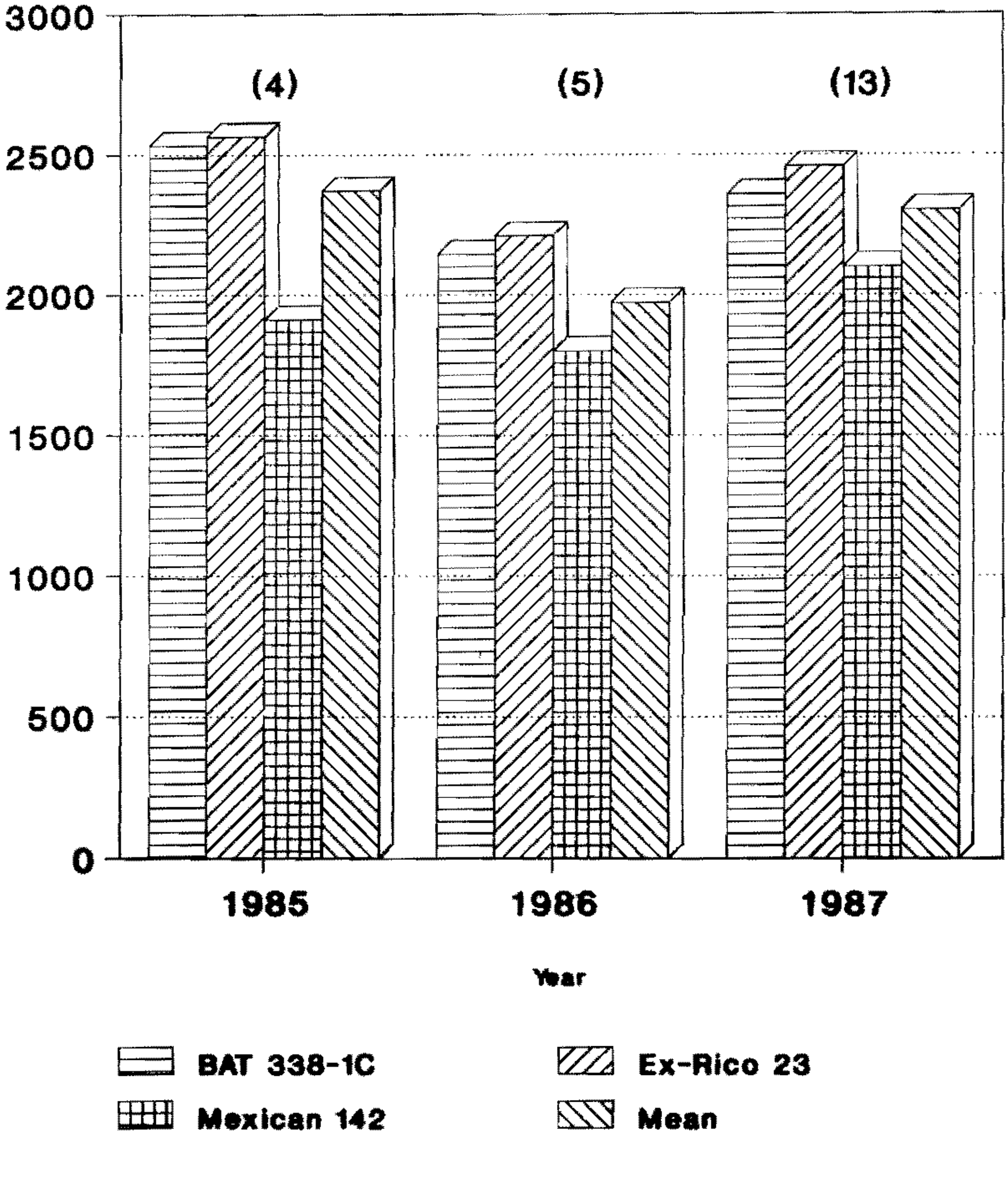
Combined analysis of the three years results showed two varieties (Ex-Rico 23 and BAT 338-1C) to be significantly (P=0.05) better yielding (2,411 and 2,344 kg/ha, respectively) than Mexican 142, the standard check (1,937 kg/ha).

Table 3. Numbers and types of entries introduced from CIAT (1984-1987)

Year	Trial name and no.	Number of entries
1984	IBYAN No 39004	11
	IBYAN No 45907	19
	VIRAF No 75605	17
1985	IBYAN No 3904	12
	IBYAN No 45907	19
	IBYAN No 75605	17
1986	CIAT germplasm	1,566
	IBYAN	102
	BIDAN	67
1987	AFBYAN	25
	VEF 86	868
	Total	2,723

Variety Ex-Rico 23 is more tolerant to rust than Mexican 142, but susceptible to anthracnose which is a problem in high altitude, humid areas. Thus, Ex-Rico 23 is recommended for central Ethiopia where the rainfall is not heavy. Ex-Rico 23 is also early maturing and has excellent canning quality, characters that

Figure 2. Seed yields (kg/ha)
White Pea Bean Series



Numbers in parenthesis show number of locations are greatly desired in farming communities of central Ethiopia.

Though BAT 338-1C produced slightly poorer yields than Ex-Rico 23, it showed better tolerance to common bacterial blight, rust and anthracnose than all other varieties in this trial series. BAT 338-1C is also widely adapted in bean growing areas of the country, but its canning quality is not as good as that of the standard check and Ex-Rico 23. However, it is well accepted for both local use and export.

In 1988, Ex-Rico 23 and BAT 338-1C were in Verification Trials (10 m x 10 m plots) to demonstrate their performance to the National Crop Release Committee. Both performed well and are expected to be released.

Medium-sized colored beans. The standard check used in the Medium-sized Colored Bean series (Black Dessie) is black in seed color. It was released long ago, and it is a high yielder and tolerant to many diseases, but has not been accepted by consumers due to its seed color. Its replacement by more acceptable seed types is therefore long overdue.

In an advanced adaptation trial conducted in 1985 at six locations, the mean yield of Black Dessie was 3,086 kg/ha, significantly greater than all other entries, except 997-CH-173 (2,743 kg/ha), A 176 (2,630 kg/ha) and Carioca (2,605 kg/ha). In 1986, these three were included in Pre-National Variety Trials at five locations, and in 1987 in National Variety Trials at 11 locations. In the Pre-National Variety Trial, the three top yielding varieties were 997-CH-173 (2,021 kg/ha), A 176 (2,186 kg/ha) and Carioca (2,200 kg/ha) compared with 1,821 kg/ha from Black Dessie.

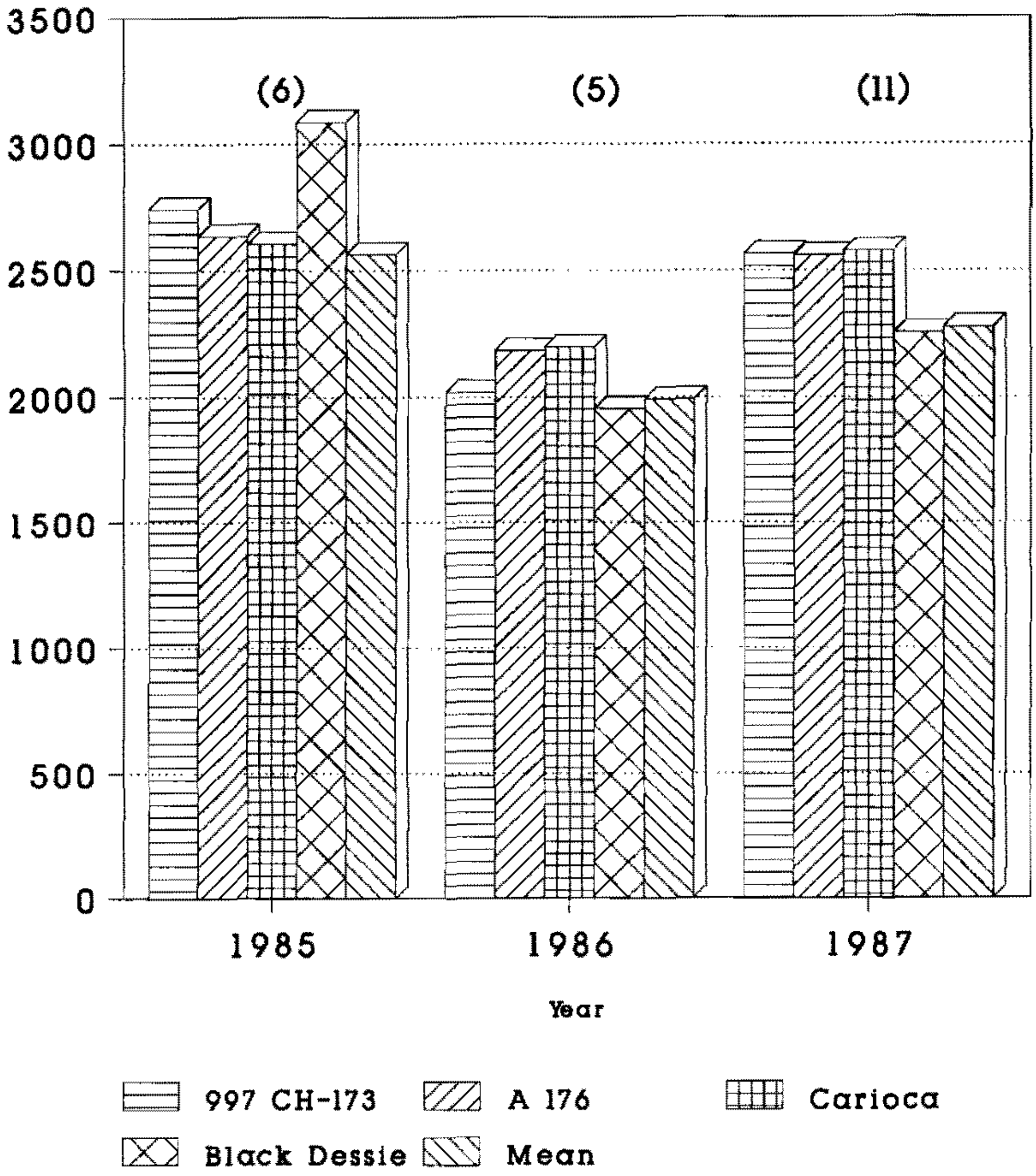
Similarly, the three ranked top in National Variety Trials in 1987 (Figure 3). Based on the three years results, the three varieties were recommended for release. 997-CH-173 was subsequently withdrawn due to a longer cooking time than Black Dessie and Carioca because of severe damage by bean fly in Verification Trials. A 176 has been approved for release.

Large-seeded Beans. Large-seeded beans were few among the 1984 introductions and locally collected materials, but A 410 and A 267, introduced from CIAT in 1985, ranked top in preliminary tests and were promoted directly to Pre-National Variety Trials in the following year. They have continued among the top yielders in the Large-Seeded Bean group trials in 1986 and 1987 (Figure 4), but will undergo further tests to obtain sufficient data to support recommendations for release. A third variety, Aguascalientes, was found to be very susceptible to rust and has been dropped from National Variety Trials.

Pathology

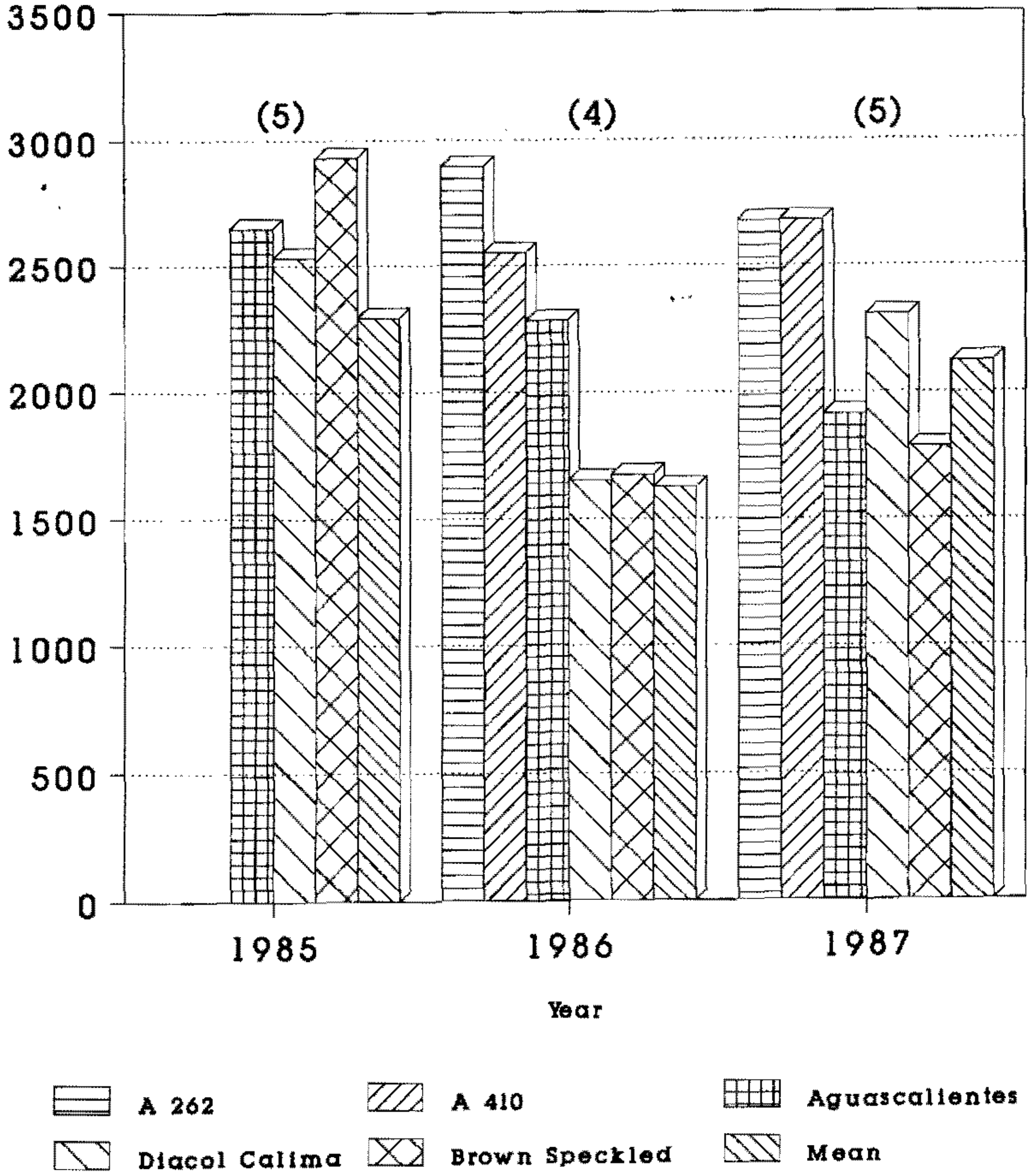
All introduced varieties are evaluated for their disease reactions in different ecological zones. Varieties tolerant to

Figure 3. Seed yields (kg/ha)
Medium-sized Coloured Bean Series



Numbers in parentheses show number of locations

Figure 4. Seed yields (kg/ha)
Large-seeded Bean Series



Numbers in parenthesis show number of locations rust, CBB, virus and anthracnose have been identified and are available for use by the breeders.

Food science

The cooking time of all the varieties is being determined using the Mattson bar-drop experimental cooker. The data for cooking time is one of the parameters for the selection of varieties for the following stage of testing of the Medium-Sized Colored and Large-Seeded Beans. Canning quality tests are used in the selection of the White Pea Beans.

Entomology

1640 germplasm and breeding materials, received from CIAT in 1986, were planted very late (end of July) in Melkassa (altitude 1500 masl) and received supplementary irrigation to support plant growth. Severe beanfly attack in the early vegetative and flowering stages enabled the entomologist to select varieties with low levels of infestation and good yields. Selected materials were further evaluated for tolerance to bean fly in 1987 at Melkassa and Awassa, where bean fly is very damaging. A few (Table 4) showed much better levels of resistance than other entries in the trials and are undergoing further tests.

Table 4. Percentages of plants killed by beanfly and seed yields of bean varieties selected for tolerance to bean fly in 1986 at Melkassa and Awassa in 1987.

	Percentage of plants killed by bean fly		Seed yields (kg/ha)	
	Awassa	Melkassa	Awassa	Melkassa
G 3844	6	6	2284	1177
G 3696	7	6	2636	739
G 2005	8	5	2355	1485
G 4858	8	8	1738	1066
G 1483	9	9	1018	632
G 2472	10	10	2370	1340
G 4458	11	12	831	166
EMP 81	10	7	2402	1205
G 404	12	7	1191	389
G 11292	11	10	2102	760
G 3645	14	6	2310	651
G 124	12	8	1882	532
G 9409	10	9	934	600

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UGANDA

Ms. B.S. Male-Kayiwa and Ms. M.S. Musaana

ABSTRACT

Bean breeding dates back to 1960. Disease resistance has been emphasised and a series of improved varieties, selections from landraces and the products of hybridization programmes, were released during the sixties, the best known being K 20.

Interrupted twice by civil war, the breeding programme has recently resumed, based on new local collections and materials introduced from CIAT and from African countries. The disease reactions of local collections and introductions are evaluated over locations and seasons. Promising materials proceed to preliminary and then multi-location trials and are used as parents in crossing programmes.

Several introductions are now in preliminary trials. G 13671, T 3, BAT 1220, Carioca, and the local varieties, K 20, Namunye Red, Nkulyembaluke, Mutike and White Haricot are in on-farm tests. Local varieties are much-favoured for their taste and rapid cooking but are very susceptible to diseases. Crossing to incorporate ascochyta blight and common bacterial blight resistance has started as part of regionally funded research projects.

Release of new varieties is subject to approval by the Varietal Release Committee. Seed multiplication and distribution are the responsibilities of the Seed Project.

INTRODUCTION

The bean programme started in 1960 (Rubaihayo *et al.*, 1980) and diseases were identified as the major factors contributing to low yields. Breeding work started with screening of both local and introduced varieties against the major bean diseases, namely, anthracnose, common bacterial blight, angular leaf spot and rust.

Cultivars, Mutike 4, Canadian Wonder, Bukalasa and Abundance were improved and recommended for better seed type and yield but their infusion into the farming community was very limited. Variety Banja 2 (a multi-line composed of five selections from the landrace, Banja) resistant to anthracnose, was released but was unsuccessful due to the poor keeping quality of cooked beans. Variety Kabanima was released from Makerere.

Multiple crosses among Banja 2, No. 15, No. 77 and No. 78 resulted in 1968 in K 20 which was resistant to anthracnose and angular leaf spot. K 20 was susceptible to common bacterial blight and rust, though these were not thought to affect yield appreciably. K 20 now comprises a major part of the crop in many areas of Uganda. Both Kabanima and K 20 are determinate with medium to large red mottled type seeds. Evaluation of lines from the hybridization programme resulted in the release on a limited basis of a multiline variety K 130. This variety never moved beyond the seed project.

From 1979 onwards the programme has been intermittently affected by civil war and consequent loss of germplasm. By 1983 the breeders had to start reassembling the remaining varieties and introducing new germplasm for quick assessment and release. Variety K 20 had deteriorated over the years and proved very susceptible to common bacterial blight and production of disease-free seed for distribution to farmers was impossible. Improved varieties especially in IBYAN trials of red mottled varieties and a crossing block variety assortment were received from CIAT and tested at Kawanda and Bukalasa in 1985. Selection of red mottled varieties were made for advancement to yield trials and subsequent release. This work too was interrupted in 1985 and though some varieties were retained, the descriptive information on them was lost with the files. A fresh start was made in the first season of 1986.

BREEDING SEQUENCE

The steps followed in evaluation of the bean varieties are as follows :

1. All introductions from CIAT, neighbouring countries, and local collections are planted out at Kawanda for general screening whereby records on vigour, habit and disease and pest reactions and yield are taken. All the varieties that are poorly adapted or very susceptible to disease are discarded. Where possible the varieties are screened at Kachwekano in a cool highland environment.

2. Screening nurseries for various diseases are made up with selections from the germplasm and are planted initially at one location, Kawanda or Kachwekano (e.g. common bacterial blight, rust and ascochyta nurseries). International disease nurseries from CIAT are also evaluated.

3. The disease nurseries are repeated at two or more sites and inoculated with the respective pathogen under review. It is at this stage that selections for parental materials or varieties for advancement are identified.

4. The selected parental varieties are used in the crossing block for improvement of popular varieties or a request is sent to CIAT for assistance in incorporation of specific characteristics into the selected varieties. On the other hand varieties selected for advancement are seed multiplied.

5. Preliminary yield trials of advanced varieties at one location. The varieties with best performance are promoted to multilocation trials.

6. Yield trials of selected varieties at Variety Testing Centres (VTCs) at several locations. This testing requires a minimum of three seasons to get data to back up the release of a variety. Seed multiplication and on-farm testing of the varieties proceeds concurrently.

7. The best varieties are presented for release to the variety release committee with the supporting data. Released varieties are then given to the seeds project for seed increase to go to the farmers.

PRESENT STATUS OF BREEDING PROGRAMME

Introductions made in 1986 included: F_2 and F_4 generations of crosses made at CIAT using some Uganda varieties as parents; IBYAN climbing reds; AFBYAN 86 varieties; and some Rwanda varieties selected by the breeders on a visit there (National Bean Programme, 1987). Single plant and family selections were made in the crosses, while varietal selections were made from IBYAN climbing reds and the AFBYAN. The selections from crosses and climbing reds are still under multiplication. The eighteen varieties selected from the AFBYAN were included in multilocation variety trials which started in the second season of 1987. From these trials five varieties, namely, G 13671, White Haricot, Black Haricot, Rubona 5 and T 3 have been outstanding and are under characterization in preparation for the Variety Release Committee.

Introductions made in 1987 included 1200 germplasm accessions from CIAT, VEF 86, segregating populations from multiple crosses done at CIAT, IBYAN (coccineus) and disease nurseries for rust, common bacterial blight, anthracnose, halo blight and ascochyta (National Bean Programme, 1988). A beanfly nursery was also received. Evaluation for yield, adaptation and disease resistance within the CIAT accessions and VEF 86 resulted in the selection of 206 varieties which were among the entries in disease nurseries. From these selections, eight varieties are in seed increase for a preliminary yield trial in the first season of 1989. The following varieties are to be advanced without further improvement for the purpose indicated :

No.	**Variety name**	**Origin**	**Purpose**
G 2472	Guerrero 29-C	Mexico	Barter trade
G 2698	S-234 = VNZ-23	Venezuela	Barter trade
G 787	Norvell No. 2598	Guatemala	Home market
G 2056	Gentry 21526	Nicaragua	Home market
G 2689	I-841 = VNZ-2	Venezuela	Home market

Variety HARLAN No. 307 FRENCH BEAN was also selected for its high yield and disease resistance but will be advanced after selection for seed colour uniformity.

CIAT varieties which had performed well in trials prior to 1985 were re-introduced and after preliminary yield trials they were advanced to multilocational trials commencing in the second season 1988. These varieties included PVA 2303, ZAA 84098, RIZ 43, ZAA 84034, MCD 251, ZAA 84032, PVAD 791, DOR 340 and 997-CH-73. One selection from multiple crosses which had stabilized in growth habit and seed colour is among the entries in this trial.

VEF 87 was received in the second season 1987 and 59 varieties have been selected at Kawanda for advancement. The selections were based on adaptation and pod load. Some of the selections will need to be improved for resistance to common bacterial blight and angular leaf spot. This screening trial will be repeated at Kachwekano.

Introductions from Rwanda have been evaluated for disease reaction and pod load in the cool highlands of Kachwekano and selections have been made for use in on-farm trials in Kabale District bordering Rwanda.

The IBYAN (coccineus) is still under review at Kachwekano. Varieties selected will be distributed to farmers in the area and evaluated on-farm.

Variation in nodulation of beans on farmers' fields and research stations were surveyed and nodules were collected and forwarded to CIAT headquarters for *Rhizobium* isolation and tests of effectiveness.

ON-FARM TRIALS

These have proved useful in obtaining information on the performance of varieties that are to be released as well as providing guidelines on characteristics of preferred varieties. On-farm variety trials have been conducted in the districts of Rakai, Mpigi, Kabale and Luwero using varieties G 13671, T 3, BAT 1220, Carioca, K 20, Namunye Red, Nkulyembaluke, Mutike and White Haricot. Information acquired through these trials has been taken into account while selecting among introductions.

VARIETAL RELEASE PROCEDURES

A 2 kg sample of seed of the variety to be proposed for release should be submitted to the Seed Project for independent observations of distinctness, uniformity and stability (DUS test).

The Varietal Release Committee then considers data from the concerned breeder to support release, including: origin; breeding procedure; descriptive information for identification purposes; performance in comparison with standard varieties at several locations for at least three consecutive seasons; area of adaptation; proposed end product; amount of seed available for distribution; recommended method of seed increase and maintenance; and proposed method of breeder's seed distribution. Approval for release is by vote.

SEED MULTIPLICATION AND DISTRIBUTION

In the case of beans, the breeder supplies the Seed Project with 15 kg of breeder's seed to multiply through an agreed number of generations of prefoundation seed. The seed then passes through the conventional Foundation, Certified and Registered seed stages. All stages are handled by the Seed Project, sometimes through contract growers. Seed quality is maintained by regular inspection by staff of the Quality Control Unit of the Seed Project.

Seed marketing and distribution are handled by the Co-operative Movement with the Central Co-operative Union (UCCU), acting as sales agent. In addition, seed is distributed to District Agricultural Offices, so as to move seeds nearer to the small farmer. The Seed Project offices at ministry headquarters and at Kawanda also participate in the sale of seed.

FARMERS' AND CONSUMERS' REACTIONS

Though variety K 20 was well received by farmers and appreciated for its yield and tolerance of different production constraints e.g. diseases and low soil fertility, farmers and consumers continue to favour certain land races. Problems with K 20 include hard testa and long cooking time, which are not found in the more tasty land races like Kanyebwa, Kampulike Purple, and Nkulyembaluke. The landraces are particularly susceptible to rust, angular leaf spot and common bacterial blight besides being inherently poor yielding. In search of a quick release of a variety that is very similar to the landraces, 124 introductions have been received from CIAT in the Red Kidney and Sugar Bean Nurseries. Selections have been made based on disease reaction, pod load, habit and yield. All varieties that show black root are eliminated. As seed is multiplied and tested through the breeding sequence some of these varieties will be passed on to farmers in on-farm trials.

REGIONAL PROJECTS

Two crossing blocks were established at Kawanda to incorporate ascochyta and common bacterial blight resistance into favoured but susceptible varieties. This work forms part of the research projects for which Uganda is responsible at a regional level. Presently the parental varieties consist of local susceptible varieties and land races from Uganda, with selections from the International Ascochyta and Common Bacterial Blight Nurseries, serving as donor parents.

Hybridization work started in second season of 1988 and F_1 seed will be multiplied in first season of 1989, followed by inoculation of F_2 plants with specific isolates. Selections will then be advanced using the pedigree and single seed or single pod descent methods. Through monitoring tours and collaborative work with the pathologists and breeders in the Great Lakes and SADCC Regions, more varieties from other regions will be incorporated in the ascochyta and common bacterial blight studies. Regional disease nurseries will be set up.

Current breeding activities are listed in Table 1.

CONCLUSIONS

Many varieties have been selected for advancement from the various introductions made so far. It is hoped that with continuous evaluation through the breeding sequence more varieties will be officially released in the future beginning in 1989. Black root has been prominent, particularly in CIAT accessions, and the varieties which are susceptible will either be referred to CIAT for incorporation of resistance or discarded. The collaborative work with CIAT has made it possible to advance faster in identification of superior varieties than would otherwise be the case.

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Table 1. Current activities

Location	Experiment
Kawanda	Angular Leaf Spot Nursery Rust Nursery Study of methods of spreading CBB East Africa Regional CBB Nursery VEF 87 screening Crossing blocks for ascochyta and common bacterial blight Screening of introductions from Rwanda Burundi and Kenya AFBYAN 88 Variety Trial (VTC multilocation) - 3rd stage Variety Trial (VTC multilocation) - 1st stage Nitrogen fixation trial - study of nodulation of five varieties under inoculation and different fertilizer levels Characterization of varieties for release
Bukalasa	Variety Trials VTC - 1st and 3rd stage Selections from Red Kidney and Sugar Bean nurseries Evaluation of selections from CIAT accessions and VEF 86 Crossing block for CBB Common Bacterial Blight Nursery Preliminary Yield Trial K 20 maintenance breeding plot Seed multiplication of AFBYAN 88
Kachwekano	IBYAN (coccineus) CIAT accessions screening VEF 86 screening Seed multiplication of selected climbing and bush types for on-farm trials Variety trials VTC-1st and 3rd stage
Mubuku Irrigation Scheme	Variety Trials VTC -1st and 3rd stage
Rubaare	Variety Trials VTC -1st and 3rd stage
Kamenyamigo	Variety Trials VTC -1st and 3rd stage
Bulindi	Variety Trials VTC -3rd stage only
Nakabango	Variety Trials VTC -3rd stage only

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MAURITIUS

Hassambhye Rojoa

ABSTRACT

In Mauritius, beans have been traditionally consumed as green pods. In a White Paper published in 1983, the increase of dry bean production was assigned priority. The cultivar, Long Tom, introduced from the Netherlands in the sixties, is suitable for both green pod and dry seed use but is susceptible to the major diseases. Materials introduced from CIAT have combined good yields of dry seed with disease resistance, but their seed and pod characteristics have proved unacceptable. A further set of materials is now being evaluated and crosses with Long Tom have been initiated.

INTRODUCTION

Mauritius, a small island of about 1856 km^2 is situated off the east coast of Africa, around 20^o latitude and $57^o48'$ longitude. The island is of volcanic origin, with early and late lava flows forming soils of volcanic series. On the upper plateau, about 580 masl, there are soil catenas with inceptisols on the upper slopes and vertisols in the valley bottoms. Orisols are formed only on the north western side, which is a dry zone as illustrated in the map (Figure 1).

Three major climatic zones are distinguished on the basis of annual rainfall - superhumid (over 2400 mm), humid (1600-2400 mm) and dry (0-1600 mm). Temperatures vary between 22 and 28^oC in summer (October to April) and 16 and 22^oC in winter. During winter months, occasional rains support crop growth and soil reserves are replenished by torrential rains in November. Cyclones or depressions bring rain during January and February.

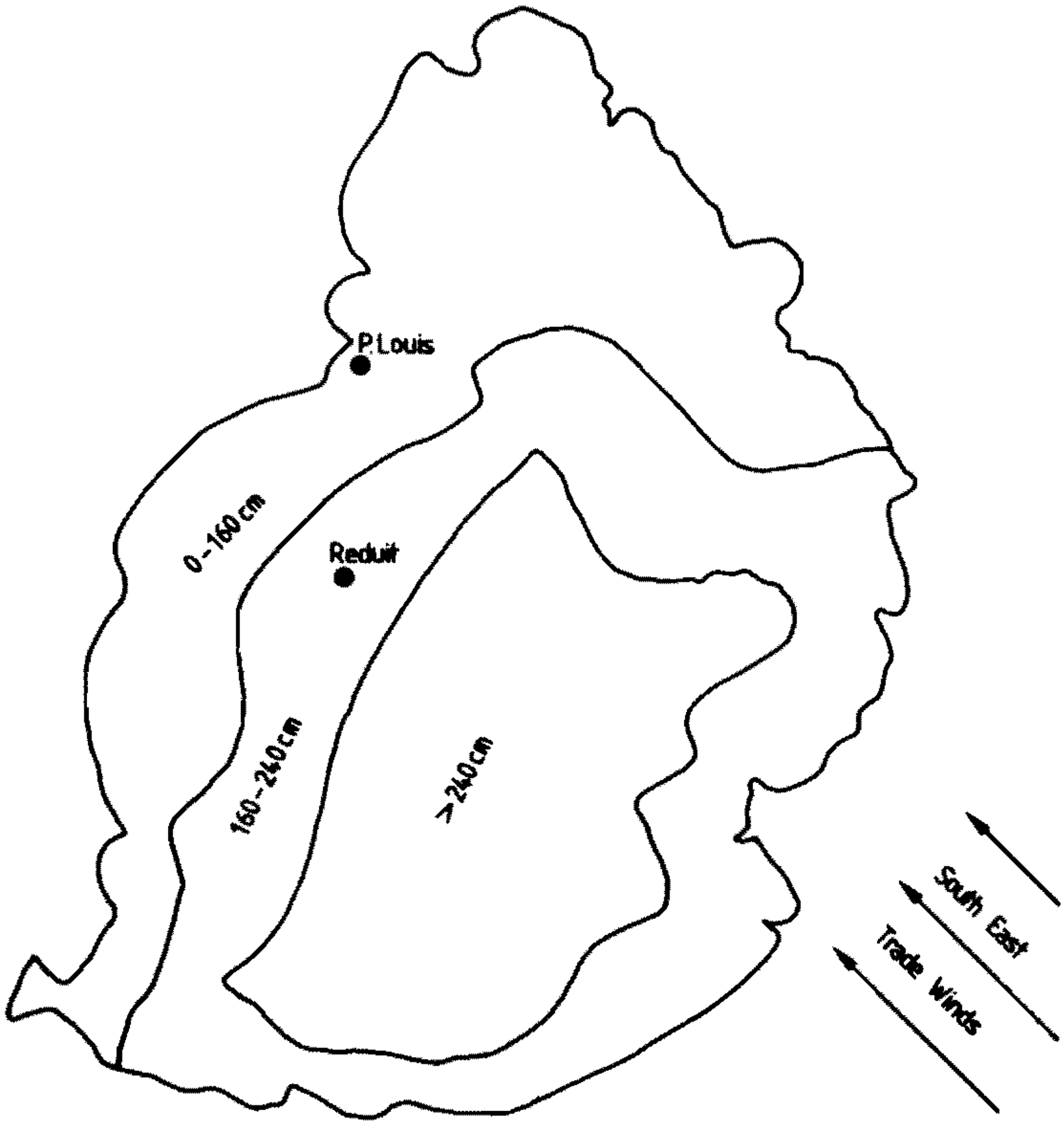
Beans (*Phaseolus vulgaris* L.) are an old European introduction, mainly grown in kitchen gardens for green beans. Excess pod production is either sold on the local market or allowed to attain physiological maturity (haricot pales) for use in soups or to supplement meat or meat products.

A White Paper in 1983 assigned priority to the improvement of bean production and the cultivation of beans as dry pulses became a commercial enterprise under the supervision of the Agricultural Marketing Board. Research was conducted by the Division of Agronomy within the Ministry of Agriculture.

EXISTING CULTIVARS

The cultivars, Noorinbee, Contender and Teebus are presently recommended for snap bean production. Long Tom, initially regarded as a dual purpose type for the production of both snap

Figure 1. Mauritius with annual rainfall and wind directions



and dry beans, is now the established dry pulse cultivar.

Obtained from Holland in the sixties, Long Tom is determinate, with long pods (13-15 cms) containing 5-6 red kidney seeds weighing 48-52 g/100. Under favourable conditions, Long Tom produces up to 2.2 tonnes of dry seeds/ha. It is susceptible to halo blight (*Pseudomonas phaseolicola*), common blight (*Xanthomonas phaseoli*) and rust (*Uromyces phaseoli*). Recently, Long Tom has also shown symptoms of fusarium wilt (*Fusarium solani*) and rhizoctonia (*Rhizoctonia solani*). Since dry seed yields are reduced dramatically by diseases, the replacement of Long Tom is imperative for the survival of bean cultivation.

BEAN CROPPING SYSTEMS

Beans are sown in both winter and summer. The winter season (crop cycle between 95 and 105 days) extends from the end of March to mid August and summer (85 to 92 days), from mid August to November.

They are sown in pure stand or in association with sugar cane. In the latter system, sugar cane is planted in April (Grande saison) and beans are sown between the rows of ratooned cane following harvest, from July to December. Beans thereby make use of the residual moisture from sugar cane irrigation, supplement income and make optimum use of labour (opportunity cost).

RESEARCH

The Division of Agronomy has identified BAT 1296 and BAT 1297 among IBYANs and other breeding materials introduced from CIAT from 1978 onwards. In trials, for example in 1981 (Table 1), they have yielded between 2.5 and 2.8 tonnes of dry seeds per hectare and have produced satisfactory yields even during adverse climatic conditions when local cultivars have failed. The two lines were released in 1985 for commercial production but the Marketing Board and consumers have been reluctant to accept them because their seeds are smaller (38 g/100) and rounder than those of existing cultivars and their pods are too short (11 cm) for use as snap beans.

Meanwhile, in addition to agronomic experiments aimed at developing technology to decrease production costs, the screening of new lines has remained a priority. Two red kidneys and two brilliant white navy beans have been identified among 137 lines introduced from CIAT in 1984 and are now at pre-release stage. To date, yield data from both experimental and large scale tests are encouraging - for example, from experiments carried out at the Central Experiment Station, at Reduit in the humid zone, and at Rodrigues (Table 2).

In 1987, 46 new accessions were obtained from CIAT and are being evaluated.

Table 1. Seed yields (t/ha) and other agronomic characteristics of bean cultivars in trials in Mauritius.

Cultivars	Seed* yields	Days to flowering	Plant height (cm)	Pods/ plant
BAT 1230	3.02a	41	39.5±0.8	11.9±0.8
BAT 1297	2.98a	39	41.0±2.5	14.4±0.9
BAT 1296	2.57b	38	38.0±2.7	11.5±0.3
Linea 22	1.99c	34	38.0±1.6	6.9±0.9
Linea 23	1.79cd	36	28.0±1.7	5.7±0.8
Linea 24	1.63d	34	29.0±1.8	7.4±1.2
Canellino (control)	1.09e	29	50.3±2.0	6.6±1.8

Table 2. Seed yields (t/ha) of entries in trials at Reduit and Rodrigues.

	Central Experiment Station, Reduit		Rodrigues
Entry number	April sown	August sown	May sown
4	1.34dc	0.70de	0.76cd
5	1.55c	0.50de	0.84c
7	1.75c	0.70de	0.65d
27	3.00a	1.10c	1.26b
30	2.10b	1.27c	1.02b
34	1.00e	1.23c	0.90e
87	1.40de	1.80b	1.92a
89	1.00e	2.10a	1.17b
95	0.65f	0.93d	-
Long Tom	1.80e	-	-
Local red	-	1.04d	0.55d
Rodrigues Navy Bean	0.88f	-	0.80c

* Means followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test

The testing and selection scheme is as follows:

CIAT INTRODUCTIONS	OTHER SOURCES

PRE-SCREENING	
↓	
SCREENING	disease resistance
↓	
PRELIMINARY TRIAL	disease resistance, yield
↓	
CONFIRMATION TRIALS	yield
↓	
ON-FARM TRIALS	
↓	
RELEASE	
↓	
MULTI DISCIPLINARY TRIALS	

BREEDING

Following discussions with Professor Marechal (*Phaseolus and Vigna* taxonomist) and Dr. Baudouin of the Universite Agronomique de Gembloux in Belgium, thirty lines have been obtained from crosses of Long Tom with introductions from CIAT and are being studied.

SESSION V - EAST AFRICA COUNTRY REPORTS - DISCUSSION

Sperling: Why are beans increasing in importance in Ethiopia?

Abebe: Partly because of drought, since beans are shorter duration and better adapted to the Ethiopian lowlands than are other pulses. Partly also because of export potential.

Dessert: I liked Male-Kayiwa's selection scheme, particularly the disease nurseries at several sites. Would you please comment on the difficulties that you may encounter. Do you get good pressure?

Male-Kayiwa: Pressure is variable, with season.

Musaana: We supplement natural infection with artificial inoculation.

Nchimbi: Re storability of cooked beans, are there genetic differences and might there be effects of food preparations ?

Male-Kayiwa: Casual observations suggest there may be such differences.

Musaana: Local needs are for a cooked bean preparation to last all day.

Tohme: A 176 cooks in 15 minutes according to Abebe. How is the cooking done?

Abebe: In the lab using bar drop cooker.

Tohme: Under domestic conditions, how long would A 176 take to cook ?

Abebe: A good question. This needs investigation.

Kirkby: No quantitative data yet available from Ethiopia.

Dessert: In Rwanda, cooking times ranged between 1-3 hrs.

Kirkby: From the Rwanda work, beans were shown to be the slowest cooking component of the diet.

Mushi: Both the Uganda and Ethiopia presentations indicated that the percentage of successful crosses in the field was very low. Would a CIAT breeder comment?

Davis: Crossing success improves with practice, as found in Rwanda. In a glasshouse you should obtain 80-90%. In the field, make crosses very early and lay out field to minimise disease and insect damage.

Baert: What specific characteristics have you observed in A 140 in Ethiopia? What is farmer acceptability and its future in Ethiopia?

Abebe: Seed colour is very different from local cultivars. We dont yet know its acceptability but A 140 is well adapted to high rainfall areas.

Baert: It does well in dry areas in northern Burundi and poorly in humid highlands.

Musaana: How do new cultivars in Ethiopia compete with weeds, which I understand to be a major problem because weeding is rarely practised?

Abebe: We are looking for types that compete with weeds. But in some areas, weeding is practised.

Kirkby: There is concern that the new cv. Ex Rico 23, which is less competitive than Mexico 142, can compete adequately with weeds. Farmer practices may need to change.

Camacho: Are farmers producing their own seed or is there a seed production scheme in Ethiopia?

Abebe: It depends on the type. There is a multiplication scheme for export types, but not yet for food beans. We need to strengthen seed increase methods.

Allen: Salih mentioned curly top in beans in the Sudan, where it seems to be whitefly transmitted. Is this critically identified as the gemini virus known as curly top ?

Salih: The symptoms are a yellowing and dwarfing and apparently whitefly transmitted.

Silbernagel: We suspect curly top was introduced into the USA from the Mediterranean, so it is possible that it is the same virus. This is reinforced by the fact that curly top resistant cultivars stand up in the Middle East.

Abebe: From your (Salih's) experience in the Sudan, can you recommend varieties with leaf tolerance? Beans in northern Ethiopia (e.g. Gambela) are grown under very hot conditions.

Salih: Beans are generally grown under highland conditions in the Sudan, where temperatures are not extreme.

Davis: Could Rojoa give identification of codes (e.g. "CIAT 27") of the accessions described ?

Rojoa: The numbers are long, so we use short codes for simplicity.

Kirkby: Understood. But for a scientific meeting like this, the full identities should be given.

Tohme: At CIAT, we assign G numbers to germplasm accessions. We have a one or three letter code and a short sequential number for CIAT advanced lines.

Venge: Rojoa describes long-podded types. Do you find correlations between leaf size and pod length?

Rojoa: Yes, generally so.

Mushi: Is the association between leaf size and pod length an observation or a genetic correlation?

Abebe: My experience is different. Large leaved types do not permit light penetration through the canopy and small leaves are associated with heavy yield.

Rojoa: Of course, yield and leaf size are correlated. What we are discussing is pod length.

Silbernagel: Are the Mauritius selections with long pods with or without string ?

Rojoa: We have both types.

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SESSION VI - MISCELLANEOUS REPORTS - GREAT LAKES

BURUNDI

Dr. Ir. T.G. BAERT

ABSTRACT

Burundi has one of the largest population densities in Africa. Bean consumption is one of the highest in the World. Beans are produced in three seasons: February to May (accounting for 51 % of total production); October to January (37 %); June to October, on marshes during the long, dry season (12 %). Bean research started in 1933 and gained its own program in 1984, when the regional program was initiated under the auspices of CIAT.

Varietal improvement has concentrated on the evaluation of local and introduced materials through Screening, Preliminary, Definitive and Comparative Trials. Improved cultivars are now emerging from the system. The PREELAC has helped in screening for biotic and abiotic stresses. Since 1979, eleven bush bean and four climbing bean varieties have been released. Selection in segregating populations received from CIAT commenced in 1985.

Contacts with the regional program have strengthened genetic improvement activities. Emphasis is now turning to a package including improvements in cultural practices. The regional trial system serves as a model for trials and nurseries in other regions.

INTRODUCTION

Burundi has an area of 27,834 km^2 (of which 1885 km^2 is lakes). The Republic belongs to the Economic Community of the Great Lakes Region (CEPGL). Ninety four per cent of the five million inhabitants live in rural areas. The growth rate of the population is 2.93% (Baris and Zaslavsky, 1986). Burundi and its neighbour Rwanda have the highest population density in Africa with some villages in the northern part of the republic having densities over 500 inhabitants/km^2.

Burundi is mountainous with altitudes ranging between 785 and 2665 masl. It has two dry seasons, a short one in January and a long dry season between June and October. The annual rainfall varies betwen 800 mm in the lowlands and 1800 mm in highland areas. Often the short dry season is not pronounced; sometimes a dry period can occur in March, just after planting. In the lowlands (Imbo and Moso), the beginning of the rains after the long dry season is irregular, delaying planting to even the end of November. The start of the long dry season can be several weeks too early (1984 and 1988), causing premature ripening and loss in yield.

Bean consumption in Burundi is considered one of the highest in the world (65 kg of dry beans/inhabitant/year) and a research program is fully justified since beans are the main source of protein. However, bean production has stagnated relative to tubers (Figure 1). This is partly due to the rapid decrease of soil fertility, especially in areas with high population density and also in upland areas with mostly acid soils and Al toxicity.

Bean production in the first rainy season (October-January) (generally designated the A season) is subject to many problems because of heavy rainfall during the growing and harvesting periods. The second season (B) (February to May) is the most important period for the bean crop, which is harvested at the start of the long dry season. A small area of beans is produced in marshes during that dry season (C). The Department of Agriculture estimates that 37 % of the total area of beans are grown in the first season, 51 % during the second season and 12 % during the dry season in marshes (Devos et al., 1983).

BEAN IMPROVEMENT

Introduction

Bean research in Burundi started in 1933 with the introduction of ten varieties from Guatemala. However, the national institute for agronomic research (INEAC and, since 1962 ISABU) concentrated its efforts mainly on industrial crops. Only in 1979 was a separate research program for beans, soya and groundnuts created, subdivided in 1984 into two different programs with their own staff, one for bean research, and another for research on soya and groundnuts. That same year, the CIAT regional program for the Great Lakes was initiated, with which ISABU fully collaborated from the beginning.

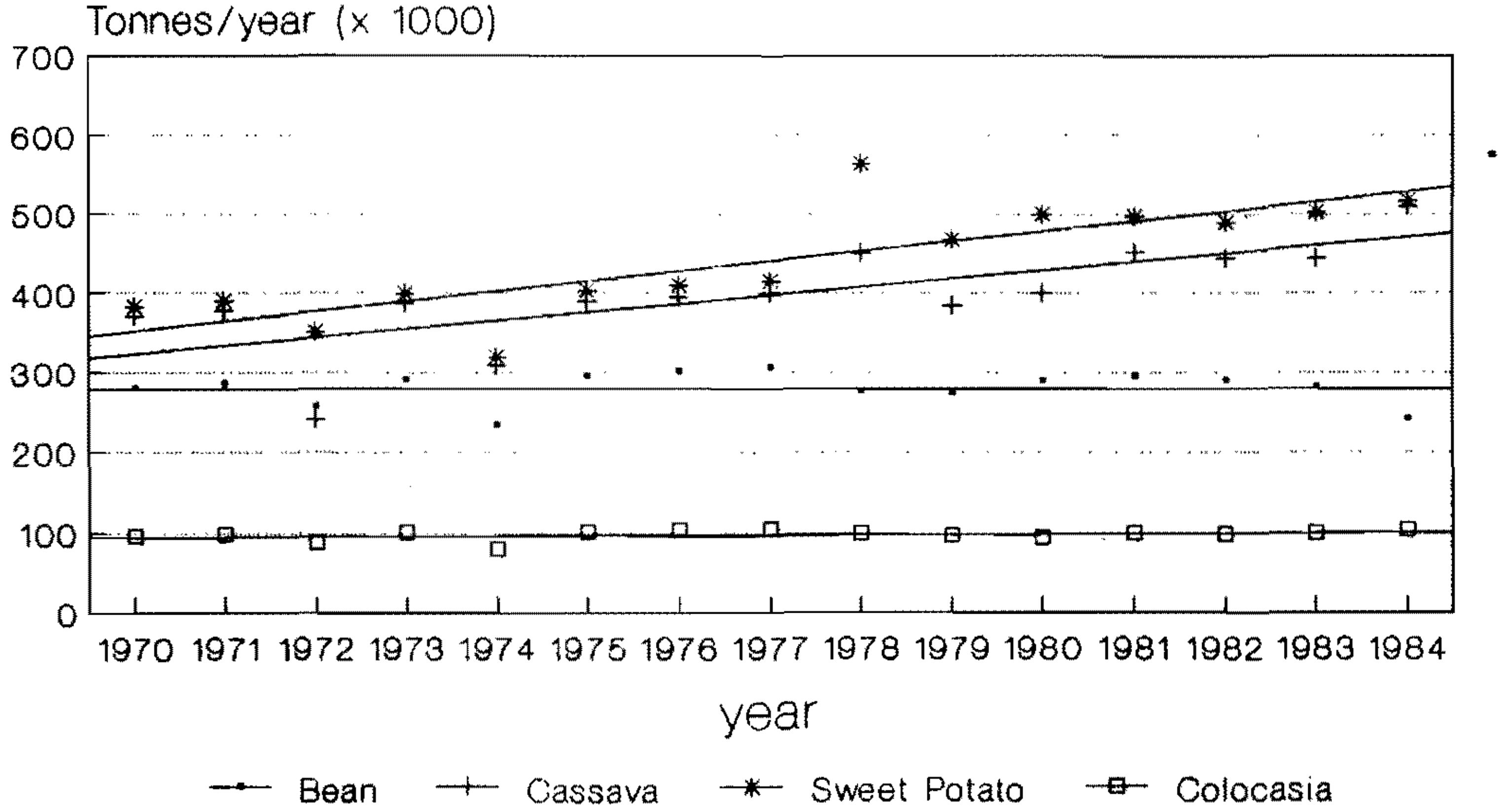
Bean research activities are now principally funded bythe Belgian Administration for Development Cooperation, Marsveldplein 5 in Brussels.

Genetic and varietal improvement

Genetic Improvement: In 1985-1986, ISABU started its own breeding program but, because of lack of personnel, this program is unable to produce its own crosses and is limited actually to selection in families received from CIAT-headquarters or from the regional breeder, based in Rwanda. The strategy at ISABU is to select individual plants in F_2, F_4 and F_6 generations and families in F_3, F_5 and F_7 generations. Special attention is given to halo blight resistance: selection is practised under halo blight stress in Gisozi (2100 masl), where there are now about sixty families in the F_6 generation, most of them from crosses with local parents. The crosses were made in Colombia and initially screened in Colombia, U.K. and Rwanda before the F_5 generation arrived in Burundi.

Figure 1.

FOOD CROP PRODUCTION
in BURUNDI
(trend)



Baris & Zaslavsky, PNUD, 1986
Le secteur vivrier au Burundi

Varietal selection: Since 1979, two cycles of varietal selection have been completed in bush type beans, resulting in the identification of eleven varieties for different ecological areas, and one cycle in climbing beans, resulting in the release of four varieties.

The scheme of varietal selection used at ISABU and its connection with the regional program is shown in Figure 2.

Screening Trials are sown for at least two seasons at four ecologically different sites (Imbo, 800 masl; Moso, 1270 masl; Murongwe, 1450 masl; and Gisozi, 2100 mals). Each trial is a single replicate with every tenth plot a check (the most recent improved variety for the region). Since 1988B, the fifth cycle for bush beans is comparing the performance of 220 varieties; the second cycle for climbing beans contains about 80 introductions.

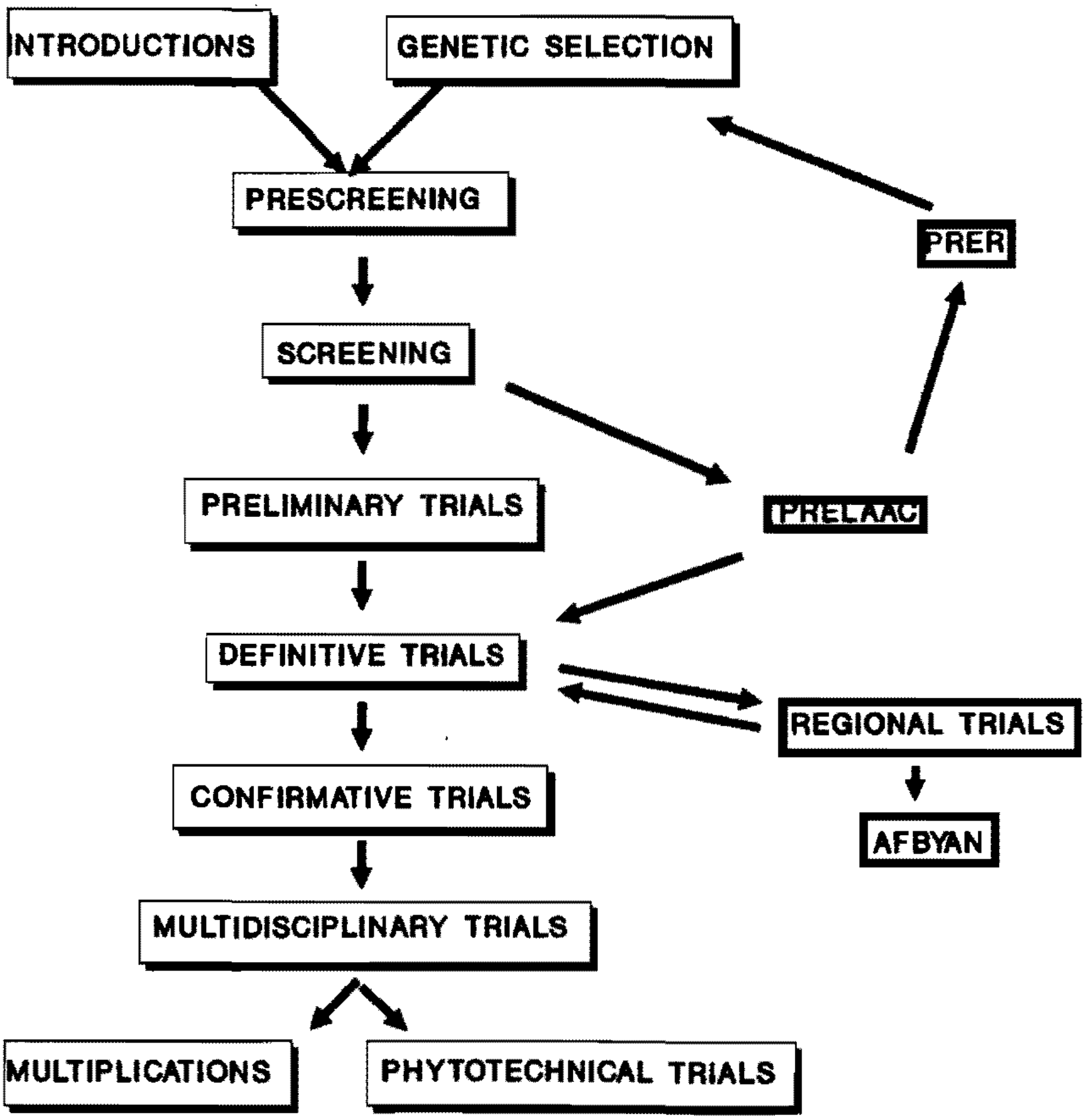
Preliminary trials (now in the fourth cycle for bush types with sixty varieties) are also multilocational and compare the best materials from the screening trials in a single trial. This kind of trial investigates both the performance of the pure variety and its competitive ability with a local mixture (since most beans are grown in varietal mixtures), as well as its performance in mixed cropping. This is achieved by conducting the trial: in pure stand (4 rows, taking into account only the two central rows); in competition (one row between rows of a local mixture); and in mixed cropping (2 rows between maize or cassava). Each trial is replicated four times and runs for at least two seasons. The same varieties are tested within the regional program for their resistance or tolerance to different biotic and abiotic stresses in the regional subprograms and in the PRELAAC (Pepinere Regionale pour l' Evaluation des Lignees Avancees en Afrique Centrale = Regional Evaluational Nursery for Advanced Lines in Central Africa). The results of the preliminary trials and the PRELAAC are used to select some ten entries for Definitive Trials.

Definitive Trials (the fourth cycle is to be started in the 1989A season) are local trials, comparing only the best varieties for particular regions. The test sites are the same as above, but with two more sites (Ngozi-Gisha, 1600 masl; and Gitega-Rutegama, 1700 masl). They also comprise the same three cropping systems as the Preliminary Trials (pure, competition with a local mixture, mixed cropping), again with four replicates over at least two seasons.

Confirmative trials (ISABU started its 3rd cycle in 1988B) are performed on-farm. Three to five new varieties per region are tested on-farm in comparison with the locally used mixture or variety. Each plot is 2 x 5 m, and the practices used are those of the farmer (plant density, use of organic or mineral fertilizer, weeding). In each region, five to ten farmers collaborate, each growing a single replicate. They grow the varieties for at least two seasons, using their own first harvest partially as seed for the second season. The most important

Figure 2.

BEAN SELECTION IN BURUNDI



ISABU-Bean program

criteria of selection in this final phase are yield and acceptability to the producers. They consider characters including productivity, seed color, seed size, cooking time (wood is scarce in Burundi) and taste. Researchers return to the farms one to three seasons later to observe what varieties are still grown, whether pure or mixed with other varieties, and how much. These observations provide most valuable information regarding the acceptability of a new variety.

The bean program is also involved in so-called, Multidisciplinary Trials, in which varieties chosen from Confirmative Trials, are tested on a larger number of farms and in collaboration with other research programs.

The varieties selected for diffusion are first multiplied through two generations by the research institute. The prebasic seed is grown in small plots with total protection (insecticides and fungicides), with a weekly rogueing of plants showing symptoms of BCMV or bacterial disease. The basic seed is grown in larger plots under total protection, and with at least three rogueings. Since 1988B all the fields have been inspected by the seed certification service. The first class prebasic-seed is used to restart a prebasic multiplication. Basic seed is grown from first and second class prebasic seed. This basic seed is sold to projects, which have to multiply it for distribution in rural areas.

ISABU is starting with a small number of farmers in the northern part of the Imbo Valley to test the possibilities of producing clean seed of the newly proposed variety A 410 on pilot farms. This test is conducted in collaboration with local authorities, the project for rural development and with the local cooperative that will buy the seed at a higher price and will sell it again in small quantities to other farmers.

Results: Table 1 gives a summary of the varieties actually proposed for diffusion in Burundi. Karama, Calima, Dore de Kirundo and Urubonobono were proposed after the first cycle of selection. Figure 3 shows the yield of the four proposed climbing beans in terms of the mean yield of all varieties in a Definitive Trial. Table 2 gives the first results of on-farm trials of the third selection cycle.

The variety A 321 seems to have a very good potential in all the environments in which it was tested. The variety is very tolerant to anthracnose, a disease causing substantial losses at altitudes between 1600 and 2300 masl. The cream seed color is appreciated in many places but not in others. It has a Mexican parent in common with A 410, the variety already selected for the lowlands.

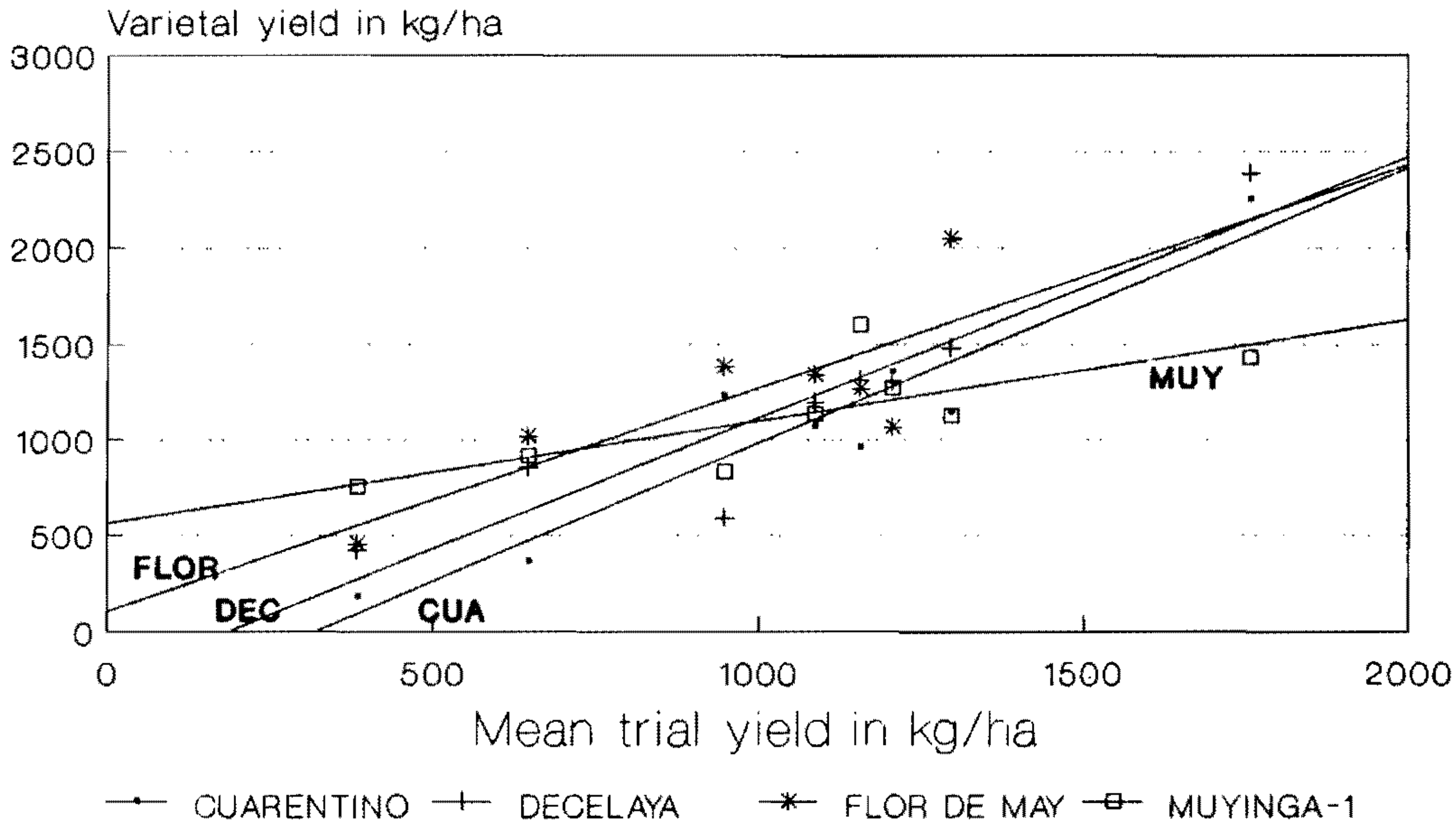
Table 1. Bush beans in diffusion in Burundi

Variety	Zone (masl)	Advantages	Disadvantages	Origin
Karama	800-1000 Imbo	Short duration, yield, seed size, cooking time	CBB, ALS	Rwanda
Aroana	800-1000 Imbo	Yield	Long duration, CBB	CIAT
A 410	800-1300 Imbo-Moso	Yield, cooking time, taste	Not stabilised genetically	CIAT
PVA 779	1200-1300 Moso	Yield, seed color and size	ALS, FLS	CIAT
Calima	800-1600	Yield on good soil, seed color and size	ALS, FLS	Col-ombia
PVA 1186	1600-1800 Buyenzi	Yield	Long duration	CIAT
HM 21-7	1600-1800 Buyenzi	Yield, seed color	ALS, FLS, HB	Cross, Moso
Urubobo-bono	1300-2100	Yield on good and bad soil, halo blight resistance	Seed color, taste and cooking time	Local
H 75	1500-2300	Yield and seed color	BCMV, HB, anthracnose	Local
Dore de Kirundo	1500-2300	Yield, taste, seed color	HB, ALS	Local
HM 5-1	1800-2300	Yield, seed color, taste	HB, ALS	Cross, Moso

For climbing beans, a problem of acceptability is still to be overcome. Most farmers do not want to grow them because of the extra labour required. Decelaya and Flor de Mayo are Mexican varieties, but Decelaya is very susceptible to BCMV, and ISABU may have to withdraw it. Two other varieties are proposed: Cuarentino and Muyinga-1, a local variety. The varieties are released more for adaptation to soil fertility than to altitude (Figure 3). Muyinga-1 is a good yielder in poor conditions: Flor de Mayo, Decelaya and Cuarentino give the best results on better soils, where Muyinga is less good.

Figure 3.

ENVIRONMENTAL INDEX
CLIMBING BEANS



ISABU-BEAN PROGRAM
First selection cycle

Table 2. Seed yields (kg/ha) of entries in on-farm trials for the third cycle of varietal selection of bush beans in Burundi (1988B).

Region masl	Imbo-N 800	Karuzi 1500	Buyenzi 1800	Kisozi 2100
A 321	1063	827	1650	1928
A 358	533			
Rabia el Gato	714			
Kiburu Moshi	791			
Muyinga-1		560	1156	
Chichicaste		789	1336	
A 442				1002
H 842				1496
Checks				
A 410	920			
H 75		660	1178	
Dore			1220	1660
Local	674	642	376	1246
Mean	782	696	1153	1456
LSD 5%	215***	n.s.	n.s.	426**
CV %	21	28	51	22

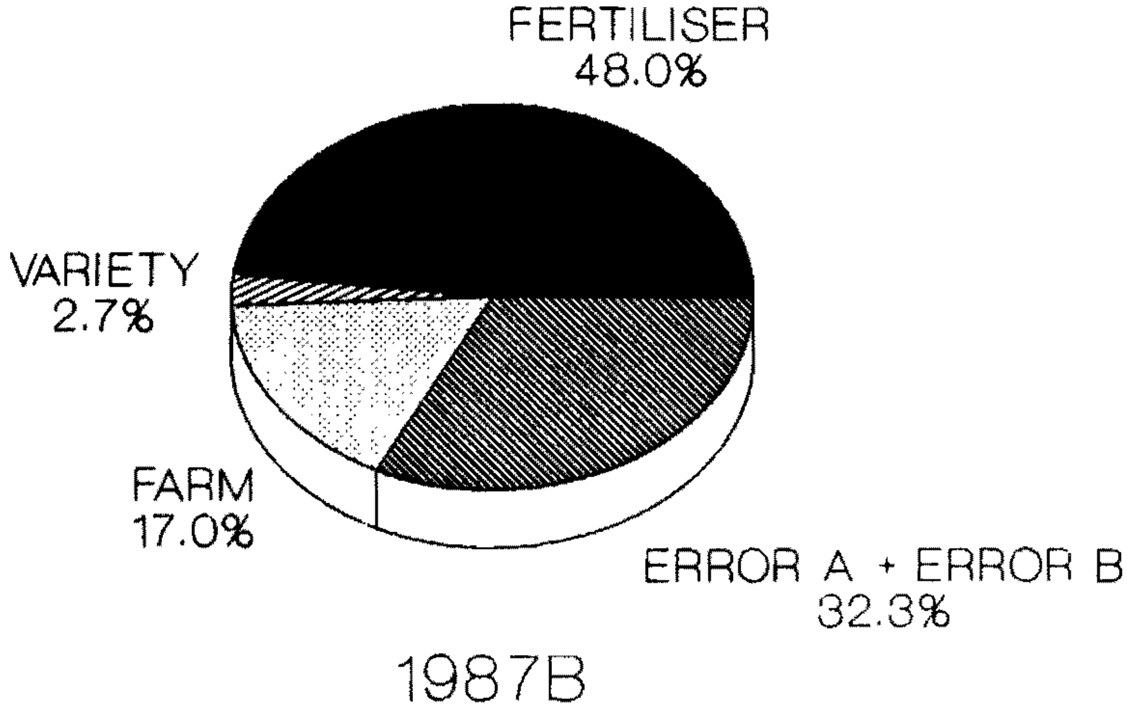
Conclusions

Some progress has been made in bean improvement in Burundi in recent years. Progress is partially due to a better knowledge of the work done in Rwanda and Zaire as well as at CIAT in Colombia. The regional program for the Great Lakes made this possible. Regional collaboration provides national programs with opportunities to obtain equipment and share scientific knowledge, in these ways, increasing efficiency.

Nonetheless, trials of ISABU reveal that progress in yield can be made even with local varieties, using better cultural practices. Yield advances from improved cultural practices can be more spectacular than from genetic improvement alone. In a trial in the Buyenzi area in 1987B, with or without fertiliser (DAP, 100 kg/ha), the variety effect accounts for only 2.7% of the total variance while the effect of fertiliser accounts for 48% (Figure 4). This led to a new direction taken by the research program for beans. Genetic improvement, although not to be neglected, should be combined with better agronomic practices in order to ensure that a variety with good potential is grown in an environment wherein it can express its potential. The recently started five year plan for bean research at ISABU is now putting more emphasis on increasing production by means of small inputs in soil fertility, seed coating with pesticides or lime, crop protection with minimal application of fungicides, and so on.

Figure 4.

COMPONENTS OF VARIATION
BUYENZI TRIALS



5 varieties, 17 farms
split-plot without or with 100 kg DAP/ha
no significant interactions

Recommendations

The regional program for the Great Lakes region has substantial experience in collaboration with national programs. The regional nurseries (PRELAAC and PRER) could easily be adapted to other similar programs and the varieties of the PRER could be combined with resistant varieties from other regional programs in Africa to form an African gene bank for resistance.

The AFBYAN could be composed of an equal number of varieties from each country. Perhaps two or three different AFBYANs could be organised on the basis of environmental adaptation.

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PROGRESS REPORT ON GERMPLASM ACTIVITIES OF IRAZ

Ir. M. Nahimana

ABSTRACT

Collections of bean germplasm already acquired have established the occurrence of wide variability in beans in the Great Lakes. Collection should be intensified with a view to assembling all plant materials threatened by genetic erosion. Characterization and evaluation should be effectively conducted for a better appreciation of the value of these resources. The regional network for these operations requires strengthening. Collaboration among IRAZ, national institutions, CIAT and other similar organizations remains a viable means of achieving these objectives.

INTRODUCTION

The Economic Community ofthe Great Lake Countries, a sub-regional organization comprising Burundi, Rwanda and Zaire, was established on 20 September 1976. Over the years, various specialist units have been formed of which the Agriculture and Livestock Research Institute (IRAZ) was created on 9 December 1979.

The mandate of the Institute is to evaluate and implement community agricultural and livestock production projects. The objective of research conducted by IRAZ should be to meet the nutritional requirements of the populations of the sub-region.

In the collection and conservation of plant genetic resources, particular emphasis has been placed on beans, which are considered with good reason, a staple food of the community.

The crop has been grown in the Great Lakes Region for centuries. Earlier cultivars have long been subjected to natural and artificial selection, which has resulted in the development of the following important characteristics:

- adaptability and or/ plasticity to climatic conditions and traditional cropping systems;

- good organoleptic qualities; and

- resistance to some local diseases.

Introduced cultivars have thus adapted and become endemic in some villages.

A wide variety of forms has been obtained from these cultivars, some with exceptional qualities. This diversity has recently been discovered during collection and classification missions undertaken within the community.

The aim of the above activities (collection and classification) is to preserve this plant material from genetic erosion and to encourage its utilization in breeding programmes. It will also enrich existing collections in national research institutions.

COLLECTION

IRAZ has undertaken bean germplasm collection missions within the community, in collaboration with national research institutions.

Collection priorities were determined taking into account the threat of genetic erosion as well as the anticipated variability in the region.

In Burundi, the natural regions of Imbo, Mosso and Bugesera have been systematically collected and partial collections have been made in the Mumirwa, Mugamba, Kirimiro and Bweru regions (Figure 1).

In Rwanda, bean germplasm collection has been conducted by ISAR/OPROVIA/USAID. A few samples adapted for intercropping with banana trees were collected in the Bugesera and Mayaga Regions (Figure 2).

Collection in Zaire began in northern Kivu (Rutshuru, Lubero, Masisi, Goma), where variability appears greatest, and continued in Lower-Zaire and Bandundu in 1987 (Figure 3).

During these collection missions a wide variety of bean germplasm was collected (Table 1).

GENETIC VARIABILITY IN THE COLLECTION

The wide genetic variability of beans has been recorded by several authors (Kayuku, 1961; Devos *et al*, 1983) and has been confirmed by the preliminary collections and classifications already undertaken by IRAZ.

Significant variability was noted especially in mixtures. Mixtures are frequently found composed of at least ten traditional cultivars as well as recently introduced improved material (for example, Calima, Dore de Kirundo, Urubonobono, Karama 1/2). Furthermore, investigations have revealed inter- and intra-regional variations in samples of the IRAZ gene bank.

Characters such as growth habits and grain colour (Coutil, 1982) were taken into account for a better evaluation of this variability.

CHARACTERIZATION

Preliminary data collected during a data collection mission are fragmentary and have to be complemented by systematic and

Figure 1. Burundi—natural regions and number of collections

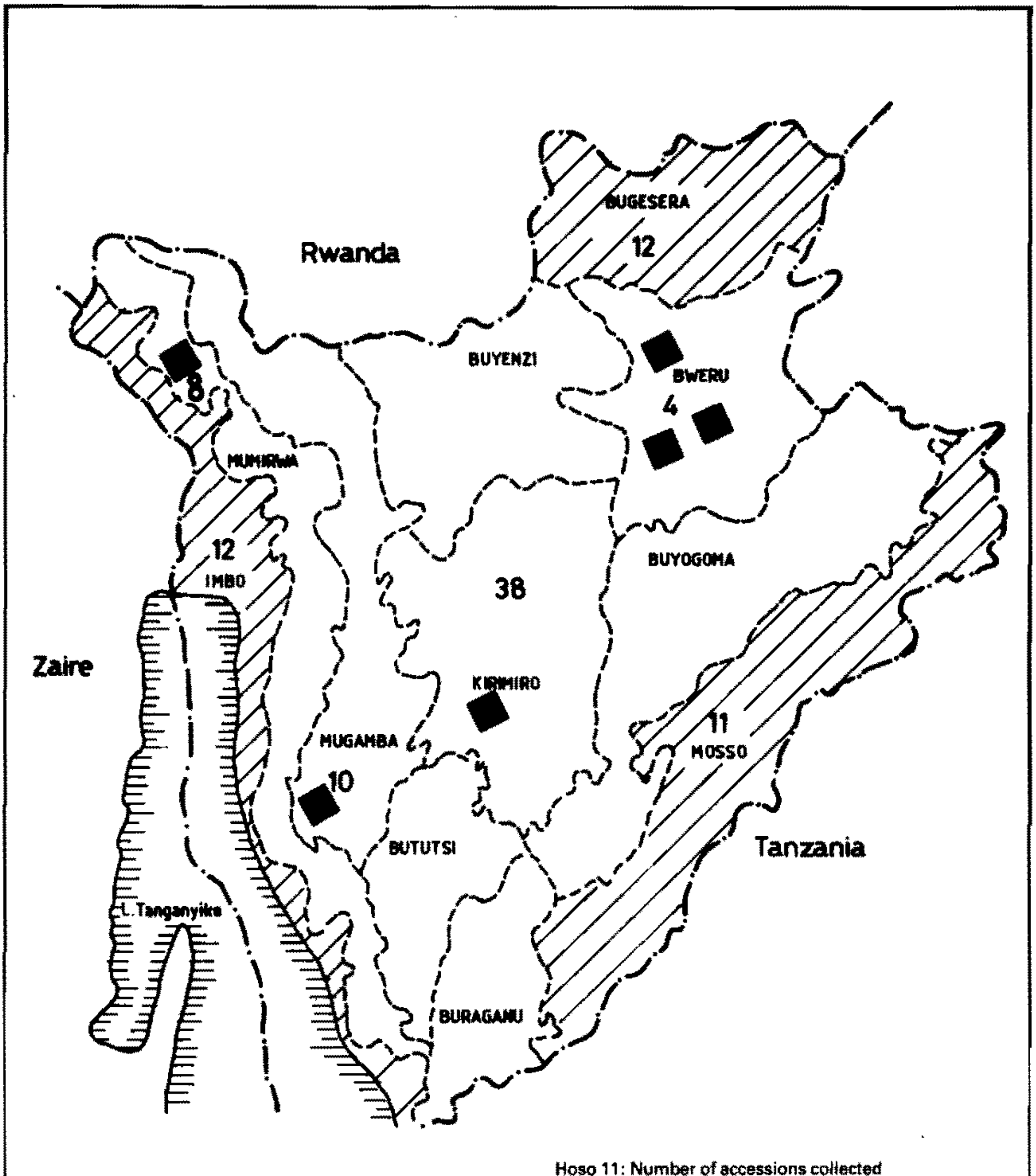


Figure 2. Rwanda agricultural regions and number of collections

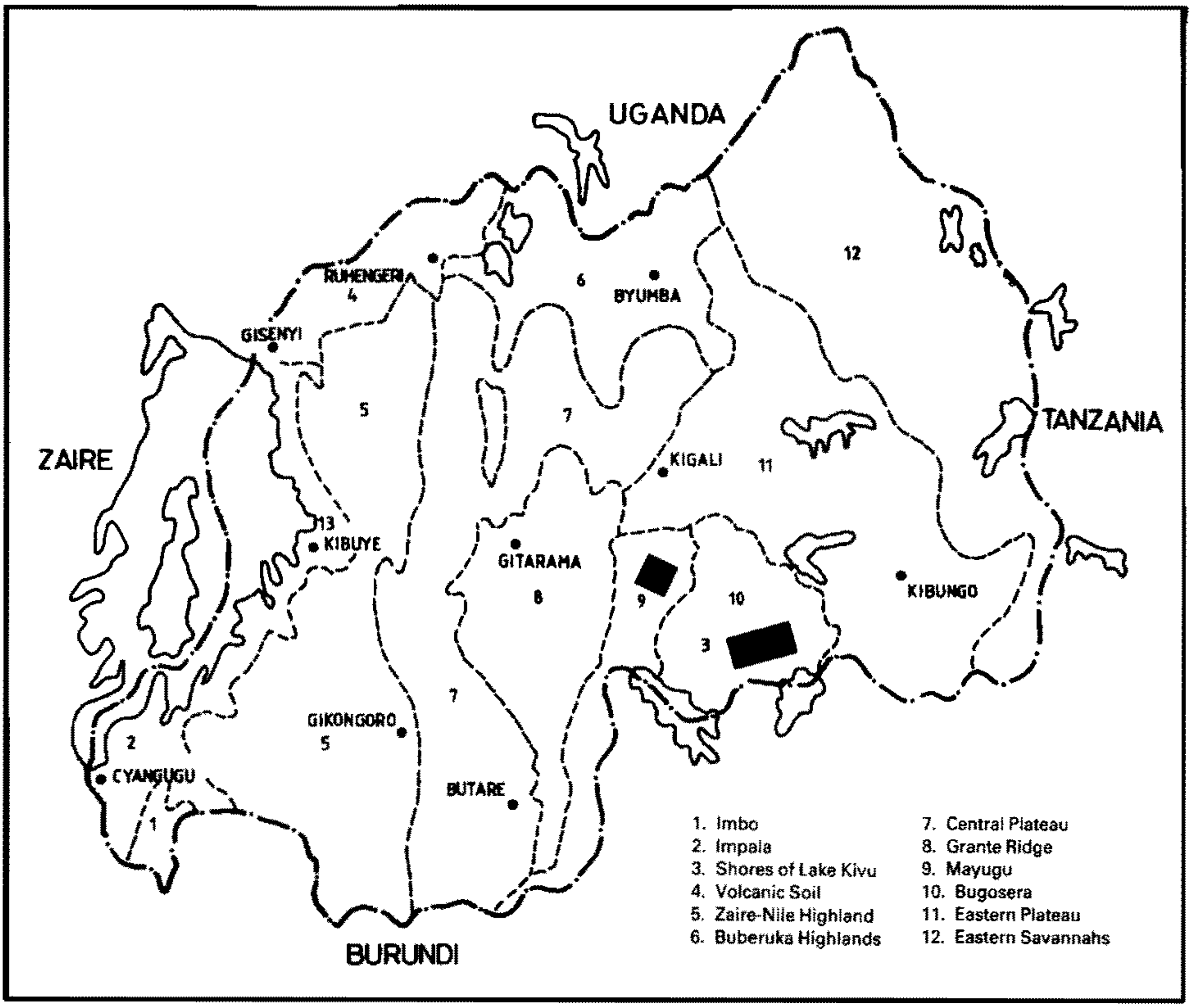
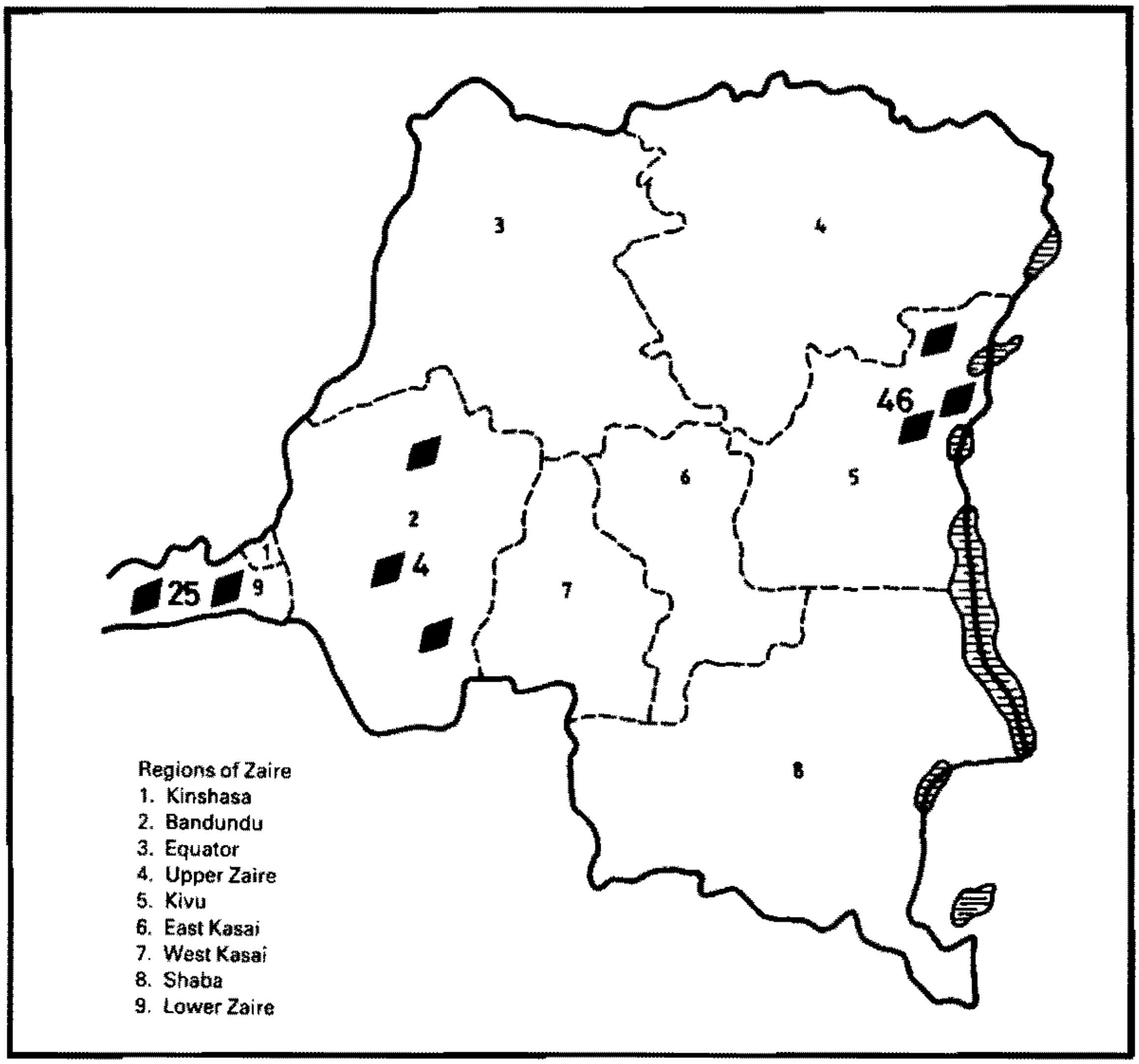


Figure 3. Zaire regions and number of collections



accurate surveys. Characterization enables the identification of duplicates and the preparation of a descriptive card of each sample. Vegetative and reproductive characteristics also assist in characterization.

Table 1. Number of accessions collected.

Country	Regions	Number of accessions
Burundi	Kirimiro	38
	Bugesera	12
	Imbo	12
	Mosso	11
	Mugamba	10
	Mumirwa	8
	Total	95
Rwanda	Bugesera	3
	Mayaga	1
	Total	4
Zaire	North-Kivu	46
	Lower-Zaire	25
	Bandundu	4
	Total	75
Grand total		174

Furthermore, as mixtures have been traditionally cultivated in the Great Lakes Region, they can only be evaluated after identification of their various components. Characterization (identification) is also a tool in this operation.

The eleven accessions collected in Kirimiro were sorted according to the colour and shape of the grains to obtain 249 sub-accessions. These are currently undergoing preliminary characterization involving 27 characters, some of them of immediate interest to the breeder.

They include:

- growth habit;
- yield components;
- form and colour of pods;
- grain characters; and,
- length of vegetative period.

As characterization is accompanied by multiplication, an adequate amount of seeds should be obtained for more advanced evaluation.

CONSERVATION OF BEAN GERMPLASM

The samples collected did not always have the characteristics required for use in breeding. On the other hand, their in-field conservation requires planting twice a year in order to maintain seed germinability at an acceptable level. This entails financial expense. The institute therefore adopted short and long term grain conservation strategies (NLandu ne Nsaku, 1988).

The grains are currently kept in domestic freezers. The seeds are dried (5-7 % humidity) and packeted in plastic-coated aluminum packets made air-tight by sealing with a sealing device.

This packaging system appears reliable and economical for several reasons:

- a significant decrease in storage space required;
- packet size can be varied to suit the amount of seeds;
- airtightness is ensured when sealing is done correctly;
- part of the contents of a package can be used and the package resealed;
- the cost is modest compared to that of purchasing vials or hermetically sealed boxes.

This method of conservation facilitates the maintenance of the viability and integrity of collected samples provided germination tests are conducted to determine the need for regeneration.

REGIONAL COLLABORATION

On its establishment, IRAZ was requested to establish close contacts with national institutions wit' a view to acting as a catalyst in the exchange of materials anu data.

Materials collected by IRAZ, in collaboration with national and international institutions should, in principle, be utilized in current or future breeding programmes.

This is however effective only when the true value of the material is known. To this end, evaluation and classification are necessary.

Considering the Mashitsi experimental site (Gitega) includes only some ecological systems of the Community, bean germplasm evaluations were conducted in other ecological systems with the collaboration of research stations of national institutions. These included Mosso and Kisozi stations (ISABU), Mulungu and Mvuazi (INERA) and Rubona and Karama (ISAR).

Evaluations of resistance to diseases were conducted in most of the stations mentioned above.

These multilocation evaluations were used by the IRAZ plant genetic resources programme to conserve proven material and compile a comprehensive catalogue. IRAZ accessions, accompanied by a descriptive card, will automatically be despatched to research workers in national institutions on request.

IRAZ also takes an interest in plant material, whether upgraded or not, in national research institutions. This should in principle be documented and conserved. It has been noted that germplasm accessions which do not meet the required standard are sometimes eliminated, even though they may contain genes which may eventually be of interest. A further role of IRAZ is to collect such material for conservation and utilization when needed.

The major preoccupation of IRAZ is to strengthen regional collaboration so that material collected is accessible, particularly, to breeders in the Community.

Finally, IRAZ is interested in exchanging information and/or plant material with bodies working on bean germplasm. Such exchanges have already been made with institutions such as CIAT, IBPGR and the Faculty of Agricultural Sciences of Gembloux.

FUTURE PROSPECTS

Future prospects are geared towards the following topics:

1. The continuing exploration of regions of Burundi, Rwanda and Zaire from which collections have not yet been obtained;

2. continuing characterization and evaluation of material already acquired;

3. follow-up of evaluation of germinability of seed of preserved germplasm using appropriate analytic methods;

4. logistical and structural strengthening of national centres invited to collaborate with the IRAZ regional centre;

5. closer collaboration with national and international institutions working on bean germplasm; and

6. improvement of documentation and publication systems for research materials on beans.

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ZAIRE

Ir. L. Lama

ABSTRACT

Beans are a major source of protein in Lower Zaire but yields are poor. The crop is produced during three periods, two (A and B) during the rains and one (C) in the dry season. Diseases (especially web blight) are important causes of yield loss. Medium to large white seeds are preferred though other colours are also grown. Locally collected germplasm and introduced materials are being evaluated, proceeding through preliminary, advanced and multilocation trials. In trials at M'Vuazi, entries from the African Bean Yield Adaptation Nursery (AFBYAN) and from a white seeded nursery have produced significantly better yields than local cultivars.

INTRODUCTION

The common bean is a major source of protein and income for the populations of Lower Zaire . The proximity of Kinshasha contributes to the increasing demand for this commodity. Production, however, remains low. Cultivated acreage should therefore be increased and appropriate farming techniques and improved cultivars introduced. These cultivars should possess good yield potential and resistance to the main diseases (web blight and common bacterial blight) and have seeds acceptable to both farmers and consumers in terms of characteristics such as palatability, seed type (medium to large and white, yellow, red or khaki colour) and germinability (Anon, 1988a).

The National Legumes Programme (PNL) based in M'Vuazi in Lower Zaire, is responsible for the development of improved cultivars and appropriate farming techniques. M'Vuazi is situated at latitude 5°27'S and longitude 14°54'E at an altitude of 505 masl. The soil is of average fertility with a pH of about 4. Mean annual temperature is 23.6°C and mean annual rainfall 1425 mm.

Beans are grown during three seasons each year:

Season A: September/October to December/January
Season B: February to May
Season C: May to August.

Seasons A and B are rain seasons and the crop is cultivated on ridged slopes to drain off excess moisture.

The crop is cultivated in depressions and former marshes during Season C, the dry season. This is the most important season and the bean crop draws on residual moisture.

PROBLEMS ENCOUNTERED

Poor yields

Average yields from cultivars grown by farmers are about 300 kg/ha for bush types and between 400 and 500 kg/ha for spreading types. Spreading cultivars are grown as an alternative to climbers because of difficulties involved in using stakes. With these yields, the poorer Zaire smallholder cannot produce sufficient beans for his own consumption let alone for sale. Low yields, are due to many factors, primarily diseases and low soil fertility.

Diseases

Fungal and bacterial diseases are important causes of yield loss. Web blight (*Thanatephorus cucumeris*) is prevalent during the rains, particularly from stage R7, causing wet rot and desiccation of leaves and concomitant pod rot. This disease can cause total crop loss.

Common bacterial blight (*Xanthomonas phaseoli*) often interacts with web blight. It is more prevalent during the dry season although the attack is delayed in most cases.

Colour and size of grains

These two factors are important to producers and consumers. In general, white, medium-sized to large, grains are preferred although red, yellow and khaki grains are also grown. It has been established that the white-grained types currently being distributed germinate very poorly after three months in store.

Economic constraints

The use of the high yielding beans produced by research frequently involves increased production costs. Appropriate technology will also have to be developed.

STRATEGIES

The following strategies have been adopted (Anon, 1988a):

Evaluation of existing germplasm and local collection

Studies of existing germplasm and cultivars obtained from farmers are being conducted to identify interesting types.

Introduction of materials from CIAT and regional programmes in Africa.

Advanced lines are being evaluated to identify high yielding, adapted materials.

Varietal trials

Selected materials will be evaluated in a series of preliminary, advanced and multilocational variety trials. Advanced yield trials are already in progress, though problems are being encountered, especially web blight.

Identification of high yielding varieties

Seed of high-yielding varieties that meet producers' and consumers' requirements will be distributed and others will be used in a hybridisation programme.

ACHIEVEMENTS

The following results were obtained from on-station trials:

African Bean Yield Adaptation Nursery (AFBYAN)

In an AFBYAN grown at M'Vuazi in 1987/88, yields varied between 550 and 663 kg/ha (Table 1). Black Dessie, G 2816, Carioca, Calima and T-3 produced significantly higher yields than the local Ntendezi and were resistant to web blight.

Table 1. Seed yields and web blight reactions of entries in the AFBYAN at M'Vuazi in 1987/88.

Entries	Seed yields (kg/ha)	Web blight scores
Black Dessie	663	4
G 2816	602	2
Carioca	601	4
Calima	551	2
T-3	550	4
Ntendezi (control)	338	5
LSD 0.05	378	2
C.V. %	32.09	24.1

Source: Anon, 1988b

White Bean Nursery

In 1988C, BLM 42, G 17496, BLM 32, BLM 53, PAN 169, PAC 8 and BLM 69 were superior, with yields of between 703 and 866 kg/ha (Table 2). The yield of the control PV013 was only 416 kg/ha. Common bacterial blight occurred at moderate levels, late in the season.

Red Bean NUrsery

Also in 1988C, RAB 4, AFR 252, RAB 336, APN 82 and RAB 391 yielded highest with between 807 and 1068 kg/ha (Table 3). The controls PV013 and PV014/2 produced 182 and 495kg/ha respectively. Reactions to bacterial blight were moderate.

Table 2. Seed yields and web blight reactions of white-seeded beans in CIAT nurseries at M'Vuazi in 1988C.

Entries	Seed yields (kg/ha)	Web blight scores
BLM 42	886	6
G 17496	860	4
BLM 32	807	3
BLM 53	781	6
PAN 169	755	4
PAC 18	730	5
BLM 69	703	7
PVO 13 (Control)	417	5
LSD 0.05	303	1
C.V. %	24.6	8.9

Source: Anon, 1988b

Table 3. Seed yields and web blight scores of red-seeded beans in CIAT nurseries at M'Vuazi in 1988C.

Entries	Seed yields (kg/ha)	Web blight scores
RAB 416	1068	5
AFR 252	964	5
RAB 361	938	6
RAB 366	860	4
APN 82	860	5
RAB 391	807	5
PVO 14/2 (Control 1)	495	5
PVO 13 (Control 2)	182	5
LSD 0.05	255	NS
C.V. %	17.0	16.2

Source: Anon, 1988b

Advanced Yield Trial

Yields from an advanced yield trial in 1988C, were low due to late sowing. No entries were superior to the control (Table 4).

Table 4. Seed yields and web blight reactions of entries in Advanced Yield Trial at M'Vuazi in 1988C.

Varieties	Seed yields (kg/ha)	Web blight scores
G 5473	389	4
T-3	371	4
AFR 260	332	5
PAI 92	332	5
A 442	320	6
Calima	244	5
PVO 14/2 (Control 1)	132	5
PVO 13 (Control 2)	81	7
LSD 0.05	NS	NS
C.V. %	49	13.1

Source: Anon, 1988b

CONCLUSIONS

There were no major problems associated with the cultivation of beans during the dry season as there was neither web blight nor other diseases. The best performing line during the dry season will undergo further on-station and on-farm tests during the coming dry seasons. The major objective remains to develop bean cultivars that are resistant to web blight and thus capable of producing heavy yields in the rainy season.

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SESSION VI - GREAT LAKES MISCELLANEOUS REPORTS - DISCUSSION

Tohme: Do you know the origin of the variety Tostado in Rwanda?

Nahimana: I was not covering the origin of varieties but more conservation of genetic resources.

Ukiliho: Tostado was probably selected a long time ago by INIAC.

Davis: I presume that Tostado came from Latin America.

Baert: Testado did not appear in Burundi until the regional trials commenced.

Dessert: Has the regional sub-project in Rwanda improved the efficiency of screening for resistance to anthracnose?

Ukiliho: It is true that in the past a number of varieties were released that were susceptible to anthracnose. The initiation of the sub-project has improved screening for and identification of anthracnose resistant sources, and there are 35 resistant sources for incorporation in a backcross programme. However, a problem is that there appear to be races of this pathogen.

Massey: It would appear in Burundi that after 20 to 30 years of variety testing that yields are still the same.

Baert: The yields presented were a mean across the country although yield levels have probably been adversely affected by declining soil fertility. Some of the new varieties tested have shown 50% yield increases over the local varieties.

Camacho: Do newly released pure line varieties in Burundi soon become mixed?

Baert: Mixing usually takes a few years to occur but this does not occur with farmers who are producing seed commercially for sale.

Camacho: What multiplication scheme exists in Burundi?

Baert: Regional institutes multiply breeders seed for two generations and then pass the seed to agricultural projects in the country for multiplication and distribution to the farmers. However, there is little control (of purity) in these projects.

Silbernagel: The variety Muyungi in Burundi gives a heavy yield under poor conditions but a relatively light yield under good conditions. Are you hopeful of producing a new variety that yields well in all conditions?

Baert: There is a local variety in Burundi that does this but we have not yet had one with this characteristic.

Camacho: What is the bean cropping system in Bas Zaire?

Lama: In the dry season, sole crop beans, and in the rainy season, sole crop or in association with cassava or maize.

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SESSION VII - COUNTRY REPORTS - SOUTHERN AFRICA

TANZANIA

Dr. O.D. Mwandemele and Dr. S.F. Nchimbi

ABSTRACT

Domesticated in Latin America, common beans are now grown throughout the cooler areas of the tropics. It is the most important grain legume in Tanzania, where it offers a cheap alternative to animal protein. Yields are low for various reasons including: the lack of heavy yielding cultivars; pests and diseases; drought; poor soil fertility; socio-economic and institutional constraints; and marketing problems.

Following approval by the Varietal Release and Seed Production Committees and seed of new cultivars goes to Foundation Seed Farms and then TANSEED for multiplication and distribution.

Most beans are grown as mixtures but more recently recommended cultivars are now entering, farmers' fields. Bean research started in 1959 and is conducted by three institutions (TARO, SUA and UAC), among whom collaborative links are strengthening, with support from Bean/Cowpea CRSP and the SADCC/CIAT regional progamme. Its main objective is the development of better yielding, disease and insect resistant cultivars with drought tolerance, acceptable cooking quality and good performance on farm.

Sources of desirable traits are being identified among local and introduced germplasm and crossing programmes have been initiated. Two new cultivars (Lyamungu 85 and Uyole 84) have recently been released.

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) provides an important source of protein in Tanzania. Most beans are grown in medium to high altitudes (800 to 2000 masl), under diverse climatic conditions and cropping systems. This in itself has made the task of those involved in bean improvement very difficult, even though this has been partially solved by evaluating bean cultivars in several environments representing the main bean growing areas in Tanzania.

The present paper provides information on breeding research and production efforts being undertaken in Tanzania in order to improve bean production and marketing and meet the increasing demand for beans as a source of protein.

BEAN PRODUCTION IN TANZANIA

Common beans were first domesticated in Central and South America more than 6,000 years ago. They spread to Europe, Africa and Asia with the Spanish and Portuguese, and are now grown throughout the cooler areas of the tropics but not in the hot semi-arid regions. They were probably introduced to Tanzania in the early 18th century, but there is no clear evidence of their status before the beginning of this century. Until the early 1960s, beans were grown predominantly in Arusha, Kigoma, Mbeya, Morogoro, Tanga and Kagera regions, but have now expanded in other regions, notably Mwanza, Ruvuma, Rukwa, Iringa and Shinyanga (Figure 1, Table 1).

Table 1.' Regional Purchases of Beans by N.M.C., 1977-1987.
(metric tonnes)

Region/ year	1977/78	78/79	79/80	88/81	81/82	82/83	83/84	84/85	85/86	86/87
Arusha	6,712	4,595	4,442	1,432	910	1,200	1,313	54	342	13,472
Iringa	2,844	577	1,828	288	383	332	116	21	44	433
Dodoma	382	398	623	267	188	11	38	8	-	455
Kagera	6,128	6,853	6,351	4,261	5,682	5,682	3,128	785	1,884	3,243
Kigoma	1,412	1,599	2,329	1,541	335	68	99	36	8	18
Kilimanj	3,448	3,915	2,739	284	397	584	29	5	16	1,868
Lindi	-	-	-	-	-	-	-	-	-	77
Mtwara	-	-	-	-	-	-	-	-	-	258
Mara	148	79	72	5	-	-	1	11	-	136
Mbeya	1,537	1,311	3,496	1,429	462	934	431	136	889	746
Morogoro	996	1,889	1,789	1,856	834	245	91	14	18	247
Mwanza	333	435	115	88	9	31	6	2	254	1,899
Rukwa	3,565	2,856	7,793	3,865	2,875	2,977	2,931	2,545	1,978	4,486
Ruvuma	758	735	485	498	236	134	50	5	2	138
Shinyang	17	165	72	21	9	21	26	6	66	392
Singida	893	175	141	67	3	-	4	-	1	247
Tabora	287	117	33	49	23	55	132	6	9	72
Tanga	3,895	4,253	3,885	1,750	1,875	887	66	110	210	1,146
Total	31,667	28,264	35,225	16,887	14,059	13,161	8,453	3,669	5,669	28,535

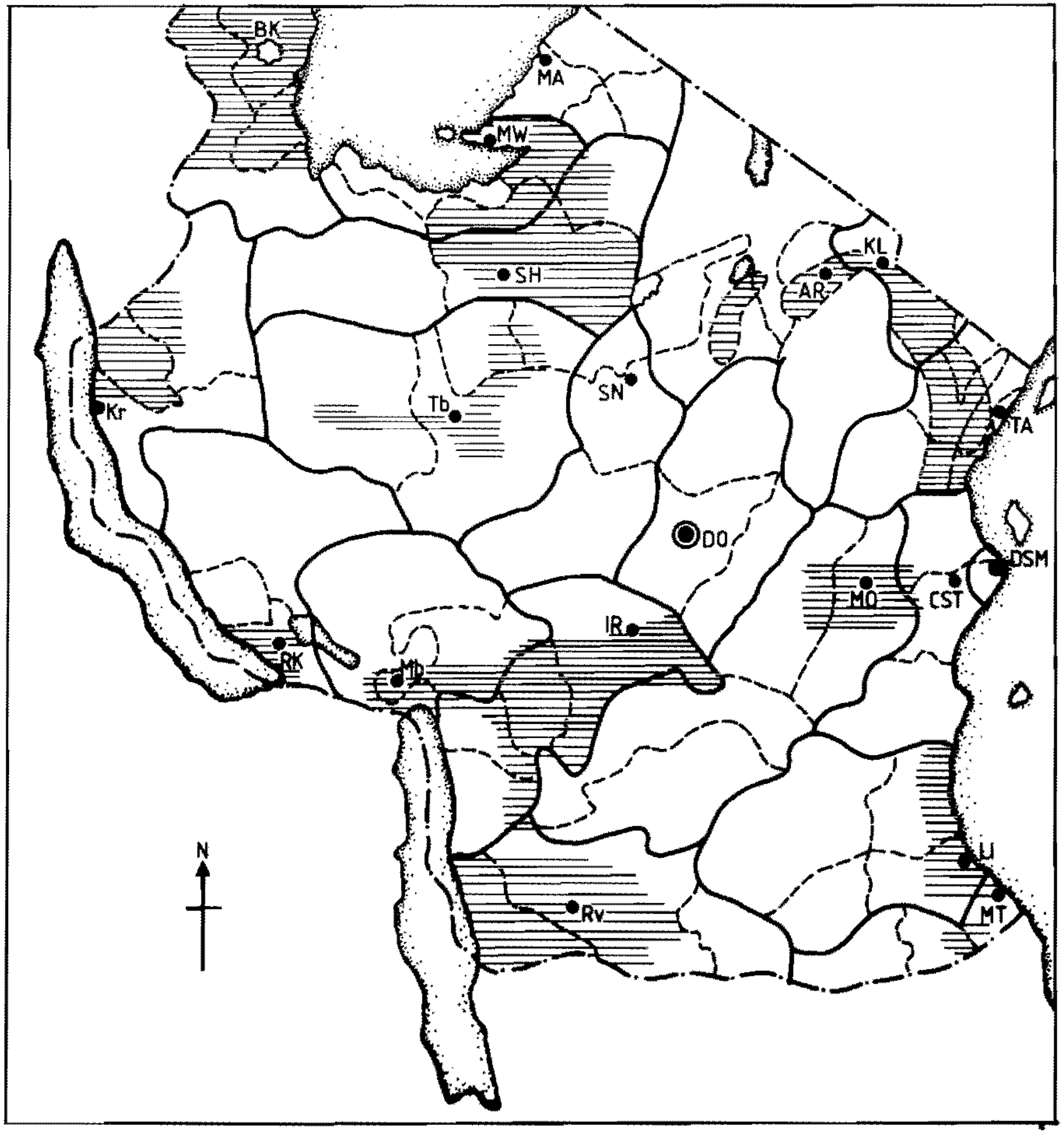
SOURCE: The National Milling Corporation,

Period of Reference: June/May.

The common bean is the most important grain legume crop in East Africa. The combined annual bean production of East African countries, comprising Kenya, Tanzania, Uganda, Burundi and Rwanda of about 822,000 t accounts for about 61% of the total production of beans for Africa which is estimated at 1.35 m tons (Karel 1985).

In Tanzania, common beans are one of the six staple food crops,

Figure 1. Tanzania — Bean growing areas



which also include maize, rice, sorghum, bananas and cassava. Given the ever increasing costs of animal protein (current beef prices range from the equivalent of about US$ 1 to 2 per kg against bean prices of US$ 0.35 to 0.45) the potential of common beans as a source of protein not only for rural people but also in urban centres is likely to be very high because unlike animal proteins, the cost of production of common bean is comparatively low and the price in the market can be afforded by most people. The probable increase in demand for beans implies that bean yields must be increased considerably if their prices are to remain low and affordable by the majority of people.

It is estimated that 545,420 ha were planted with grain legumes in Tanzania during 1986/87 and more than half of this area was common beans. Even though production has been increasing over the years, bean yields are extremely low. The bean yield figures of about 200 to 700 kg/ha given by Acland (1971), and Karel (1985) are probably still valid today. Average bean yields on research stations vary between 700 and 1300 kg/ha, which are low compared with average bean yields of 1590 kg/ha obtained in USA, even though averages as high as 2000-2300 kg have been recorded on research stations (UAC, 1986; Ndakidemi *et al*, 1988). The poor yields observed in Tanzania have been attributed to a range of constraints including drought, weeds, diseases and pests and economic as well as organisational problems.

FACTORS LIMITING BEAN PRODUCTION

Lack of adapted high yielding cultivars.

Most farmers grow genetic mixtures which may comprise up to ten different genotypes. Most cultivars used by farmers are low yielders and are highly susceptible to diseases and pests (Mkuchu *et al*, 1987). The lack of improved cultivars adapted to intercropping is possibly another constraint reducing crop yields. Improved cultivars such as Canadian Wonder, Kabanima and Selian Wonder, are being intercropped with other crops like maize even though these cultivars were selected and tested in pure stand.

The agroecological diversity of areas growing beans has been a problem making it difficult to breed and select cultivars for the different agroecological zones in the face of limited financial and human resources. For this reason, the same commercial cultivars are grown throughout the country even in areas where they are not adapted.

Pests and diseases

The pests and diseases affecting bean yields in Tanzania were reviewed in detail by Karel *et al* (1980). Foliage beetle (*Ootheca benningsen*), beanfly (*Ophiomyia* spp), aphids (*Aphis fabae*) and African bollworm (*Heliothis armigera*), and others pose serious threats to bean production. Greathead (1969) reported losses of 50 to 100 % due to beanfly and Karel and Rweyemamu (1984), losses of 18 to 31 % due to foliage beetles.

Bean diseases of serious concern include bean rust (*Uromyces phaseoli*), anthracnose (*Colletotrichum lindemuthianum*), angular leaf spot (*Phaeoisariopsis griseola*), halo blight (*Pseudomonas phaseolicola*), bean common mosaic virus, and floury leaf spot (*Ramularia phaseoli*). Even though the magnitude of crop losses due to diseases is not known precisely, it is estimated to average about a third of the potential bean production. However, losses of up to 85% due to anthracnose have been observed for some cultivars (Shao and Teri, 1985).

Weather and poor soils

Low to medium altitude areas such as Morogoro face frequent droughts which have considerably reduced production (Tesha 1985). The provision of drought tolerant cultivars is a possible solution to this problem since resources do not allow for the development of irrigation systems in the affected areas.

Many of the soils where beans are grown are poor in fertility. Most small farmers cannot afford fertilizers and those who can, lack the technological know-how for their efficient use. Also, knowledge of the fertility status of soils to assist farmers in the choice of appropriate fertilizers is usually lacking. This is a widespread problem in developing countries and can only be solved by strengthening extension services.

Socio-economic constraints

The problems facing bean researchers include satisfying the needs of consumers especially when varied preferences are encountered. Whereas beans have become indispensible in the majority of homes, preference for particular bean types makes the task of the breeder difficult. The problem is aggravated by the requirement for different types of beans for marketing and home consumption.

The low purchasing power of small farmers prevents the purchase of inputs such as improved bean seed (the price of which has recently increased), fertilizers and pesticides. The situation is worsened by the failure of cooperative unions to pay promptly for farm produce. Government intervention is needed to remove these constraints.

Institutional constraints

Bean research in Tanzania has been hampered in the past by lack of trained personnel. For example, at none of three institutions involved in the bean improvement programme - Tanzania Agricultural Research Organization (TARO), Uyole Agricultural Centre (UAC) and Sokoine University of Agriculture (SUA) - has there been an entomologist working with the bean programme. And the few agronomists at SUA or UAC are also engaged in activities on other crops. The lack of field officers trained to manage bean trials is another problem that has adversely affected bean research in Tanzania.

The USAID Bean-Cowpea Collaborative Research Support Programme (CRSP) and the SADCC/CIAT Regional Bean Improvement Programme are supporting training programmes for researchers and technicians; they should help to alleviate the shortage of personnel with training in bean research.

The shortage of extension workers and lack of transport hampers the dissemination of information to farmers. On-farm trials conducted by SUA, UAC and TARO face similar transport problems during critical periods. Considering current economic problems the situation is unlikely to improve in the near future.

Marketing

Beans are usually purchased from the farmer by Primary Cooperative Societies, which sell the beans to the National Milling Corporation (NMC), which then sells them directly to consumers or to other wholesalers. The producer price and the selling price to the consumers are set by government. In 1987/88, the producer price of beans was TShs 21.60 (US$ 1 = TShs 60 at the time) per kg while the ex-store price of NMC beans was TShs 38.22 per kg (MDB, 1987). The ex-store price of NMC beans has recently been increased to TShs 53.00 per kg (Mfanyakazi newspaper, 26 November, 1988) (US$ 1 is now equivalent to about TShs 123).

Due *et al* (1984) and Due and Rugambisa (1987) reported that farmers in Arusha and Tanga would produce 2 to 3 times more beans if the price of the crop were doubled. However, doubling producer prices will considerably increase selling prices to consumers. A move by government to reduce the number of middlemen may help to reduce prices. Marketing processes which increase producer prices and reduce retail prices are the ideal.

SEED PRODUCTION, PROCESSING AND DISTRIBUTION

The process of bean cultivar release and certification, multiplication and distribution of bean seed is summarized in Figure 2. Permission to release a new cultivar is requested from the Grain Legume Coordinating Committee which forwards a recommendation to the Variety Release Committee (VRC). The recommendation is considered by the VRC at a meeting attended by the breeder.

If accepted, the proposal for the new cultivar goes to the Seed Production Committee for approval, following which the cultivar is then certified and ready for multiplication and distribution. At this stage, a sample of the breeder's seed is sent to Tanzania Official Seed Certification Agency (TOSCA) to serve for future reference. The TOSCA has two seed testing laboratories which check seeds for germination, purity and other important attributes. The major portion of the breeder's seed goes to Foundation Seed Farms (FSF) for multiplication and production of registered seed. The registered seed is then sold to **Tanzania** Seed Company (TANSEED) for multiplication and distribution as certified seed through TANSEED depots, Cooperative Unions and seed stockists. TANSEED depends on the Extension Services of the Ministry of Agriculture and Livestock Development to provide information on the attributes of and agronomic recommendations for the new cultivar.

Figure 2. Bean seed production and distribution in Tanzania

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                                ---------------
Breeders produce--------->| Breeder's seed |
                                ---------------
                                      |
                                      V
Multiplied by                   ----------------
FSF to give   ----------->| Foundation seed |
                                ----------------
                                      |<--------Field Inspection by
                                      |               TOSCA
                                      V
                                ----------------
                               | Registered Seed |<---------Bought by
                                ----------------              TANSEED
                                      |                          |
Tested by National--------------->|<-Field inspection         |
Seed Testing Lab.                     |      by TOSCA            |
                                      |                          V
                                      |<-Field Inspection     Given to
                                      |     by TANSEED        contract
                                      |                       growers
                                      |                          |
                                      V                          V
                                 ---------------
                                | Certified Seed |            Bought by
                                 ---------------               TANSEED
                                      |                          |
                                      |                          V
                                      |                       Sold to
                                      |                         CUs
                                      |                          |
                                      |                          V
                                      |                       Grown by
                                      |                        farmers
                                      |                          |
                                      V                          V
If stocks insufficient            ------------              ---------
further multiplication------>|Common Grade|              | Milling |
is done to produce                ------------              |  Grade  |
                                                            ---------
                                                                 |
                                                                 V
                                                           Sold to NMC
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BEAN IMPROVEMENT IN TANZANIA

Karel *et al* (1980) described the history of bean improvement since 1959, when research on beans first started at Tengeru, in northern Tanzania. TARO-Lyamungu is now the the main centre and coordinates work with UAC in Mbeya and SUA in Morogoro at an annual meeting of researchers from the three institutions to review progress made and plan future strategies. Proposals are then approved independently by the three organizations.

Origins of current cultivars

Most small holders grow beans as mixtures of individual lines. In some landraces there is a wide diversity of seed type: in others the seed type is fairly uniform. Most landraces in Tanzania have coloured beans. Since the release of the cultivars Mexico 142, Tengeru 8 and Tengeru 16, in the early 1960s and Kabanima and T 3 in 1979 by Tengeru, other bean cultivars have found their way to farmers' fields. Among them, in varying degrees of purity, are Selian Wonder, Kabanima, Kablanketi, Masusu, Canadian Wonder, Sumbawanga A, Masai Red, Kiburu, Kabanyolo and T 23. The origins of most of these cultivars are obscure but are being investigated.

Official recommended cultivars

Recommended cultivars of beans include: Canadian Wonder, for medium to marginal rainfall areas; Uyole 84 and Kabanima for high altitude and high rainfall areas of southern Tanzania; and Masai Red for high to medium altitude and moderate rainfall areas and Lyamungu 85, for high, medium and low altitude areas of medium to marginal rainfall in northern Tanzania. The performances of these cultivars are summarised in Table 2. Uyole 84 is a selection from a CIAT line in the germplasm collection of Uyole, while Lyamungu 85 is a selection from the cultivar T 23.

Table 2: Performance of five recommended bean cultivars at Lambo (high altitude) and Gairo (medium altitude) during 1988 (Koinange *et al*, 1988).

Cultivar	Location	Plant height cm	Number of pods/plant	Weight of 100 seeds g	Yield kg/ha	Plant type
Kabanima	Lambo	63.0	12.8	52.3	1777	1
	Gairo	31.8	11.8	32.5	1063	
Masai Red	Lambo	238.5	14.8	-	2380	3b
	Gairo	-	-	-		
Canadian Wonder	Lambo	57.0	11.3	56.1	2283	2b
	Gairo	34.8	5.5	30.1	1050	
Lyamungu 85	Lambo	59.5	11.0	64.4	2234	1
	Gairo	27.3	10.3	45.0	1513	
Uyole 84	Lambo	-	-	-	-	-
	Gairo	57.8	8.0	45.0	1038	3b

These cultivars are susceptible to a number of diseases. For instance, Lyamungu 85 is susceptible to angular leaf spot (ALS), floury leaf spot (FLS) and white mold, while Kabanima is susceptible to ALS and FLS. Efforts are being made to incorporate disease resistance through crosses with resistant sources.

Present status of the bean improvement programme:

The main objective of the national bean improvement programme is to develop better yielding, disease and insect resistant cultivars which are drought tolerant, of acceptable cooking quality and which can perform well in farmers' fields.

The achievement of this objective requires a high degree of collaboration among disciplines, including breeders, plant pathologists, entomologists, agronomists, soil scientists and food technologists, each contributing in a different manner towards development of improved bean cultivars. The overall bean improvement activities of the institutions are summarised in Figure 3.

Intercropping

Most small farmers in Tanzania grow their beans in association with maize, the beans being broadcast, in separate rows or in the same rows as the maize. In the Southern Highlands, some bean genotypes performed better than others when intercropped (UAC, 1986), but Mbuya *et al* (1985) noted that the best performing lines in monoculture were also the best lines in association with maize. These studies emphasize the need for further research to establish the need for evaluation of beans in association as well as or rather than in monoculture.

In Tanzania, farmers apply fertilizer to maize but not to beans. Scientists are therefore cosidering the possibility of selecting cultivars that perform well without fertilizer. Such genotypes would be expected to nodulate well with native rhizobia.

Pathology research

Diseases continue to be a major factor reducing bean yields. Table 3 shows that none of the current recommended cultivars is resistant to all the major diseases. Mkuchu *et al* (1987) noted that the popular cultivars Kablanketi, Masusu, Chipukupuku and Sumbawanga A, which are used by farmers were very susceptible to the major diseases and produced very low yields. An urgent need was expressed to replace these cultivars with high yielding, disease resistant cultivars that incorporate the other qualities required by farmers.

Screening for disease resistance is being conducted by plant pathologists in all three institutions. Resistant genotypes are used in crosses with potentially high yielding but susceptible cultivars. Recently, studies of the genetic variation of pathogens such as rust (Mmbaga 1984) and halo blight (Gondwe, 1978a) have been initiated. This kind of information is vital for the development of stable, durable resistance and for temporal and spatial gene deployment for effective control of diseases.

Figure 3. Outline of bean improvement strategy in Tanzania.

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                    PATHOLOGY
                        |
                        v
SOCIO-ECONQMICS----->Breeding<-----ENTOMOLOGY
                        |
                        |
     NUTRITION          |           BNF
                        v
          Hybridisation, selection and
        screening for various attributes
                    up to F5
                        |
                        v
                   Preliminary
                  Yield Trials
                        |
                        v
                    Advanced
                  Yield Trials
                        |
                        v
                    National
                  Yield Trials
                        |
                        v
                     On-farm
                      Trials
                        |
                        v
                     TANSEED
                        |
                        v
              Cultivar release and
               seed distribution
                        |
                        v
                Involvement of
              Extension Services
                        |
                        v
                  Post release
                    studies
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Entomology

Recent research has been directed at screening cultivars for pest resistance, determining mechanisms of resistances, integrated pest management techniques and chemical control (Karel, 1984; Karel and Rweyemamu 1984; Mushebezy and Karel, 1985; Karel, 1985; Gondwe and Slumpa, 1988).

Table 3(a) Disease reactions of currently recommended cultivars at Lyamungu in 1988

Cultivar	Halo blight	ALS	Anth	White mould
Kabanima	1.5	4.0	1.0	2.5
Canadian Wonder	2.0	4.0	1.5	6.0
Masai Red	1.5	4.0	1.0	6.0
Uyole 84	1.5	4.0	1.0	5.0
Lyamungu 85	1.5	6.5	1.0	6.0

Table 3(b) Disease reactions of currently recommended cultivars at Uyole in 1988

	ALS	Scab	FLS	Rust	HB	Anth	BCMV
Kabanima	4.5	1.5	4.5	2.0	3.0	1.0	1.5
Canadian Wonder	5.5	4.5	3.5	3.0	4.0	4.0	2.5
Masai Red	3.0	1.0	3.0	4.5	1.5	2.5	2.5
Uyole 84	-	-	-	7.0	-	-	-
Lyamungu 85	6.0	2.8	4.5	2.0	2.5	2.3	1.0

Karel (1985) has emphasized the importance of integrated pest management (IPM), which he defines as an ecological approach to the management of pest populations which utilizes a variety of compatible techniques in a unified management programme that will ensure favourable economic, ecological and sociological consequences. The components of an integrated pest management programme in a bean agroecosystem include host plant resistance, selective and judicious use of insecticides, biological control using parasites, predators and pathogens, and cultural control (Karel, 1985). While IPM appears to be very attractive, the use of insecticides should be minimized and the search for host plant resistance intensified. Further research into cultural practices such as that conducted by Mohamed and Karel (1985), which revealed that intercropping may reduce damage by insect pests, is also being undertaken.

Breeding

Sources of breeding material: The main sources of genetic variability are: collections of landraces from different parts of Tanzania, introductions from neighbouring countries and overseas (mainly CIAT and Bean/Cowpea CRSP at Prosser); and hybridization. Advances so far have been achieved through screening of local and introduced germplasm. Each institution has now initiated hybridisation programmes to recombine desirable attributes. Recently, a Tanzania Germplasm Collection has been assembled, composed of collections from TARO, UAC and SUA, which will facilitate the exchange of genetic materials among breeders.

Resistance to environmental stresses: The following areas of research are being undertaken to reduce the vulnerability of plants to stresses.

1. Identification of resistance genes by studying the morphological, physiological and biochemical differences between susceptible and resistant varieties. Steadman and Shaik (1988) recently showed that rust resistance can be conferred by increased leaf pubescence. Msangi and Karel (1985) found that leaf pubescence was also negatively correlated with numbers of beanfly larvae and pupae on plants. Cultivars with high hair density were better seed yielders than those with low hair density. Such research findings may aid the development of resistant cultivars.

2. Breeding cultivars that are tolerant to drought by selecting cultivars with more extensive root systems. Tesha (1985) and Mgema *et al* (1987) identified drought tolerant lines using the physiological parameters stomatal resistance, electrical conductivity and relative water content. The identified genotypes (e.g. TMO 101) are being used as parents in the development of drought tolerant cultivars.

It is possible to make progress in stress resistance through conventional breeding, but the greatest long-term progress is likely to come from reinforcing these approaches with new genetic manipulation techniques if facilities are made available.

Breeding for adaptation: National Variety Trials for high, medium and low altitude zones have been established. During 1987 and 1988 sixteen bean lines were evaluated in each set. Entries like Lyamungu 85 and TMO 216 proved to have wide adaptation, performing well at all altitudes, while others did well at one altitude and poorly in others. The importance of these trials cannot be overemphasized but it must be ensured that entries are worthy of inclusion by more care in selection of materials in earlier stages of testing. Entries for the 1989 National Variety Trial (Table 4) were selected at a meeting on 27 September 1988 at SUA, based on their performances in previous seasons.

Breeding for consumer acceptability: Misangu and Maeda (1986) and Maeda (1987) have identified rapid cooking lines and these are being evaluated further. A PhD candidate at the University of Dar es Salaam in collaboration with the Department of Food Science and Technology of SUA is studying the heritability of cookability and other associated characteristics which influence the cookability of beans. The information gained will assist breeders intending to improve cookability. The work of Mwandemele *et al* (1984) on soyabeans lends hope to the possibility of obtaining better yielding and faster cooking cultivars through genetic manipulation.

Table 4. Proposed entries for National Variety Trials 1989

Entry no.	High altitude	Medium altitude	Low altitude
1	Uyole 84	Uyole 84	Uyole 84
2	Kabanima	Kabanima	Kabanima
3	T3	P 285	Lyamungu 85
4	RKSPS 3b	LB 110	TMO 101
5	FB/GP 246-3	TB79/420	TMO 216
6	NN (2)	EMP 86	TMO 224
7	NN (92)	Carioca Sel.2	TMO 241
8	PVAD 566	G 5621	TMO 333
9	PVAD 758	CWSPS 13-3	TMO 959
10	PVAD 1275	TMO 244	Canadian Wonder
11	Line 100	TMO 959	G 5621
12	Lyamungu 85	Lyamungu 85	EMP 86
13	EMP 86	Loto	LB 110
14	Carioca Sel.2	RKSPS-16	CWSPS 13-3
15	G 5621	Anchor	TB 79-420
16	TMO 224	PVA 773	UAC 56

Other considerations: In view of the importance of intercropping, efforts are being made to evaluate genotypes in association with maize. Mbuya *et al* (1987) and Mbuya and Koinange (1987) found recently released Lyamungu 85 to be the best yielder in both monoculture and association with maize, while UAC (1986) reported that some bean cultivars performed better than others when grown in association with maize. These results indicate that breeding and selection of bean cultivars adapted to intercropping is possible. Cultivars like Lyamungu 85, that show a wide range of adaptation are to be preferred.

On-farm trials being conducted in Tanga, Arusha, Kilimanjaro and Morogoro facilitate the rejection of cultivars that perform poorly under conditions of minimum or zero inputs. Nodulation of promising cultivars by native or inoculated rhizobia is also being investigated.

ACHIEVEMENTS

Research carried out so far in Tanzania has generated information that can be exploited for the improvement of bean production in the country. What is now needed is to ensure that information gathered does reach the intended targets, the farmers. Recently two new cultivars, Lyamungu 85 and Uyole 84, were released and others may be released in the near future. However, despite this considerable success in the past 8 years, much remains to be done, especially in relation to providing genotypes that are resistant to diseases and pests, because these stresses continue to be the major obstacles to increased bean production in Tanzania.

We are hopeful that the developing collaboration among the scientists and institutions involved in bean research and continued support from the SADCC/CIAT Regional Bean Improvement Programme and Bean/Cowpea CRSP will facilitate the elimination of these obstacles. Considering these factors, the future of the bean improvement programme in Tanzania appears bright. We look forward to increased support from government and continuing external assistance to achieve our aims.

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MALAWI

J.M. Bokosi

ABSTRACT

This paper describes bean improvement in Malawi, including outlines of the: environments; distribution of beans; area and production; cropping systems; constraints; origins of existing cultivars; current breeding activities; and procedures for release and multiplication. Attention is also drawn to the collaborative research work that the Bean Research Programme at Bunda has with other agricultural research establishments.

INTRODUCTION

The common bean, *Phaseolus vulgaris* L. is second only to groundnuts in grain legume production in Malawi. It provides a cheap source of protein for the majority of people of the country (Bokosi, 1986). It is widely grown and variable, differing with respect to growth habit, maturity and seed characteristics. Mixed cropping is common, especially among smallholders, who produce the bulk of the crop. The main constraints to bean production in Malawi are: the lack of suitable varieties and production technology; diseases and pests; soil infertility; and inadequate and unevenly distributed rainfall.

Organized plant improvement was commenced in 1969 at the agricultural faculty of the University of Malawi at Bunda College. Six cultivars have so far been released but all are very susceptible to important diseases. The college has collected over 3,000 accessions of bean germplasm. The primary objectives of the Bean Research Commodity Team at Bunda are twofold: to develop high yielding varieties with stable and durable resistance to diseases and insect pests and acceptable to both growers and consumers; and to develop improved cultural practices and production systems.

The Bean Research Programme at Bunda has fostered research and training partnerships with agricultural research establishments working towards enhanced production.

ENVIRONMENTS

Malawi's topography ranges from the Rift Valley floor, almost at sea level, to mountains rising to about 3,000 masl.

There are three seasons - a cool dry period from mid-April, a hot period with some humidity between August and mid-November, and a period of tropical rains between November and April. Within this broad pattern, many areas have micro-climates, with annual levels of rainfall varying from 800 to 2500 mm (Anon, 1988).

The country is divided into three administrative regions: the Northern, Central and Southern Regions. There are three distinct topographic zones (Figure 1). To the east is the Rift Valley enclosing Lake Malawi and the Shire Valley. Bordering the Rift Valley are the escarpment and highland areas of Malawi, some of them rising to 2300 masl. The highland areas of Malawi run from north to south. The main area for agriculture is the medium plateau bordering the highland areas. The plateau has gently undulating farmland at altitudes between 1000 and 1400 masl and occupies three-quarters of the area of the country.

Four agroecological zones can be distinguished (Anon, 1986). They are:

i) The lower Shire Valley in the southern part of the Rift Valley. It lies about 250 masl and has low rainfall and semi-arid savanna grassland and shrub vegetation.

ii) The lakeshore and upper Shire Valley. This lies at altitudes between 300 and 600 masl and has lakeshore savanna grassland and shrub vegetation.

iii) The medium plateau area of the Northern and Central Regions, lying between 800 and 1600 masl. The vegetation is *miombo* woodland, dominated by *Brachystegia* and *Julbernadia* spp.

iv) The highland areas, ranging from 1600 to 3000 masl. Rainfall is generally high and temperatures are low. Vegetation consists of mountain grasslands on the high plateau, while *miombo* woodland dominates at lower altitudes.

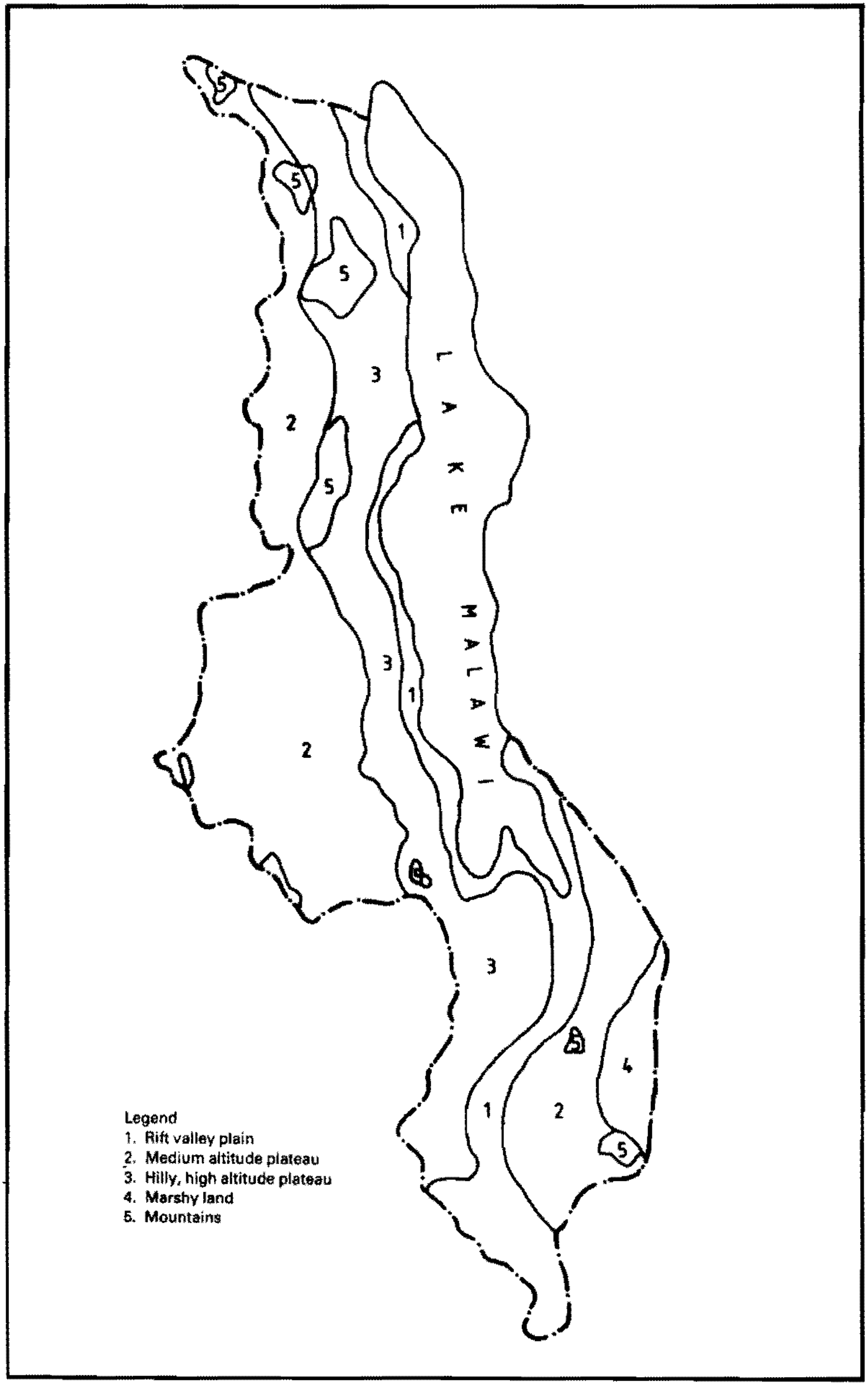
CLIMATE

Malawi's climate is semi-arid in the upper and lower Shire Valley (rainfall below 750 mm per annum) and semi-arid to sub-humid in the plateau and highland areas, where rainfall may exceed 1600 mm per annum. Some high altitude areas such as the Shire Highlands may receive showers during the cool months of May, June and July. Mean annual temperatures vary with altitude from 25°C in the Shire Valley to 13°C on the Nyika Plateau.

SOILS

Around Lake Malawi, in the Shire Valley and on the plain adjoining Lake Chirwa, most soils are of alluvial origin. They are fertile and highly suitable for agricultural production. Elsewhere the soils are typically formed *in situ* over sedimentary, or to a smaller extent, crystalline rocks. Such soils are ancient, heavily leached and of medium to low fertility. These soils occupy much of the cultivated agricultural land of Malawi. In many highland areas, the soils are shallow and therefore not suitable for agriculture. The Shire Highlands and Lilongwe Plains have red loam soils which are fertile and are very suitable for agriculture.

Figure 1. Malawi major physiographic units



The administration of agriculture is through Agricultural Development Divisions (ADDs). Research carried out at any station is supported by an adaptive research team (multi-disciplinary team) at ADD level. The National Bean Programme has established research sites in some of the ADDs, in collaboration with the Ministry of Agriculture.

BEAN DISTRIBUTION, AREA AND PRODUCTION

Beans are grown throughout the country but are found mainly between 1000 and 2000 masl, on well drained soils with rainfall between 800 and 1500 mm.

Between 1977 and 1987, bean area increased from 95,000 to about 133,000 hectares (Table 1) while production rose only from about 60,000 to 70,000 metric tonnes accompanied by a decrease in yield from above 600 to less than 500 kg per hectare (FAO, 1987). In a local publication (Anon, 1989), national average yields for beans are reported to be 260 kg per hectare for mixed stands and 724 kg per hectare for sole crop beans. Similar low yields were reported as early as 1927 (Edje *et al*, 1981) and have not improved in spite of advances in agricultural technology. Increases in production have thus stemmed from expansion in area rather than from improved yields.

Table 1. Dry bean production in Malawi, 1977-1987.

Year	Area harvested (1000 ha)	Yield (kg/ha)	Production (1000 t)
1977	95	624	61
1978	95	653	62
1979	96	625	60
1980	95	653	62
1981	95	653	62
1982	120	533	64
1983	126	532	67
1984	130	538	70
1985	133	541	72
1986	133	489	65

Source: FAO Production Year Book (1987)

CROPPING SYSTEMS

Beans are traditionally grown principally in mixed stands of two or more crops, on ridges (ridge intercropping). Arrangements vary with district and bean growth habits, but generally, climbing beans are sown on the same hill as the maize with the latter providing support. Relay cropping is common in areas with prolonged rainfall such as Thyolo, Mulanje and Chiradzulu, where beans are sown into maize crops that are at physiological maturity. Double cropping of beans, on residual moisture (and fertilizer) following tobacco, is becoming an important feature of estates where beans are an important food component for their labour force. Double cropping is also common in areas of bimodal rainfall such as Karonga.

CONTRAINTS

Varieties

Beans grown in Malawi are usually mixtures, varying in complexity, of differing seed types (colour pattern, size and shape) and growth habits (Smithson and Allen, 1988). These have been cultivated for centuries but, although they have adapted well to the environments in which they are grown, their productivity is low.

In almost two decades of bean improvement work in Malawi, only six pure line varieties have been released and all of them are very susceptible to important diseases. There are also problems of availability and distribution of seeds. The National Seed Company of Malawi (NSCM), which has the mandate to multiply bean seed, has been unable to meet national seed demand. Similarly, the Agricultural Development and Marketing Organisation (ADMARC), charged with seed distribution, has been unable to ensure availability of seed to all farmers wishing to grow beans. These problems may account for the low plant populations in farmers fields - 20 to 60 thousand plants per hectare in mixed stands and 50 to 80 thousand in sole crop beans (Edje *et al.*, 1981).

Production technology

Currently most beans grown by smallholders are in association with a variety of crops. While this system may be adequate to meet subsistence demands, it is inadequate to meet total national requirements. Past experiments and recommendations were directed principally at sole crop beans and there is need to develop technologies to improve yields in mixed cropping situations.

Diseases

Diseases are the most important factors limiting bean yields in Malawi. The most important of these are: anthracnose (*Colletotrichum lindemuthianum*), halo blight (*Pseudomonas phaseolicola*), angular leaf spot (*Phaeoisariopsis griseola*), common bacterial blight (*Xanthomonas campestris*), rust (*Uromyces phaseoli*), bean common mosaic virus, web blight and root-rots.

Insects

A number of insect pests attack beans in Malawi. Most important in the field are: beanfly (*Ophiomyia* spp), beetles (*Ootheca* spp), American boll worm (*Heliothis armigera*), aphids (*Aphis fabae*), cut worms and bean pod weevil (*Apion godmani*). In storage, most common are the bruchids, *Zabrotes subfasciatus* and *Acanthoscelides obtectus*.

Nematodes

Nematodes (*Meloidogyne* spp) have been found to cause considerable damage in some situations.

Drought

Inadequate and unevenly distributed rainfall are important causes of reductions in bean production in Africa (Bokosi, 1988). In Malawi, the fall in bean production in 1987 (Table 1) may largely be attributed to drought in some parts of the country. Drought has become more common in recent years leading to the replacement of beans by cowpeas, which are more tolerant to drought, in some areas that formerly grew beans.

Soil fertility

Beans are frequently grown on soils of poor fertility and do not receive fertilizer as they are a subsistence and bonus crop, usually grown in association with other crops such as maize. They sometimes benefit indirectly from nirogen and phosphate applied to maize.

Satisfactory bean yields are obtainable only if the crop receives nitrogen, which is the most limiting nutrient in Malawi soils, but fertilizers are not only expensive but also often unavailable.

ORIGINS OF EXISTING CULTIVARS

The first bean cultivar to attract significant attention in Malawi was Canadian Wonder, seeds of which were introduced on various occasions from the 1940s onwards. More recently, six cultivars have been released by the bean improvement programme at Bunda College. These are: Nasaka, Kamtsilo, Kanzama, Bwenzilawana, Sapelekedwa and Namajengo.

All are pure line selections from country-wide landrace collections conducted by the Bunda College Crop Production staff members. Selection was largely based on agronomic characteristics. Derived from local germplasm, some are well-adapted in a number of environments, but their susceptibility to major bean diseases has limited their yield potential and adoption by growers.

CURRENT BREEDING ACTIVITIES

Yield

The Bean/Cowpea CRSP programme has identified, from the local germplasm collection, some lines with good agronomic characteristics and potential for heavy yields. Evaluation of introduced material has also produced encouraging results (Table 2). Some of these lines are already in national variety trials. Of interest, too, is the development of determinate snap bean lines, three of which are also in national trials.

Table 2. Growth habits, seed yields (kg/ha) and sources of twelve bean varieties at three sites in 1987/88.

Variety/line	Growth habit	Seed yield Bunda	Champhira	Dedza	Mean	Seed source
5-2	II	1249	954	288	830	
21-5	IV	1603	1196	423	1074	CRSP
8-7	II	1452	1111	815	1126	CRSP
12-4	IV	1647	1012	541	1066	CRSP
6-5	IV	1279	1235	1230	1248	CRSP
A 286	II	1796	1790	434	1340	INT
A 344	II	1025	1997	609	1210	INT
25-2-1 x 8-7	-	1251	1062	678	997	CRSP
Nasaka	I	1345	1147	211	901	LCV
21 x P 692	-	-	844	947	895	CRSPxINT
2-10 x 8-7	-	-	1304	516	910	CRSP
Mean		1323	1297	697		

CRSP - Bean/Cowpea-CRSP selections from local landraces
INT - Introduced material
LCV - Local check variety

The evaluation of germplasm - local and introduced - continues, to identify additional high yielding lines: and crosses are being made to improve on adaptation and other agronomic characters.

Disease and pest resistance

Breeding for disease and pest resistance has been one of the main objectives of bean improvement in Malawi, largely because diseases are the most important factors reducing bean yield and because all released varieties are susceptible to the major diseases and pests.

Screening for halo blight resistance has led to the identification of resistant sources and a hybridization programme has resulted in the isolation of 153 progenies of halo blight resistant material. These progenies are now being evaluated in three areas favourable for development of the disease: Dedza, Chitipa and Thyolo.

Breeding to incorporate anthracnose and angular leaf spot resistance into released varieties and other promising lines was commenced in 1988. Sources of resistance are from local and introduced germplasm. Over 30 parents were utilized in making more than 200 different crosses. About 2,500 F_1 plants have been obtained. Some of these are in the field and others are in the greenhouse. Segregating populations from these will be evaluated for disease resistance in different bean growing areas of the country.

Screening is in progress to identify further sources of resistance to these and other diseases.

In addition to screening for disease resistance, attention is also given to the evaluation of local and introduced germplasm for resistance to pests and drought and for increased nitrogen fixation. For the moment, the major emphasis is on the identification of promising genotypes.

PROCEDURES FOR RELEASE AND MULTIPLICATION

Every variety to be released has to pass before a Variety Release Committee. It is recommended that both morphological and physiological distinctive characteristics be tabled before a variety is released. This includes: maturity; area of adaptation; photoperiodism (e.g. soyabean and beans); colour of stems, leaves, silk, seed and cob; average height; and synchronization of pollination (hybrids). It is also suggested that seed certification personnel should be given an opportunity to study and observe the characteristics of promising varieties for distinctness, stability, uniformity and general appearance, for at least two to three seasons before release.

Breeders seed and sometimes basic seed is currently produced by the National Bean Programme at Bunda College of Agriculture. Certified seed is multiplied by the NSCM, usually on its own seed estate or by contracting estates or smallholders but under the direct supervision of a Seed Technology Unit at Chitedze Research Station, which is five miles (8 km) from Lilongwe. Seed bean crops registered with the STU require fairly exhaustive field and laboratory inspection before final certification.

COLLABORATIVE RESEARCH PROGRAMMES

The Bean Research Programme at Bunda has fostered research and training partnerships with several institutions/governments. The principal objective is to enhance bean production.

Bean/Cowpea (CRSP)

Since its inception, this project has focussed on the understanding of the genetic and socio-cultural factors underlying diversity in the present Malawian beans. The primary goal of a three-year extension is to quantify and describe the variability found within major preferred seed classes, as an antecedent to the release of improved cultivars.

Research priorities are: first, to elucidate the genetic relationships between prevalent fungal pathogens and the diversity within and among landraces; and second, to improve major seed types in respect of one or more economic and/or culinary characteristics.

SADCC/CIAT Regional Bean Programme

The objective of the SADCC/CIAT programme is to develop and transfer bean production technology with the aim of improving the productivity of beans in pure stands and in associated cropping, as well as improving the nutritional and cooking quality of beans in SADCC countries.

Research priorities include: identification of local bean production constraints; collection, transferring, and testing of local and introduced germplasm and improved varieties and populations; breeding improved varieties with regard to yield potential, yield stability and lower production risks, and better nutritional and cooking quality; and the development of improved cultural practices and production systems.

FRG - ISRAEL-MALAWI PROJECT

This is a new collaborative programme between the Federal Republic of Germany, Israel and Malawi aimed at screening for heat and drought tolerance in common bean.

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ZAMBIA

Drs. Musonda J. Mulila-Mitti, J. Kannaiyan, and S. Sithanantham

ABSTRACT

Between 1982 and 1986, annual bean production in Zambia was around 1,300 tonnes, nearly half of which came from the Northern Province. Beans are grown mainly by small farmers, in association with other crops. The main constraints are: the lack of suitable varieties; inadequate agronomic practices and damage by pests and diseases. Released varieties are described. Emphasis has been on the evaluation of local and introduced bush and climbing types. Among bush types, one cultivar, Carioca, has already been released. VRA 81054, a climbing type, was accepted for pre-release tests in 1988. Screening for disease and pest resistance have received major attention. Varietal release is the responsibility of a Varietal Release Committee. Following pre-release, new cultivars undergo at least two years of on-farm and other tests before qualifying for final release.

INTRODUCTION

Beans (*Phaseolus vulgaris*) are the most important food legume crop in Zambia. It is a major source of protein for both rural and urban populations. Bean consumption has become more popular recently. Due to the high demand for beans, especially by landless town dwellers, prices may be up to K20 per kilogram (K10 = US $1) on the informal market. This high price indicates that national bean production is inadequate to meet local consumption needs.

Beans are mostly used dry but also as shelled green seeds, green pods and tender leaves, which are boiled and used as relish.

TYPES

The bean crop in Zambia is predominantly dwarf, very few climbing types being grown. Both local landraces and introductions vary greatly in grain type - seed coat colour, size and shape. Most popular are: mixtures of large, round, white and yellow seeds with or without red or purple speckling; large olive-brown kidney types; large pink oval seeds with red mottling; and small, pale green seeds with wrinkled seed coats. Black and small red types are not liked.

In the past, bean materials were imported from South Africa and neighbouring countries. Recent introductions are mostly from CIAT.

PRODUCTION, AREA, ENVIRONMENT, YIELD LEVELS

The bean crop is mainly grown by small farmers and most produce is sold on the informal market, so statistics (Table 1) underestimate production.

Most of the crop is produced in the higher altitude, cooler and high rainfall zone (Northern, North-Western and Luapula Provinces) followed by the medium rainfall warm zone (Central, and Eastern Provinces). The drier and lower altitude Western and Southern Provinces are probably too hot for bean production (Figure 1). Table 2 gives climatic and soil characteristics of the different zones.

Bean yields on farmers' fields average between 400 and 600 kg/ha while improved management can boost yield to 800 kg/ha. Under commercial management, yields of up to 2000 kg/ha are possible.

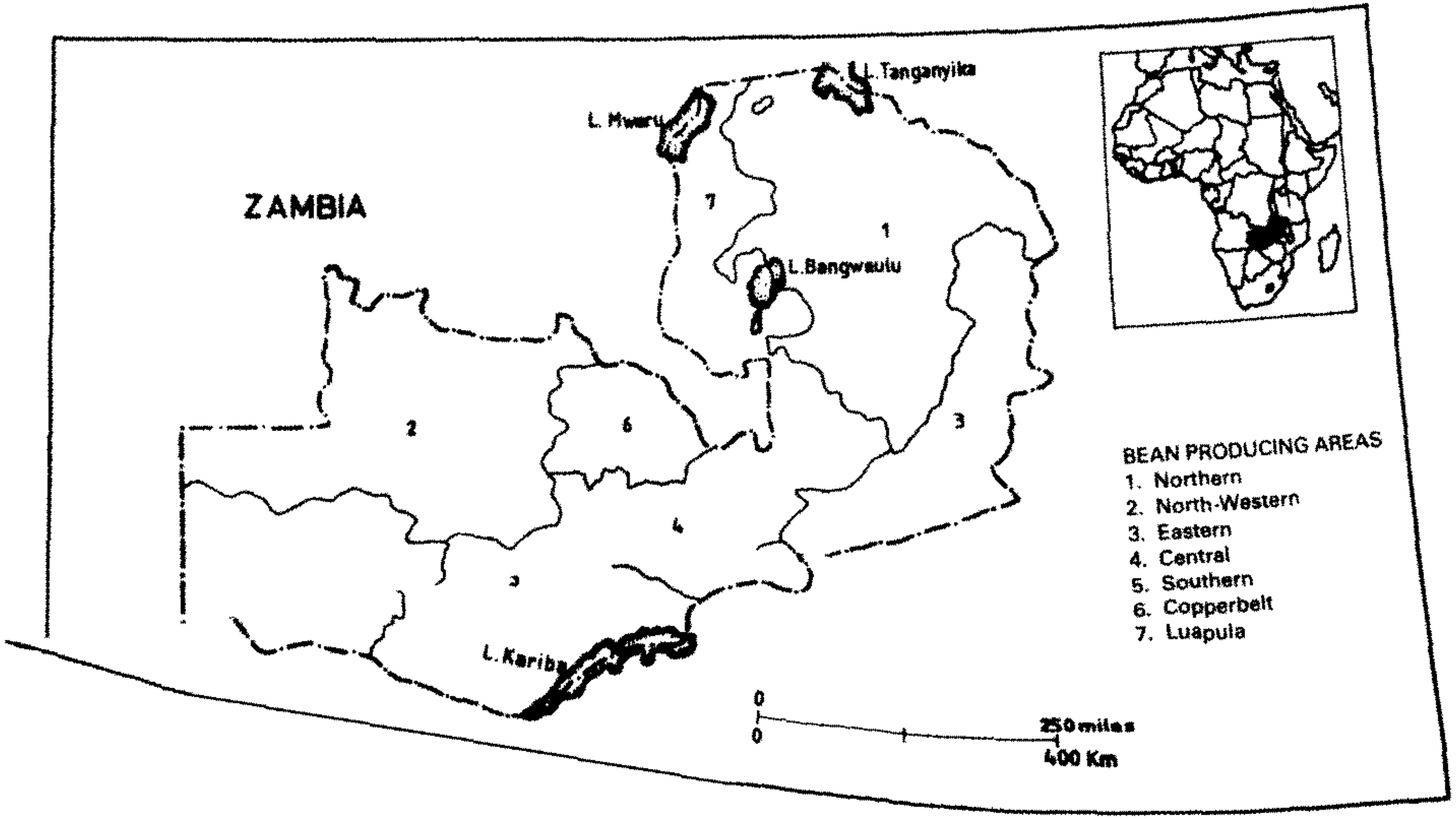
Table 1 Bean marketing, by province in Zambia, 1982-1986

Province	Marketed (90 kg bags)
Northern	6.228
North-western	413
Eastern	3,612
Copperbelt	637
Central and Lusaka	2,562
Luapula	668
Southern	175
Western	5
Total	14,300

Table 2. Environments of major bean growing provinces of Zambia.

Province	Altitude (masl)	Rainfall (mm)	Mean temp. (°C)	Soils
Northern, Luapula, North-Western and Copperbelt	1200-1700	1000-1500	17-22	Strongly leached red clays, red brown loams or sandbelt.
Central, Lusaka and Eastern	1000-1300	900-1100	20-25	Sandbelt, red brown loams and black clays.

Figure 1. Zambia - bean producing areas.



AGRONOMIC PRACTICES AND CROPPING SYSTEMS

Beans are predominantly grown by small farmers (in association with maize, sweet potatoes or cassava) but they are also grown by commercial farmers, mostly for seed production under improved management, including sole cropping.

The time of planting varies according to location but is usually between December and the end of February, as long as sufficient soil moisture is available. The main bean crop is grown during the rainy season but a dry season crop may also be grown, especially in dambos (depressed areas of high moisture content) from May to July. Most seed growers also prefer to grow their crop during the dry season under irrigation to avoid diseases. Most farmers do not apply fertilizer to their bean crop and the few who do, rarely use more than 30 kg/ha. The plant population used on small farmers' fields is also well below the recommended rate. Farmers usually weed their bean crop at least once during the growing season.

In the Mwamba area of Mbala, in the major bean growing area of the Northern Province, farmers plant at least two bean crops during the rainy season. The first crop is planted in December and harvested in February. This is followed by a second main crop which is planted from mid-March to mid-April. The first crop is weeded at least once, while the second is not usually weeded. Although the first crop erves to bulk seed for the second, main season, it also eases famers' cash flow problems, commanding a premium price. Yields ae larger than in the second season, though disease pressure:are greater, especially if sowing is delayed. In years with o much rain in March, the late March-planted crop yields poo. In years when the rains end early, the April-planted crop poor.

Whereas beans are sown ridges in most areas, in Mwamba, more than half the farmers on mounds. Local varieties used are predominantly mixtures There are three most common bean seed mixtures according to ailing soils or climates (Table 3).

Table 3. Types of mis grown in the Mwamba area and eir uses.

Mixture	l name	Use
Yellow Small white Spotted	ba bala aka	when rains are too early and on poor soils.
Round yellow Round white	aka uma	for high fertility soils.
Purple larg	ulangeti	for medium to good fertile soils.

CONSTRAINTS TO BEAN PRODUCTION

The major constraints to bean production in Zambia are lack of suitable varieties, inadequate agronomic practices and damage by diseases and pests.

Unsuitable varieties.

Most farmers grow local landraces. Although their yield potential is greater, commercially produced seeds are not popular due to multiplication and distribution problems and their higher price.

Inadequate agronomic practices.

Planting, weeding and harvesting of beans are frequently delayed because priority for labour is usually given to the maize crop. Few farmers apply fertilizer to beans and then only in small quantities.

Diseases

It is estimated that bean yields are reduced by 25 to 50 % in Zambia due to diseases. The yield losses caused by individual diseases to beans are shown in Table 4. The most important is bean common mosaic virus (BCMV) which causes considerable yield loss, especially in the warmer, medium rainfall zone. Diseases which are more prevalent in the cooler, wetter areas are anthracnose, angular leaf spot, scab, rust and ascochyta blight. Common bacterial blight and halo blight are also important.

Table 4. Yield losses (kg/ha per unit increase in disease scores on a scale of 1-9) caused by bean diseases in Zambia.

Disease	Yield loss
Ascochyta blight	57-341
Anthracnose	21-321
Angular leaf spot	25-192
Scab	24-130
Rust	0-50
Bean common mosaic virus	25-195
Bacterial blight	31-37

Insects

The major insect pests of bean are beanfly (*Ophiomyia* spp.), aphid (*Aphis craccivora*), leaf beetles (*Ootheca* spp.) and spotted pod borer (*Maruca testulalis*). The beanfly is the most important of these pests and causes severe damage to unprotected bean crops.

Soils and rainfall also affect bean production. Soil acidity, suboptimal phosphorus levels and poor micronutrient status are problems in the high rainfall zone. The low rainfall zone is beset by soil moisture deficits, leading to low yields and even crop failure.

COMMERCIAL VARIETIES

Various cultivars have been recommended for cultivation. They include:

Misamfu stringless: Misamfu Stringless originated from a code numbered sample from a South African seed company. It is an early-maturing snap bean with medium, cylindrical white seeds and good pod flavour. It was identified in the bean collection at Misamfu Research Station in 1967. It is susceptible to angular leaf spot and rust but resists anthracnose.

Misamfu speckled sugar: This originated from a locally available commercial strain. It is early to medium maturing with medium-sized, oval, slightly kidney-shaped seeds, that are beige with brownish red speckling.

It is very popular due to its excellent grain and cooking qualities. It is however susceptible to BCMV and to most fungal diseases, especially angular leaf spot.

Carioca: Carioca originated from Brazil. It is a medium maturing variety with small light cream, brown-striped grains which have a mild cowpea flavour. Carioca is adapted to most regions in the country and is tolerant of major foliar diseases. It is however, susceptible to black root, especially in warmer regions. Carioca is appreciably better yielding than earlier cultivars (more than 1,000 kg/ha). It has become very popular in the Central and North-Western Provinces, but farmers in Northern Province do not like the small seeds.

Mexican 142: This cultivar was imported from Kenya in 1967. It is a late maturing type with a small round white seed with a matt surface. It is a canning variety and is unpopular as a dry bean because of its small seed size. It is moderately susceptible to rust and anthracnose.

BEAN IMPROVEMENT

Germplasm

The bean germplasm collection comprises about one thousand accessions collected locally by the Commodity Research Team and FAO/IBPGR missions and introductions from CIAT and other sources.

Evaluation has been in progress since 1983-1984. Accessions (both local and exotic) with greater yield potential than the most recent highest yielding check, Carioca, have been identified. Some accessions also appear to be more resistant to major diseases and pests.

Varietal evaluation

Promising dwarf bean genotypes selected from local and exotic germplasm progress through preliminary trials (plots of 2 rows with 2 replicates at Msekera and Mbala) to National Variety Trials (plots of 4 rows with 3-4 replicates at 6-8 locations. In addition to Msekera and Mbala, the locations include: Misamfu, Mansa, Mufulira, Mutanda (high rainfall, cool region), Mt. Makulu and Kabwe (medium rainfall, warm). In the 1986/1987 and 1987/1988 National Variety Trials, five entries - PAT 10, PAT 78, PAT 12, A 429 and BAC 76 - were very promising, outyielding the improved check, Carioca.

Since 1986-87, materials selected from CIAT nurseries have been included in the Zambia Bean Yield and Adaptation Nursery (ZABYAN). The AFBYAN has also been evaluated for two seasons at Msekera and one season at Mbala (Table 5). Three varieties from the AFBYAN (BAC 76, T23 and A 197) and one from the ZABYAN (DOR 335) have been included in the 1988-89 National Variety Trial.

In addition to the above trials, advanced breeding lines of dwarf beans from CIAT are also evaluated in unreplicated plots at Msekera and Mbala. Special nurseries of red kidney, snap bean and sugar bean, received from CIAT, were also evaluated for the first time in 1987/1988 season at Msekera.

Little work has been done in Zambia on climbing beans though these are grown by small farmers as an intercrop with maize. Trials of climbing bean varieties were initiated by the Commodity Research Team in 1983-84 and, in 1986-87 and 1987-88, CIAT materials which had shown promise were evaluated across locations (Table 6). The best yielding entry, VRA 81054 has already been accepted for pre-release testing nationwide in 1988.

Disease resistance

Since 1982-83 a large number of genotypes has been evaluated for their yield potential and their resistance/tolerance to diseases in the major bean growing areas of the country. Disease observations have been made in replicated breeding trials and in unreplicated observation trials such as germplasm collections and CIAT advanced lines at Chipata (warm and medium rainfall zone) and Mbala (cooler and higher rainfall). Natural outbreaks of diseases are frequently uniformly severe with highly susceptible lines being destroyed, providing reliable screening of genotypes for resistance or tolerance to several diseases.

Materials showing least levels of disease have been included in disease nurseries, with frequent spreaders sown two weeks prior to the test lines.

Specific nurseries have been grown for BCMV at Msekera and for foliar diseases - scab, rust, angular leaf spot, anthracnose and ascochyta blight - at Mbala.

Table 5. Days to flowering, seed sizes and grain yields of entries in the African Bean Yield and Adaptation Nursery (AFBYAN) grown at Msekera (1986 and 1987) and Mbala (1987).

Entry	Days 50% flowering	Weight of 100 seeds (g)	Grain yield (kg/ha) 86/87a	87/88b
BAC 76	39	20	2049	626
K 20	37	37	1580	252
ZPV 292	35	35	1397	290
A 197	35	49	1196	465
Calima·	35	45	1333	213
PVA 1272	36	43	1257	233
Carioca	40	23	1176	255
Rubona 5	38	39	1109	318
Kirundo	32	33	1093	235
Kilyumukwe	32	39	1122	302
T 23	37	43	1045	275
G 2816	33	32	928	287
Black Dessie	39	18	957	249
Ikinimba	33	34	878	304
PVA 880	38	39	1025	149
Nain de Kyondo	44	21	799	344
T 3	38	23	822	196
PVA 563	39	37	869	88
Muhinga	33	28	762	151
Mbala Local	33	25	687	170
Kabanima	38	34	685	154
Red Wolaita	38	23	614	207
Urubonobono	34	29	584	211
G 13671	52	35	553	189
G 12470	40	45	464	170
Mean	37	33	999	245

In two seasons (1985/86 and 1986/87) at Msekera, twelve out of 100 entries in a BCMV nursery were found promising (Table 7). Tests of a set of differential cultivars suggest that the BCMV strain is NL3 in pathogenicity group VI.

Table 6. Performance of entries in Zambia National Climbing Bean Variety Trials intercropped with maize at several locations in 1986/87 and 1987/88.

Entry	Days to 50% flowering	Weight of 100 seeds (g)	Grain yield (kg/ha)	
			86/87a	87/88b
VRA 81054	51	28	512	708
ACV 8312	52	24	514	680
ACV 84032	55	34	443	695
ACV 84029	49	35	469	647
ZAV 8313	52	33	483	599
ACV 30	76	30	-	677
ACV 55	67	33	-	623
ZAV 8344	60	28	423	577
ACV 84034	69	28	-	588
ZAV 8349	58	35	415	516
VRB 81012	54	36	356	-
ZAV 8342	74	34	-	505
ACV 8316	62	26	-	490
ZAV 8332	58	31	335	-
ACV 22	65	27	-	469
ACV 36	70	27	-	467
VCA 81007	50	30	398	402
V 8354	59	20	-	392
ZAV 84177	57	23	-	343
ZAV 8391	126	-	45	-
Mbala Local	39	26	196	290
Mean	62	28	382	537

a) Mean of 4 locations
b) Mean of 5 locations

In a scab nursery at Mbala, thirteen entries, including Carioca showed low levels of scab and moderate to good yields (Table 8). These entries provide a wider range of choice of parents for cultivar development.

There has been less success in identifying genotypes resistant to ALS, AB and anthracnose. In 1985/86, out of 627 bean lines: four (Carioca, BAT 1671, A 262 and Nanzinde) were found resistant; 68 were moderately resistant; and 41 were tolerant. Of 1438 lines screened for AB resistance in 1985-86 at Mbala, none showed a high degree of resistance. Several lines (G 3737, G 3991, G 6040, G 9603, A 152, Mexico-6 and Diacol Calima) were moderately resistant and another 10 lines were tolerant. Only two lines (A 267 and G 15971) were resistant to anthracnose at Mbala in 1985-86. Ten others, including Carioca, were moderately resistant and 7 others were tolerant.

Table 7. Characteristics of BCMV resistant/tolerant lines selected from the BCMV disease nursery at Msekera in 1985/86 and 1986/87.

Entry	1985/86		1986/87	
	BCMV score (1-9)	Grain yield (kg/ha)	BCMV score (1-9)	Grain yield (kg/ha)
ZPV 292	1.0	1042	1.0	503
ZPV 248	1.0	730	-	-
G 7077	1.5	671	2.0	483
G 10357	1.5	677	1.0	375
G 13595	1.5	711	1.0	304
G 5066	-	-	1.0	207
ZPV 425	2.5	686	2.0	550
ZPV 294	-	-	2.0	575
ZPV 230	1.5	613	2.0	457
ZPV 318	2.0	1024	-	-
ZPV 299	2.5	934	-	-
ZPV 291	2.5	611	-	-
Mbala Local	7.0	308	5.0	296
Carioca	-	-	8.5	29
Mean	2.9	440	5.0	173
LSD (0.05)	1.9	305	1.6	199

Several major diseases are frequently observed on the bean crop in Zambia at the same time. This has led to the establishment of multiple disease resistance screening.

Of 100 entries screened for multiple resistance to ALS, AB and anthracnose at Mbala for two seasons, 13 were superior to the local check, Mbala Local (Table 9). Six of them were better than the improved check, Carioca.

Pest resistance

Beanfly has been the main focus of research since it is the major pest of the bean crop. The predominant species is *O. phaseoli*. *Ophiomyia spencerella* occurs commonly later in the season, while *O. centrosematis* is found to be of limited importance.

In order to study host-plant resistance, the Regional Beanfly Resistance Nursery has been conducted since 1986. The nursery was planted at Msekera during 1986/87 and 1987/88. A few entries, A 74, A 83 and BAT 1500 have been found promising. A 74 recorded least damage (both plant mortality and lodging) by beanfly. Its overall yield was 20 to 179% more than that of local checks, while BAT 1500 recorded the highest yield in Mbala despite the high level of beanfly damage. Further studies on the mechanisms of resistance and stability across environments are being taken up while the search for additional sources of resistance is being pursued.

Table 8. Characteristics of scab resistant/tolerant entries in scab nursery at Mbala in (1985-86 and 1986-87).

	1985/86		1986/87	
Entry	Scab (1-9)	Grain yield (kg/ha)	Scab (1-9)	Grain yield (kg/ha)
A 344	1.0	238	1.0	1616
A 262	1.0	333	1.0	1488
PAI 77	1.0	604	1.0	1477
Carioca	1.0	704	1.0	1368
RIZ 429	-	-	1.0	1365
A 442	1.0	979	-	-
PAT 10	1.0	879	1.0	1046
PAI 91	1.0	404	1.0	1241
997-CH-73	1.0	463	1.0	1032
VEF-84-1004	1.0	517	1.0	1007
G 4488	1.5	233	1.0	1191
PAI 78	1.5	550	1.0	1261
A 114	2.5	408	1.0	1271
A 485	8.5	21	-	-
ZPV 292	8.0	0	5.5	514
Mean[1]	2.9	440	5.0	173
LSD (0.05)[1]	2.1	272	0.8	467

[1]Based on 100 entries.

VARIETY RELEASE PROCEDURES

The release of varieties in Zambia is a responsibility of the Variety Release Committee composed of members of the Research Branch, Seed Company, Seed Control and Certification Institute, the University of Zambia and representatives of the Commercial Farmers' Bureau and Zambia Seed Producers Association. The Chief Crop Husbandry Office represents small scale farmers on this committee.

The release procedure has two stages: pre-release and release. For a variety to be accepted for the first stage of pre-release it must prove to be superior to commonly grown varieties. After approval for pre-release, sufficient quantities of seed must be available for further testing and multiplication. Immediately after pre-release, seed increase of the variety is the responsibility of the breeder of the variety. The seed however, cannot be certified until after a variety has been released.

Table 9. Characteristics of multiple disease resistant entries in foliar disease nursery at Mbala (1986-88)

Entry	1986/87				1987/88			
	Disease severity (1-9)			Grain yield (kg/ha)	Disease severity (1-9)			Grain yield (kg/ha)
	ALS	ANTH	AB		ALS	ANTH	AB	
G 6040	2.0	3.5	2.0	2053	3.5	2.0	2.0	1289
CC9-B44 (G 3607)	1.5	2.5	2.5	1967	-	-	-	-
A 345	-	-	-	-	1.5	1.0	2.0	1211
Negro 150	3.0	3.5	3.5	1841	-	-	-	-
BAT 448	2.5	2.5	3.5	1499	2.5	1.0	3.0	962
G 4459	2.5	3.0	3.5	1470	2.0	2.0	3.5	1101
Carioca	2.5	4.0	4.5	1427	2.0	1.0	3.5	258
RIZ 43	2.5	3.0	3.0	1425	3.5	3.5	3.0	930
NAG 37	3.5	3.5	2.5	1407	3.5	2.5	2.5	1104
G 1098-1C--1C	3.0	2.5	2.0	1347	1.5	1.0	3.0	1190
G 7199	3.5	3.5	2.5	1338	3.5	1.5	3.5	1024
G 8519	3.0	2.0	2.0	1330	2.5	1.5	2.5	988
G 11254	3.5	2.5	2.5	1305	3.0	1.5	2.5	1008
BAT 1510	2.0	3.0	2.5	1255	2.5	2.0	3.5	954
Mbala Local	5.0	2.5	3.0	433	1.5	2.0	3.5	239
Mean[1]	3.2	3.7	2.9	790	2.9	2.3	3.2	679
LSD(0.05)[1]	1.9	2.0	1.6	544	2.3	2.4	1.4	344

[1]Based on 100 entries.

A variety can be released two years after pre-release. During these two years, the variety is further tested by the Commodity Research Team (CRT) and other appropriate organizations. It is imperative that the variety is widely tested on-farm by the Adaptive Research Planning Team (ARPT) during these two years. The Seed Company and Extension Branch may also be involved in testing the pre-released variety. The end users' acceptance must be established during the two years of testing by the CRT, ARPT and the Extension Branch. Seeds used in the end users' test should be free of charge.

In addition, after pre-release, a new variety also undergoes a Distinctness, Uniformity and Stability Test (DUS-test) for at least two years. This test is conducted by the Seed Control and Certification Institute which reports its findings to all concerned.

The number of findings and trials necessary in the testing programme are stipulated by CRT and other parties concerned. As a rule, the numbers of sites and trials are more for release than pre-release.

For release, the performance field trials are done to an extent that all possibilities are given to assess and verify the new variety's performance, suitability for cultivation under various agro-ecological conditions and its adaptation. The number of testing sites will vary with the crop area and intended adaptation area for the particular variety.

Further testing comprises, where possible, resistance or tolerance to lodging, shattering, drought, diseases and pests. Other aspects tested are yield potential, earliness, plant height, utilization and recommendations of adaptation area. Where applicable, the testing also examines quality aspects, such as starch, protein and oil content and digestibility and cookability.

When a variety has been released it will be included in the Specified Varieties of the Seed Notice. The list is a legal document which includess all varieties accepted for certification.

The breeder of the variety or his representative has responsibility for maintaining and supplying parental material as well as authentic samples of released varieties until they are withdrawn from the Specified Varieties of the Seed Notice.

Initially, after a new variety has been released, the breeder or appointed representative supplies seed to be multiplied for pre-basic seed under supervision of the one responsible for further multiplication of the variety.

FUTURE BREEDING STRATEGY

The major areas of future breeding in Zambia are as follows:

1. Testing the adaptation of high yielding genotypes for different agro-ecological zones (medium and high rainfall).

2. Evaluating and exploiting local land races for higher yield and stability against stress factors.

3. Initiating a hybridization programme at national level in order to increase variability and combine major yield and stability characters.

4. Utilization of multiple disease resistant sources and further investigation of management of different diseases.

5. Search for additional sources of resistance to beanfly and means of integrated pest management.

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ZIMBABWE

Olivia Mukoko

ABSTRACT

In Zimbabwe, beans are grown mainly for their dry seed. Most are grown by small and large scale farmers in summer in Natural Regions II and III. In Natural Regions IV and V, they are produced in winter under irrigation.

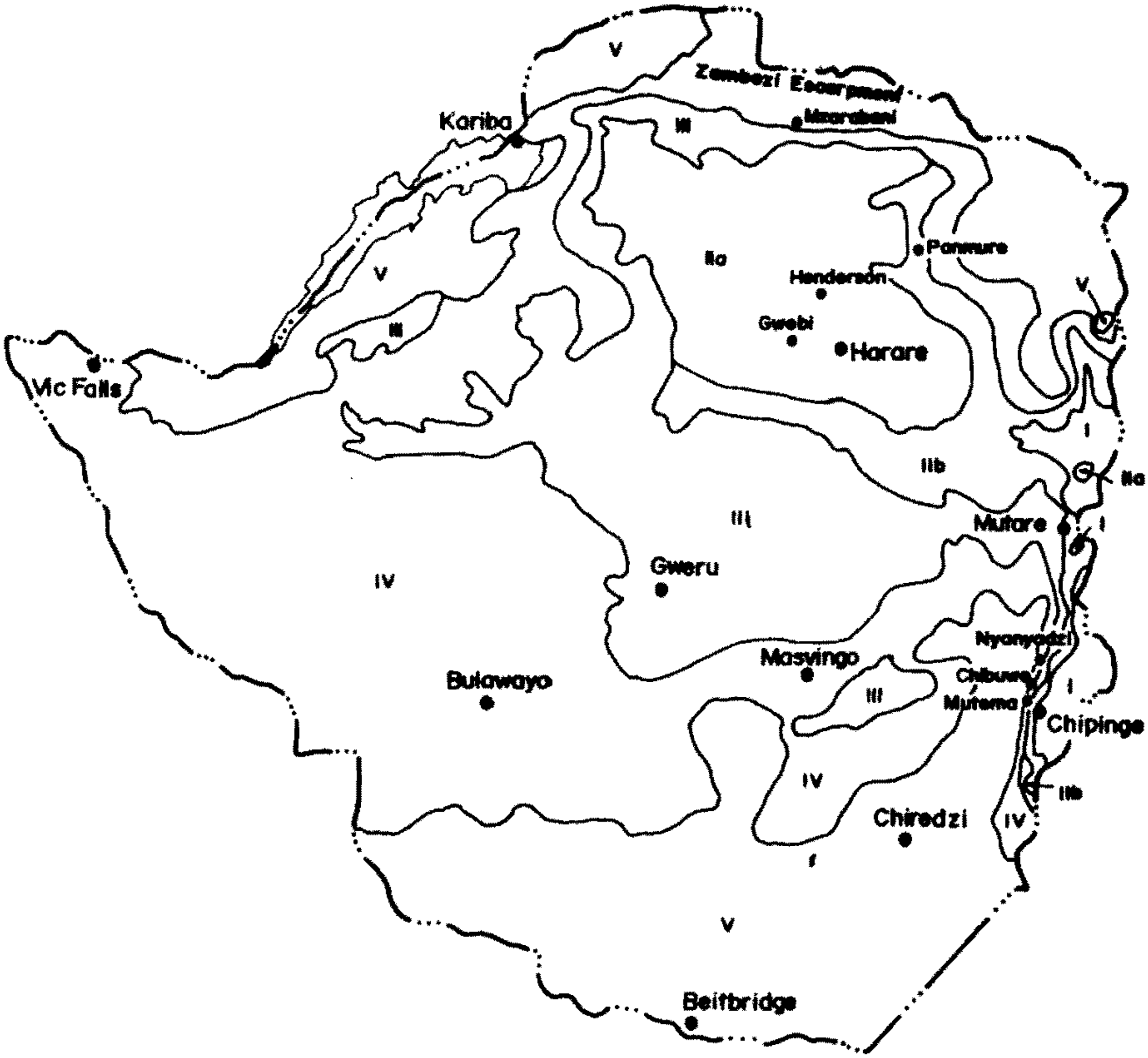
The cultivars Red Canadian Wonder and Natal Sugar are widely grown. Production and area have increased from about 8 thousand tonnes from 30 thousand hectares in 1980 to nearly 50 thousand tonnes from over 60 thousand hectares in 1986. Seed yields are poor (500 to 700 kg/ha), the chief constraints being diseases and pests. In trials, two- to threefold yield improvements over Natal Sugar have been obtained from introductions, mainly from CIAT. Procedures for varietal release are described.

INTRODUCTION

Common beans are widely grown in Zimbabwe mainly for their dry seeds, which are cooked and eaten as relish. They form an important source of cheap dietary protein. Beans have an amino acid composition complementary to that of maize, the staple food, and they are an important carbohydrate source (Matibiri, 1983). Maize and beans together provide a well-balanced protein, beans supplying the lysine (and to a lesser extent, the tryptophan) deficient in maize and maize providing the sulphur amino acids, cystine and methionine which are lacking in beans. Besides direct consumption, beans provide cash income for the producers.

Beans are grown in all the five agroecological (natural) regions of Zimbabwe which are classified on the basis of rainfall (Vincent and Thomas, 1960) (Table 1).

The bulk of the edible dry bean crop is grown by both small and large scale commercial farmers in Natural Regions II and III . The small scale farmers'crop is produced in summer and is completely rainfed. The large scale commercial crop is also grown under rainfed conditions but with supplementary irrigation. In Natural Regions IV and V, beans are produced in winter under irrigation. The main winter bean production areas are situated in low altitude (400 masl) zones in the south east and north of the country. In the south east, beans are produced on small scale irrigation schemes at Chiredzi, Chibuwe, Mutema and Nyanyadzi whilst in the north they come from Mzarabani, on the Zambezi escarpment (Figure 1).



NATURAL REGION		RAINFALL
I	Specialized and Diversified Farming	1000 mm
II	Intensive Farming Region	750 - 1000mm
III	Semi-Intensive Farming Region	650 - 800 mm
IV	Semi-intensive Farming Region	450 - 650 mm
V	Extensive Farming Region	below 650 mm

Figure I. Natural Regions of Zimbabwe.

Table 1 Main characteristics of natural regions

Natural Region		I	II	III	IV	V
Type of farming		Specialised/ diversified	Intensive	Semi-intensive	Semi-intensive	Extensive
Rainfall (mm)		over 1000	750-1000	650-800	450-650	below 650
Area 1000 ha	SSFA	26	26	51	66	45
	LSC	74	74	49	34	35
	Others	-	-	-	-	20

SSFA - small scale farming area
LSC - large scale commercial

The rainfed crop is usually planted from mid-January to early February and the winter crop in late May (Anon., 1980).

Currently, two varieties are widely grown:

1) Red Canadian Wonder, a red kidney bean with seed 1.5 cm or more in length.
2) Natal Sugar, with seed 1 to 2 cm long and a pinkish-buff base colour with red mottles.

These varieties were probably introduced from South Africa many decades ago.

Although beans are commonly grown as a sole crop, some intercropping with maize and other cereals is practised in small scale farming areas but it is not clear how much.

PRODUCTION AND AREA

Reliable production data is difficult to compile. Most of the production statistics available are either estimates or are delivery totals to the Grain Marketing Board (GMB), the government controlled purchasing body for all major food crops in Zimbabwe. Production statistics of marketed beans are however, not representative of actual production because a considerable proportion of beans does not reach the GMB as they are either locally consumed or marketed privately (i.e. through other outlets). Another factor contributing to the inaccuracy of production figures is that often several legumes may be grouped together under the general terms, dry beans or pulses.

Annual bean production prior to 1980 is summarised in Table 2. Table 3 shows annual production estimates post-independence.

Table 2. Bean production, area and yield in Zimbabwe before 1980.

Period	Sector	Area (ha)	Production (t)	Yield (kg/ha)
1951-55	LSC	2912	815	294
	SSF	39780	12417	312
1976-80	LSC	1098	459	421
	SSF	29500	8300	304

Source: J.R. Tattersfield (1982).

Table 3. Bean production, area and yield in Zimbabwe since 1980.

Period	Area (1000 ha)	Production (1000 t)	Yield (kg/ha)
1979-81	38	22	571
1983	62	45	726
1984	62	45	726
1985	63	47	746
1986	64	48	750

Source: FAO (1986).

CONSTRAINTS

Bean production in Zibwabwe is characterized by low yields, averaging about 500 to 700 kg/ha. The main factors limiting yields, and hence total production, include lack of well adapted varieties possessing resistance to disease and pests.

A total of twenty different diseases have been reported to attack beans in Zimbabwe (Grant, 1987). However, the seed-borne bean common mosaic virus (BCMV), common bacterial blight (*Xanthomanas phaseoli*) and halo blight (*Pseudomonas phaseolicola*) are the main diseases limiting bean yields. The use of untreated and/or uncertified seed increases the severity of these diseases since most farmers retain harvested seed for future planting.

Beanfly (*Ophiomyia* ssp.) is the major pest of the beans in Zimbabwe. A wide range of caterpillars such as the American bollworm (*Heliothis armigera*) attack beans at the podding stage particularly if the crop is following cotton (Archibald, 1974).

Another constraint to production is the limited research and extension work on the crop in the past.

CROP IMPROVEMENT

The bean breeding programme was initiated in 1984 for both rainfed as well as irrigated conditions. The programme aims at developing better adapted and heavier yielding varieties of beans with pest and disease resistance.

Since its inception, over one thousand lines have been introduced from various sources, mainly CIAT. Some of these lines have been selected for further testing in preliminary, intermediate and advanced variety trials. The environmental characteristics of locations where the trials are conducted are shown in Table 4.

Table 4. Environmental characteristics of locations in Zimbabwe where bean trials are conducted.

Station	Area	Altitude (masl)	Annual rainfall (mm)
Harare Research Station	Harare	1506	800
Gwebi Variety Testing Centre	Harare West	1448	800
Henderson Research Station	Mazowe	1292	800
Kadoma Cotton Research Station	Kadoma	1157	700
Panmure Experimental Station	Shamva	881	700

Some progress in yield improvement has been made through introducing material from CIAT. In the 1987/88 Preliminary Variety Trial (PVT), a total of 80 cultivars, were compared with the checks Natal Sugar and Red Canadian Wonder at two locations, Harare and Gwebi. Seventy-one of them produced better yields than Natal Sugar and 56 cultivars yielded better than Red Canadian Wonder.

In Intermediate Variety Trials (IVT), thirty six cultivars were tested at the three locations, Harare, Gwebi and Henderson. At all sites, all the introductions produced significantly heavier yields than Natal Sugar, the local check (Table 5). The mean yields of the introductions ranged from 2.16 t/ha to 3.00 t/ha compared with 1.04 t/ha from Natal Sugar, representing very large yield improvements over the local cultivar. These yields were obtained despite the occurrence of large numbers of plants with black root, confirming the presence of necrotic strains of BCMV.

Twenty-five cultivars were also included in Advanced Variety Trials (AVTs) at Harare, Gwebi and Henderson. At all sites, the the introductions produced better yields (14 to 26%) than Natal Sugar (Table 6), again despite large numbers of plants with black root.

Table 5. Seed yields of ten heaviest yielding cultivars in IVT at three locations in Zimbabwe in 1987-88.

Cultivar	Yield (t/ha)	Percentage more than Natal Sugar
RAB 263	3.00	188
XAN 191	2.93	182
PAN 131	2.92	181
RAB 303	2.92	181
CAN 31	2.91	180
AND 333	2.85	174
PAN 125	2.81	170
RAB 296	2.81	170
RAB 311	2.79	168
PAN 134	2.79	168
Natal Sugar	1.04	

Table 6. Seed yields of ten heaviest yielding cultivars in AVT at three locations in 1987-88.

Cultivar	Yield (t/ha)	Percentage more than Natal Sugar
Puebla 152-Cafe	2.68	141
A 86	2.65	139
BAT 37	2.56	131
PAN 10	2.54	129
ICA TUI	2.52	127
P 326	2.51	126
Carioca	2.50	125
A 73	2.48	123
A 107	2.47	122
Jutiapa	2.42	118
RAB 134	2.79	168
Natal Sugar	1.11	

Crosses have been made among high yielding, disease resistant materials, between local cultivars and high yielding, disease resistant lines and between local cultivars and known sources of resistance to common bacterial blight. Segregating populations are being advanced by the single seed descent method.

The breeding programme is also evaluating several nurseries, including: the bean-fly resistance nursery; the international BCMV/black root nursery; and the African bean drought nursery.

PROCEDURES FOR RELEASE AND MULTIPLICATION

To date, no improved bean variety has been released but the normal variety release procedure is outlined below.

A crop release committee decides whether a line proposed for release by a breeder has merit. Once the committee has approved the release of a line as a variety, the breeder releases Breeders' Seed to the Seed Co-op Company of Zimbabwe. The Seed Co-op is responsible for the production of Foundation Seed A, then Foundation Seed B and Certified Seed. At all stages the crop is inspected thoroughly. The certified seed is then sold to growers for commercial cultivation.

FUTURE PERSPECTIVES

Breeding for resistance to the most prevalent diseases will continue to be an important objective of the breeding programme. The production of certified seed that guarantees breeding quality and is disease-free should enhance bean production in Zimbabwe and there are plans to develop a bean certification scheme. There is also a need to develop effective bean grain storage methods and there are plans to intensify work on grain storage.

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SESSION VII - SOUTHERN AFRICA COUNTRY REPORTS - DISCUSSION

Rojoa: In Mwandamele's presentation, he showed a range of farming systems with beans in Tanzania. Why should this be? Are there differences in productivity?

Mwandamele: The main reason in that Tanzania's environment is variable and that different systems have evolved in different places. For instance, in the south, the Matengo Pit System has arisen as a soil erosion control measure on hillsides.

Allen: If I may supplement Mwandamele's reply, I should like to emphasize that Tanzania is a large and diverse country. Bean production regions range from 500-1900 masl in altitude, from about 500-2000 mm in rainfall, falling in either a unimodal or bimodal pattern, and soils range similarly from fertile organic soils to poor, infertile and eroded soils. It is scarcely surprising that a wide range of cropping systems have been developed as a result.

Camacho: In Tanzania, you said you have three separate institutions working on beans. How do you avoid research duplication ?

Mwandamele: The separate institutions essentially have responsibilities for distinct agro-ecological zones.

Allen: Perhaps I might add that effective national coordination obviously helps in ensuring the separate programmes do not overlap undesirably. Dr. Clemence Mushi has recently taken over as National Coordinator, from Mr. Epimaki Koinange who has now left for his PhD.

Smithson: Please can you expand a little on seed multiplication and distribution procedures in Malawi.

Bokosi: These have been the responsibility of the National Seed Company on its own farms or contracted out to farmers. In future, extension agencies (ADDs) will play greater part through small farmers (artesanal seed production).

Nchimbi: What is your strategy for improvement of mixtures?

Bokosi: None yet but we intend to start composing synthetic mixtures. Trials of mixtures of rust resistance and susceptible materials are in progress.

Nchimbi: What is application of isozyme analysis to these studies?

Bokosi: Not really relevant at present. It is being extended to pathogens as well as seed types.

Sperling: The practise of intercropping coffee with beans is banned in Rwanda. What is the effect of this association?

Allen: Association is common in Tanzania and Zimbabwe. It is thought that food crops extract nutrients thereby reducing coffee yields but there is no direct evidence for this.

Baert: Intercropping of coffee with beans is banned in Burundi. Also cotton: beans because of heavy pesticide use on cotton. Beans are, however, found more and more sown into young cotton and harvested before pest control begins. Beans are also sown with sugar cane.

Mushi: There is some evidence from Tanzania that coffee nematodes affect nodulation of legumes but this needs confirmation.

Baert: Your application rate for endosulphan is five to ten times the rate we use in Burundi and a recent regional meeting in Bukava indicated that some bean genotypes show phytotoxic symptoms to endosulphan. Did you find any phytotoxic reactions in Zambia?

Mulila: A study is being undertaken this season to examine if endosulphan produces any phytotoxic reactions.

Musaana: Your data shows that many of the heavy yielding lines have relatively small seeds. Is this not likely to cause them to be rejected by consumers, as has happened to Carioca in certain instances?

Mulila: Carioca was rejected in northern Zambia on a combination of seed colour, seed size and leaf size. And some released (and accepted) varieties in Zambia have relatively small seeds.

Silbernagel: I wondered whether the high prices now paid for beans in Zambia is allowing and/or stimulating the farmers to use fertilizer?

Mulila: As prices have increased, more and more farmers are applying fertilizer especially in Eastern Province. Business men are now often contracting out to farmers and paying high prices.

Dessert: I would just like to comment that many of the RAB lines that are doing well in Zimbabwe are also doing well in Central America.

Pali-Shikhulu: The yield levels given appear very heavy for small farmers. Do you know the yields such farmers obtain?

Mukoko: The yield data given is an average for commercial and small farmers, and the latter obtain much higher yields than those given and their yield levels are very variable.

Davis: Amongst your heaviest yielding lines, only one is large-seeded. Do you not try to select and retain large-seeded types even if such types are not the heaviest yielders?

Mukoko: Consumers do prefer larger seeded types but with a high demand for beans medium seed size is acceptable. All the large seeded red types evaluated have not yielded well and large seeded speckled types have yet to be evaluated.

Allen: Maybe it would be appropriate at the on-farm trial stage to have the farmers evaluate the lines differing for seed size, for consumption preference.

Camarada: What trials have you received from CIAT?

Mukoko: So far the EP and IBYAN and this season, for the first time, segregating populations.

Mushi: Why do you undertake crosses between your local landraces and introduced heavy yielding varieties? Is it the stability of the land races that is of interest?

Mukoko: The aim of the crosses is to incorporate the desirable characteristics of the selected introduced varieties into the land races. Also most of the heavy yielding introduced lines are black seeded and such a seed type is not acceptable to consumers.

Tohme: I would just like to comment that in many countries a number of the superior performing lines introduced from CIAT have Carioca as one parent. The performance of such lines may reflect Carioca's ability to yield well in acid soils.

Massey: Yield *per se* is the most important criterion for me and surely farmers will accept a smaller seeded bean that has a much heavier seed yield than an existing large seeded variety. Perhaps we must 'sell' such heavy yielders to the farmers: people will eat anything if hungry.

Pali-Shikhulu: I would agree that farmers will accept a smaller seed size if it is combined with heavier seed yield.

Allen: I believe that there is greater flexibility for yield and seed size combinations in Africa than in southern America.

Masaya: On the same theme I feel that it may take some time for farmers to accept a heavier seed yield at the expense of a smaller seed.

SESSION VIII - COUNTRY REPORTS - SOUTHERN AFRICA

MOZAMBIQUE

Ir. Manuel I.V. Amane

ABSTRACT

Beans are the third most important grain legume of Mozambique. They are grown mostly for local consumption as dry beans but are also sold for urban consumption. In northern and central areas the crop is sown rainfed in November/December and February/March: in the south, beans are sown from April to June under irrigation. In 1970, 32,134 ha produced 10,167 t of dry seeds at an average yield of 316 kg/ha. They are found intercropped with maize and in monocrop. The principal constraints include: erratic or excessive rainfall; lack of suitable cultivars; inadequate technology; pests and diseases; and various socio-economic and institutional problems. Existing cultivars are mainly landraces, but evaluation of introduced and locally collected materials is now in progress. Seed multiplication and distribution are the responsibilities of SEMOC and Boror/Agricam.

INTRODUCTION

The common bean, *Phaseolus vulgaris* L. is one of the most important pulse crops grown in Mozambique, ranking third to groundnut and cowpea among grain legumes. They are mostly grown for local consumption as dry beans. However, immature pods are also consumed, mainly in urban areas.

In addition to meeting the subsistence needs of growers, who are usually small-holder farmers, beans are also sold for cash. There is a big demand in urban areas. The present shortage is reflected in the high market prices throughout the country.

BEAN ENVIRONMENTS

Beans are grown in two different environments. In the highlands of the northern and central part of the country, they are planted in November/December and February/March under rainfed conditions. The average rainfall during the growing period (November to June) is 1037 mm. The average minimum and maximum temperatures are 14.3°C and 24.8°C, respectively.

In the lowlands of the south, beans are grown under irrigation during the cool season in the months of April/June. The average rainfall during the growing season (April to September) is 117.9 mm. The distribution is erratic. The average minimum and maximum temperatures are 13.7°C and 28.3°C, respectively.

Most soils where beans are grown are sandy loams. In the south, beans are planted on silty loam alluvial soils.

AREA AND PRODUCTION AND DISTRIBUTION

Beans are widespread in Mozambique (Figure 1). Recent accurate estimates of the area and production of beans in Mozambique are lacking. In 1970, the total area occupied by beans was estimated to be about 32,134 ha, with total production 10,167 t at a national average yield of 316 kg/ha (Table 1). The provinces that produce beans in greatest quantity are Tete and Niassa, in the centre and north, and Maputo in the south. Overall, Niassa Province is the most important area of production.

Table 1. Bean area and production in Mozambique

Province	Area (ha)	Production (t)	Yield (kg/ha)
Niassa	7,616.1	3,870.4	508
Cabo Delgado	6.0	4.0	667
Nampula	278.8	162.4	583
Zambezia	1,519.5	802.7	528
Tete	9,465.0	1,610.9	170
Manica/Sofala	3,121.6	1,437.8	461
Inhambane	343.5	55.7	162
Gaza	4,747.2	607.0	128
Maputo	5,037.2	1,615.9	321
Total	32,134.9	10,166.8	316

Source: Anon (1970a)

BEAN CROPPING SYSTEMS

Beans are grown in Mozambique, in two main cropping systems: in intercrop with maize, and as a monocrop. The typical cropping patterns are shown in Figure 2. In some parts of the North, beans in association with maize, are planted alternately with maize on ridges. In the south, beans are interplanted between rows of maize. In monocrop, they are grown on ridges 70-80 cm apart with 10-20 cm between plants on the ridge.

CONSTRAINTS

The constraints to bean production in Mozambique are grouped in three categories: physical, biological and socio-economic and institutional.

Physical constraints

In southern parts of Mozambique, the rains are erratic and the moisture-holding capacity of the soil is very low. In the north,

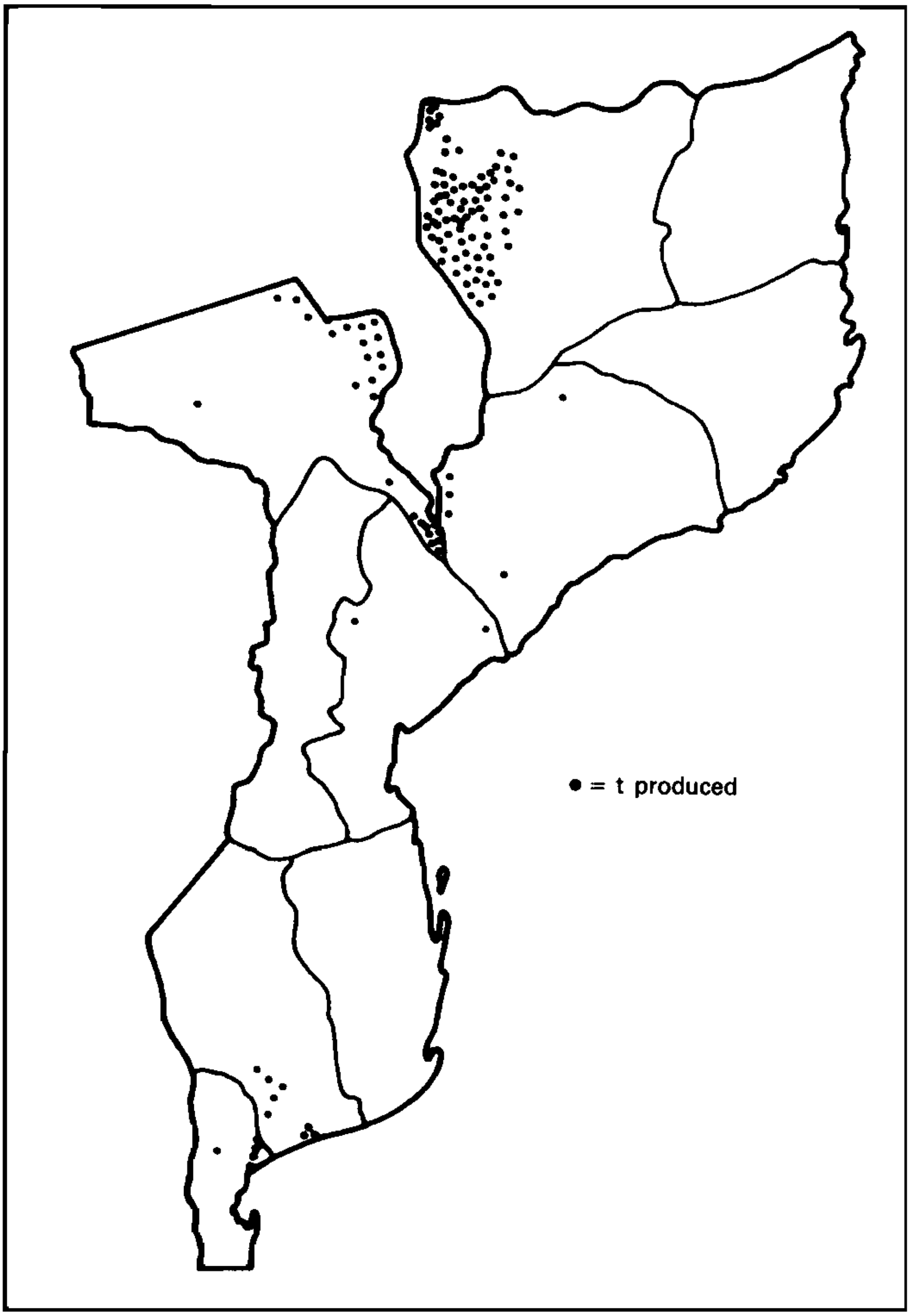

Fig.1 Areas of bean production in Mozambique

Source: Recenseamento Agricola (Agricultural Census) de 1970

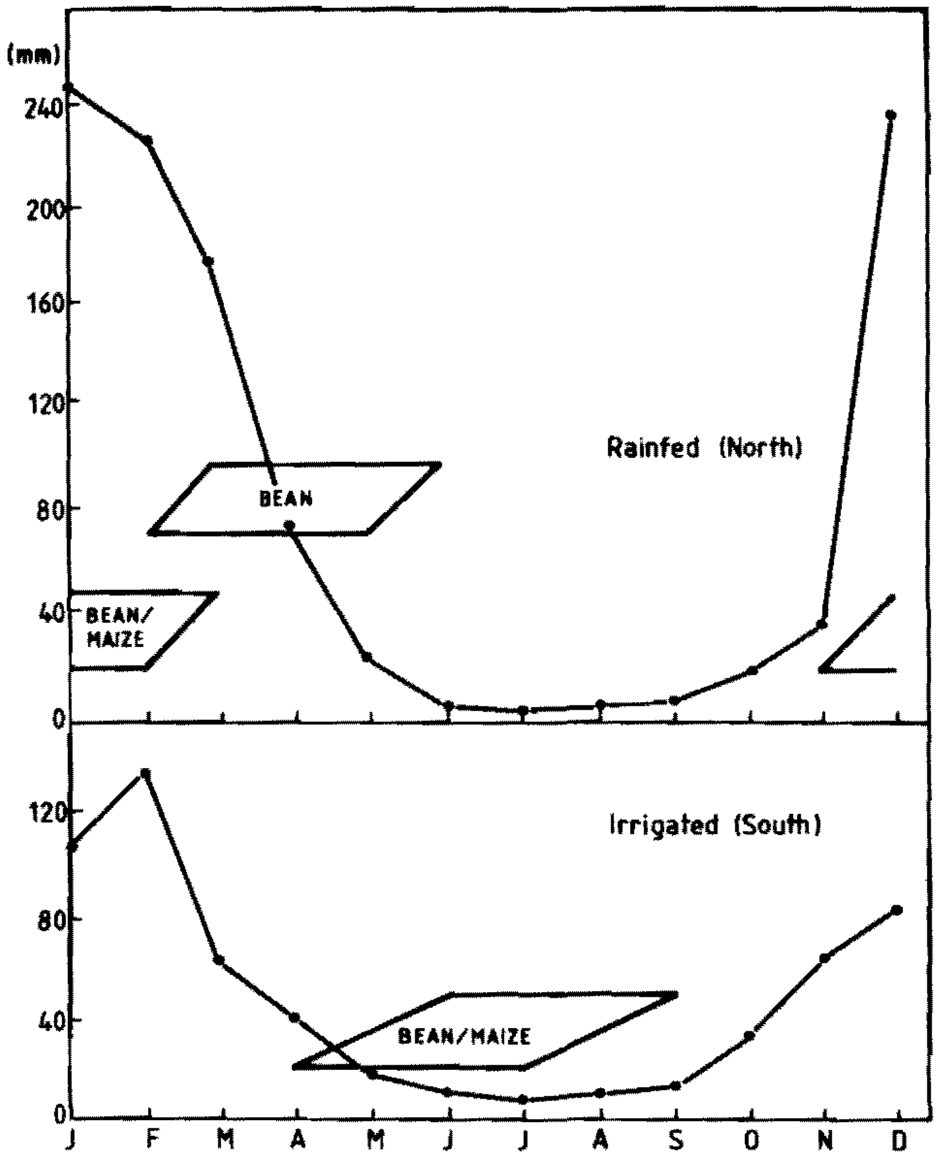

Fig. 2 Relation of cropping calendar to rainfall distribution

high rainfall causes soil erosion and leaching leading to low yields.

Biological constraints

The main constraints to bean production in Mozambique are the lack of suitable varieties, inadequate production technology and pests and diseases.

Farmers mostly grow local mixtures that sometimes exhibit pronounced differences in growth habits. Most varieties used by farmers are low yielders owing to their pest and disease susceptibility.

The most important field pest is bean fly, *Ophiomyia phaseoli* Tryon, which can reduce yields drastically in northern parts of the country. The damage is more prominent in February/March sowings than in November/December.

Other insect pests considered important are *Mylabris* spp. and storage pests.

Diseases also cause reductions in yield. The most important are rust, angular leaf spot and various bacterial and virus diseases.

Socio-economic and institutional constraints

Other important constraints to bean production are seed shortages, lack of agricultural training, insufficient research, the absence of a well-organized and well-managed extension services, shortage of inputs, particularly pesticides, and lack of capital to buy the inputs.

Long distances from production areas make transport of beans to market expensive. The railway network does not reach the places where beans are produced.

ORIGINS OF EXISTING CULTIVARS

Bean cultivars grown by small farmers in areas bordering other countries and are exchanged without control. Hence, it is not uncommon to see small farmers growing different cultivars. Cultivars/landraces were collected in 1982 and other genotypes introduced, mainly from CIAT, Brazil and South Africa. A list of indigenously grown and introduced cultivars is given in Table 2.

CURRENT BEAN IMPROVEMENT PROGRAMME

In spite of the importance of beans as a food crop, no significant research on beans was practised prior to 1982. Then, a modest bean improvement programme was started, the emphasis at that time being on varietal collection and evaluation of both local and introduced cultivars.

Table 2. Local and introduced germplasm

Country/institution	No. of samples
Mozambique	27
South Africa	11
Malawi	2
Zimbabwe	2
Argentina	2
Brazil	10
CIAT, Colombia	42
Total	96

Considering the increasing importance of beans in Mozambique, a more comprehensive bean improvement programme was developed in 1988. This programme focuses on the following aspects of bean improvement:

a) evaluation, purification and maintenance of introduced and locally collected materials;

b) hybridization; and

c) crop management with emphasis on *Rhizobium* inoculation and storage pests.

At present, purification of locally collected and introduced cultivars has been given high priority with the aim of using some of these materials in hybridization.

PROCEDURES FOR VARIETAL RELEASE AND SEED MULTIPLICATION

The National Agricultural Research Institute (INIA) is responsible for the implementation of the bean improvement programme. This institute undertakes preliminary and advanced yield testing at research stations located throughout the country.

Pre-basic seeds of the best performing varieties that are in the pipeline for release are produced at research stations. Seeds produced are then handed over to SEMOC (Mozambique Seed Company) to produce basic and certified seeds. Certified seeds are given to Boror/Agricom who are responsible for the distribution of seeds to farmers.

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ANGOLA

Castro Paulino Camarada

ABSTRACT

Beans are the most important food legume in Angola and the third most important food crop. The estimated area was 60,000 ha in 1972-73 - recent estimates are incomplete. They are grown mainly by small farmers, principally in the Central Highlands and the Malange Plateau, with a small area on the coast. They are sown in October/November (main season), February/March and July (dry, irrigated), usually intercropped with maize or cassava. The principal constraints include: shortage of good quality seeds; poor yielding cultivars; inadequate inputs; pests and diseases; and inadequate technical assistance to farmers. Local cultivars account for the majority of the crop. Their distribution and seed types are described. Local and introduced germplasm are being evaluated and three new cultivars are being multiplied for release.

INTRODUCTION

Beans, *Phaseolus vulgaris*, are extensively grown in Angola, where they are the most important food legume, and the third most important food crop after only maize and cassava.

Agricultural surveys conducted in the past by MIIA showed that in 1972-73 beans occupied an area of approximately 60,000 ha and that about 95% of this area was cultivated by small-scale farmers. According to the data from the Ministry of Agriculture the area under bean cultivation in 1986-87 was about 13,000 ha with an average yield of 350 kg/ha. In the current year the area under cultivation controlled by the Ministry of Agriculture is estimated to be 30,000 ha. These data are incomplete due to the war situation.

Since it is a subsistence crop, very little attention has been given to bean research in the past. In 1987 the Bean Research Programme was established as a joint activity of the Ministry of Agriculture's Institute of Agronomic Research (IIA) and the Faculty of Agricultural Sciences (FCA) in Huambo. The scientific staff, which is currently small and comparatively inexperienced, has concentrated its activities mainly on germplasm evaluation and on the improvement of bean cropping systems.

This brief report attempts to collate information that will enable the Regional Programme to assist the Angolan national programme in developing strategies for future bean research, particularly in varietal improvement.

AREAS OF BEAN PRODUCTION AND ENVIRONMENTS

The majority of bean farms are located in Agricultural Zones 24 (Region IX) and 3/14 (Region VIII) (Figure 1). These include the Central Highlands, comprising the provinces of Bie, Huambo, Cuanza Sul and part of Huila Province. Significant amounts of beans are also produced in the Malange Plateau and in Uige Province in the north. Some beans are also produced in the North Central Coastal Zone and along rivers of the Southern Coastal Zone.

Bean cultivation in Angola thus extends from high rainfall and relatively cool areas (the Central Highlands) to the warmer and semi-arid coastal areas. Climatic and soil conditions of the principal regions (IX and VIII) and part of the coast (II) are summarised in Table 1. However, beans are cultivated in other agro-ecological zones.

Table 1. Climate and soils in major areas of bean production of Angola.

Region[1]	Climate	Soils
IX	Humid to sub-humid, mesotermic[2] Mean ann. rainfall: 1000-1400mm (7 months) Mean ann. temperature: 18-21°C Mean relative humidity (9 hr): <70% Altitude (masl): 1750-1850	Mainly slightly ferralitic (UDULTS, USTULTS)
VIII	Sub-humid, humid to humid, mesotermic[2] Mean ann. rainfall: 1000-1400 mm Mean ann. temperature: 21-22°C Mean relative humidity (9 hr): 70-80% Altitude (masl): 1000-1250	Mainly para-ferralitic and psamoferralitic (UDULTS, USTULTS and PSAMENTS)
II	Semi-arid and arid, megatermic[2] Mean ann. rainfall: 300-600mm (5-6 months) Mean ann. temperature: 24-26°C Mean relative humidity (9 hr): 80-85% Altitude (masl): 0-250	Mainly aridic, aluviosoils and psamoferrialitic

CROPPING SYSTEMS

Beans are usually grown on small farms in some kind of intercropping system. In the north, they are intercropped with cassava and maize while, in the Central Highlands and the south, maize/bean intercropping is the dominant practice.

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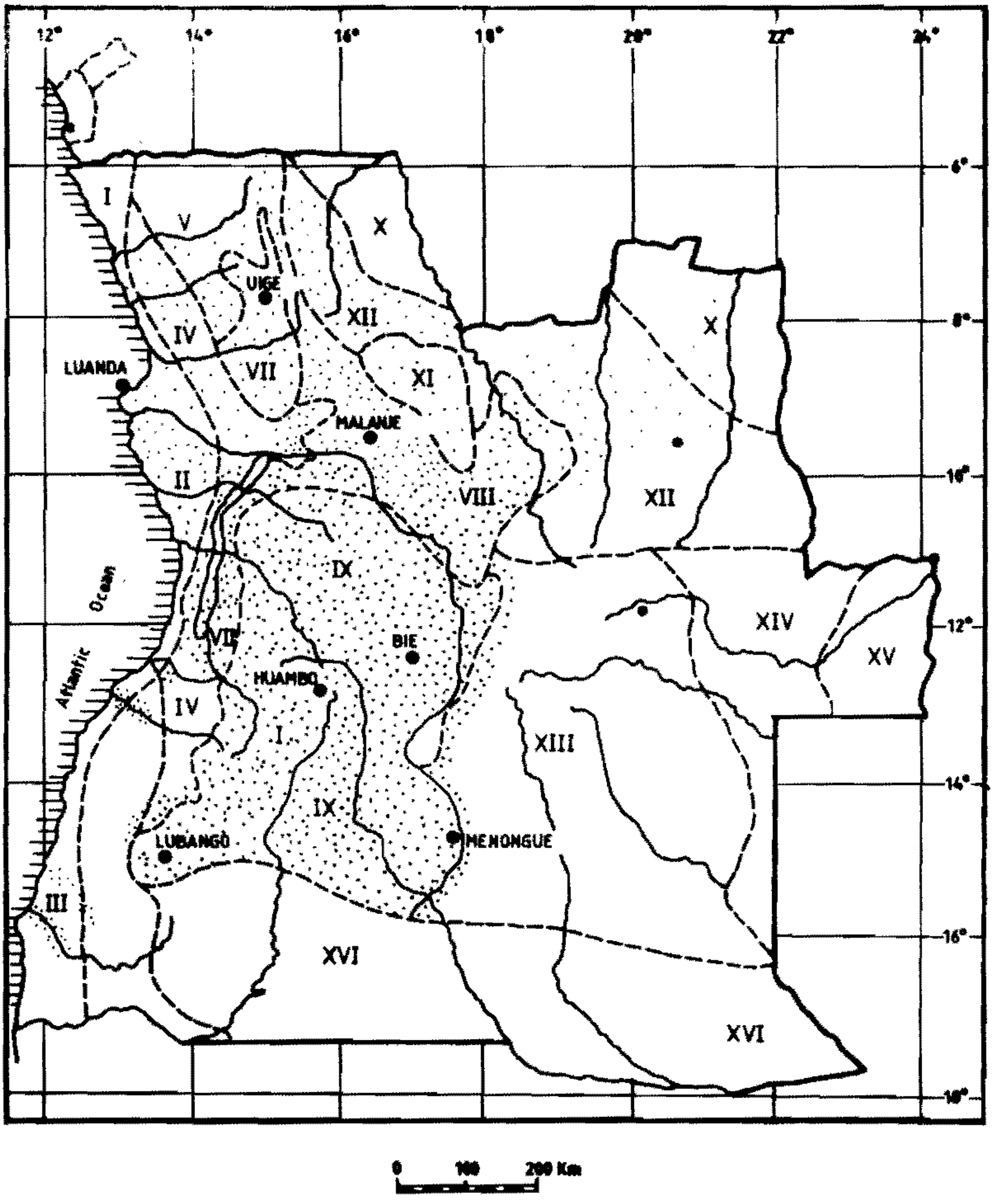
1 Adapted from Diniz e Aguiar (1969).
2 Thornthwaite classification

Figure 1. Angola major areas of bean production.



Adapted from Diniz (1969)

In Regions IX and VIII, beans can be cultivated in two seasons. The first season coincides with the beginning of the rainy season (Oct/Nov) and is more important. In this season, beans and maize are usually sown simultaneously on ridges. In the second season (Feb/Mar) some monocropping of beans is practised, sometimes on the flat. In the Central Highlands a third crop can be obtained from the lowlands (alongside rivers) in the *nacas*, where beans are sown with maize in July during the dry season. A third crop can also be obtained in the plateau area if irrigation facilities are available.

Usually farmers do not use inputs such as herbicides and insecticides, although some of them use fertilizers when available, but mostly applied to the main crop (commonly maize). Traditionally, it was common to leave land fallow for some time but, due to the instability in some areas caused by war, land around the protected villages is now under much more intensive cultivation and fallowing is no longer possible.

The main labour source is the farm family although some farmers supplement this with animal traction.

CONSTRAINTS TO BEAN PRODUCTION

The major constraints confronting bean production in Angola are:

Shortage of seed, forcing farmers to use poor quality seed purchased in local markets.

Poor yield potential of the cultivated local varieties

Inadequate farm inputs allocated to the crop

Pests and diseases. Leaf beetles cause significant damage. Anthracnose, ascochyta blight, rust and angular leaf spot are considered to be the most important diseases. Viruses are also conspicuous.

Inadequate technical assistance to farmers is an important institutional limitation.

BREEDING ACTIVITIES

Existing cultivars

Local cultivars account for the majority of the bean crop. Most are bush types (growth habits I, II and III) which were introduced centuries ago, presumably from Brazil, by the Portuguese. A pattern of regional distribution can be discerned. Manteiga or Perola (small,yellow) predominate in Bie Province while Ervilha is common in the Malange area. A green/yellow medium-sized bean (Calembe) is found in Huambo. Sondeombua (small-red) and Catiolo (small white) and striped beans are grown south of the River Cuanza.

The IIA maintains a small bean germplasm collection of about 100 accessions, including local and introduced materials, at Chianga. Some seed used by farmers is imported from Brazil by Angosementes.

CURRENT BREEDING ACTIVITIES

Before the establishment of the bean research programme, the National Seed Programme had identified promising materials in IBYANs obtained from CIAT and grown over three years at Lau, in Malange (Table 2) and are now preparing to multiply and release the three best. The comparatively high yields of Mulatinho types, also in Malange, are illustrated in Table 3. At the IIA, the main activities comprised germplasm maintenance and yield trials of local varieties. The results of two trials at Chianga are shown in Tables 4 and 5.

Table 2. Seed yields of promising entries in IBYANs.

Entry	Seed yield (kg/ha)	% of local check
RAB 64	1294	163
A 321	1211	152
RAB 59	1139	143
RAB 30	1136	143
PVMX 1591	1133	143
A 429	1133	143
A 445	978	123
PVMX 1589	953	120
RAB 94	905	114
Ervilha (TL)	794	100
BAT 1297	780	98
Raiado Escuro (TL)	628	79
PV 875	578	73
PV 1360 B	542	68
PV 901	392	49
Mean	906	
C.V. %	30.3	

Following the establishment of the Bean Research Programme, a small project of improvement by pure line selection was initiated at Chianga and single plant progenies are now growing in individual rows. The principal selection criteria are reactions to the main diseases (anthracnose, ascochyta blight and rust) and reproductive adaptation (pod load).

Progress has been made in assembling a local germplasm collection which is being evaluated in preliminary trials at Chianga.

Table 3. Seed yields of Mulatinho types.

Entry	Seed yield (kg/ha)	% of local check
EMP 150	1729	286
RIZ 64	1500	248
BAT 1780	1410	237
IPA 7419	1403	232
RIZ 62	1236	205
AFR 155	1111	184
AFR 120	1104	183
AFR 92	1028	170
AFR 153	889	147
AFR 102	882	146
AFR 154	882	146
AFR 143	819	136
AFR 129	611	101
Ervilha (LT)	604	100
Mean	1086	
C.V. %	21.5	

* Source: Annual Report, The National Seed Programme.

Table 4. Seed yields of local cultivars at Chianga.

Cultivar	Seed yield (kg/ha)	% of damaged seeds
FA 109	924	20.7
FE 75	885	8.2
FA 117	837	10.5
FR 99	805	32.0
FB 103	796	22.1
FC 25	776	24.6
FC 24	749	26.4
FA 114	740	12.3
FB 77	687	29.8
FE 20	685	9.8
FB 106	640	25.9
FA 115	626	23.8
FB 104	593	16.8
FB 108	553	21.7

Source: M. Ferrao (unpublished).

Table 5. Seed yields of 35 I.I.A. germplasm collection accessions.

Entry	Seed yield (kg/ha)	Entry	Seed yield (kg/ha)
FA 117	742	FP 34	467
FA 2	675	FE 75	454
FA 114	674	FB 103	452
FR 13	656	FA 27	450
FC 14	597	FR 48	442
FR 67	576	FE 74	436
FE 20	568	FB 77	416
FB 104	558	FB 111	402
FR 43	542	FC 24	378
FR 99	541	FB 105	376
FB 110	536	FA 61	357
FB 108	535	FA 115	334
FA 109	492	FC 25	309
FE 23	489	FE 7	277
FA 10	488	FB 106	272
FC 4	488	FR 50	253
FB 109	470	FE 9	193
LSD 5%	228	C.V. %	30.1

Source: F. Marcelino (unpublished).

Recently introduced International and African Bean Yield and Adaptation Nurseries are also being evaluated in the current season at Chianga, Huambo and further evaluations are planned for the coming season. The principal selection criteria are reactions to the main diseases and pests and productivity.

The next step will be to evaluate the best materials from the above trials in the Adaptation Varietal Yield Trial at locations in Malange (relatively warm) and Huila (high altitude and cooler).

SEED MULTIPLICATION AND RELEASE

Seed multiplication and release in Angola is the responsibility of the National Seed Programme (NSP), which is supported by FAO. The Bean Research Programme has developed collaborative links with the NSP and is responsible for breeders seed multiplication to supply the NSP.

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A NEW VARIETY OF BEAN FOR LESOTHO

Mrs. E. Pomela and Dr. G. Massey

ABSTRACT

Beans are a minor crop in Lesotho. During the past twelve years, areas have ranged between about 6 and 35 thousand hectares. They are grown as a sole crop or in association with maize or sorghum. The predominant cultivar is Small White Haricot, which is poor yielding (200 kg/ha) due to susceptibility to diseases, late maturity and poor pod set. Pintos (for example, NW 590, UI 126 and Olathe) and other introduced types have shown considerable yield improvements over Small White Haricot and Bonus in trials and larger plots on research stations and farmers' fields, and their seeds are acceptable to consumers. It is expected soon to release one or more Pinto cultivars. Good yield responses have been obtained from the application of 125-250 kg/ha of 2:3:2 fertilizer. Sowing later than mid-January results in considerable yield losses.

INTRODUCTION

The Agricultural Research Division of the Ministry of Agriculture is about to release a new cultivar of bean (a Pinto type). The new cultivar is heavier yielding with better disease resistance than present cultivars and may have export potential.

BACKGROUND

Common beans (*Phaseolus vulgaris* L.) have been grown successfully for many years in Lesotho, but the crop is minor in terms of area. During the past twelve years, the largest hectarage was 35,097 in 1975/76, and the smallest, 6,389 hectares in 1982/83. Beans are grown mainly for food although some of the crop has been sold to the RSA in the past. They are sown as a sole crop and in association with maize or sorghum.

Small White Haricot and Speckled Sugar (Bonus) are the two cultivars presently grown in Lesotho with the former being the more widely cultivated. Both cultivars are indeterminate and have the following disadvantages:

1. susceptibility to bean common mosaic virus and common bacterial blight;

2. a low flower production/seed set ratio;

3. asynchronous pod maturity;

4. a relatively long life cycle preventing the growth of two crops in a single growing season;

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RECOMMENDATIONS

Varietal release

Mulila-Mitti : Need widespread on-farm testing/validation trials

: should target varieties to zone where they will have maximum acceptability

Dessert : A small leaflet should always go with variety release. The leaflet should be prepared and distributed by the releasing institution. A new variety should not be just "released" but "launched".

Basic seed production

Silbernagel : Some of the problems with seed production could be alleviated if seed production personnel were involved in the process earlier - by exposing them, for example, to on-station and on-farm trials.

Certified seed production

Allen : Where national seed production is inadequate or can be complemented, due attention should be given to small-farmer seed production.

Bokosi : There must be a strong quality component with small farmer seed production.

Masaya : Small farmer seed production requires:

1. an area suited for quality seed production;
2. provisions for storage;
3. training of technicians and farmers; and,
4. credit for seed producers.

Dessert : Many national programs have difficulties guaranteeing the quality and quantity of basic seed.

Certified seed production

Baert : In Burundi, it is very expensive for the seed service (Services de Semences Selectionnees) to produce seed. It costs 100 FBu/kg and is sold for 40 FBu/kg.

Bokosi : In Malawi, with groundnuts, the national seed company contracts farmers to produce basic seed. Farmers then sell it back to the national seed company who also distributes it.

Masaya : There must be a premium price for seed for it to be of interest to the seed producer. In Guatemala, there has also been a bending or redefining of seed certification regulations. Small-farmer multiplied seed has become very acceptable. The quality is very similar to that of officially certified seed. Maybe, over the years, small farmer seed will become officially certified.

Seed distribution

Masaya : Package size should be restricted so that farmers can buy small quantities of seed, as they want. Selling in small quantities also discourages cheating/fraud in mixing seeds.

Sperling : In Rwanda we also have promblems of seed distribution. The central seed services distributes to farmers through development projects. Unfortunately, development projects often have a wealthier farmer bias. Poorer farmers thus don't have access to new varieties.

We have also found, that for poorer farmers, access to a new variety only once is not sufficient to enable them to maintain that variety among their stocks. Poorer farmers, in particular, often are forced to eat their seeds. They thus need repeated access to new varieties.

Dessert : Selling seed on consignement to retailer, perhaps at market centres, is an alternative to classical systems of seed distribution.

Baert : In Burundi, the seed service do sell seed in the market, in one or two kilogram quantities.

Baert	:	ISABU (in other words the breeder) directly releases seed. Two generations of seed are bred by ISABU and distributed to large development projects. Unfortunately, the seed service is breaking down. In the future, we will have to use state farms to distribute to projects. One problem is that, at present they sell seeds for consumption and not for planting.
Mussana	:	In Uganda, we have problems screening large amounts of data and in transporting seed to farmers in areas where it is most needed.
Venge	:	In Zimbabwe, breeders are required to write about varieties in the local agricultural journal.

Number of varieties:

Dessert	:	Mexico has released so many varieties that the seed production unit is unable to handle more.
Mulila-Mitti	:	There are similar problems in Zambia, with groundnuts as a result of which, the unit is not able to handle beans.
Abebe	:	In Ethiopia, the new varieties replace the old.
Dessert	:	Prefers system where the largest possible number of varieties is released because it gives choice to farmer.

Basic seed production

Mussana	:	In Uganda - it is the responsibility of the Seed Project, which has its own breeder.
Abebe	:	In Ethiopia, the breeders themselves are responsible.
Amane	:	In Mozambique, the national seed company produces basic and certified seed.
Baert	:	In Burundi, ISABU has special multiplication unit to produce basic seed. Soon the development projects will produce certified seed.
Mulila-Mitti	:	In Zambia, the breeders' responsibility to produce basic seed conflicts with their basic research activities. No one in Africa is currently contracting out basic seed production to farmers.

2. farmer-multipliers are identified. They should:

   a) have traditionally produced high yields of high quality seed;
   b) be well-known in the community;
   c) have sold to neighbours; and
   d) be strategically located.

3. basic seed is distributed to these "seed farmers"

Issue: do you give them the seed or do you sell the seed? In Latin America, farmers are willing to pay a premium for basic seed.

4. quality control by seed unit. Must monitor:

   a) agronomic practices
   b) use of fungicides
   c) fertility levels
   d) choice of area of production

Issue: should necessary inputs be given, or credit?

Eventually, good quality control will lead to: "certification" at farm level of seed based on its quality/purity and provision of farmer with tags, bags and publicity tools.

5. artesanal seed is distributed. Several options:

   a) sale of seed by farmer directly to neighbours or cooperative (at 20-30 % price premium)
   b) purchase by Seed Unit and redistribution to other areas, perhaps through network of on-farm trials or through markets (perhaps on consignment to retailers)

DISCUSSION

Varietal release

<u>Necessary criteria</u>:

Dessert : need to be sure variety is useful to farmer; need on-farm trials.

<u>Critical steps in process</u>:

Masaya : the problem of seed increase starts before the variety is released - perhaps we can use seed from on-farm trials to start to build up reserve for release.

In some cases, the variety itself may not be "acceptable" but, in other cases, very promising varieties have little chance of impact.

Central problem is follow through after varietal development. The breeder has responsibility for this follow through, both formally and informally. He must influence by his actions.

In a recent workshop on Basic Seed Production at CIAT the principal constraints to seed production identified were:

1. lack of funds
2. poor organization
3. poor planning

Varietal release

The initiation of release affects how a variety will be used. A principal problem may be lack of publicity. There may be:

- too little on-farm validation and demonstration
- poor distribution of seed to important areas
- lack of interaction with extension officers
- little availability of extension officers
- neither release ceremony nor decription pamphlet

Problems

1. poor release of variety
2. production of insufficient basic seed
3. production of insufficient certified seed
4. bottlenecks in distribution

Artesanal seed production

As a result of problems in both production and distribution of seed, many countries are today looking at "artesanal" or "farmer managed" seed production as a promising alternative.

The basics of artesanal seed production

1. breeder or seed unit produces or contracts out production of basic seed

3. a cooperative which will buy seed and resell the seed to farmers.

ISABU is responsible for:

- Pre-basic seed
- Basic seed which is then distributed to projects which multiply it by 2-3 times and sell directly to farmers.

Problems

1. ISABU can not control production processes.
2. There is little transport to follow-up and control seed distribution.

UGANDA and other countries noted the role of a Varietal Release Committee

- supporting data is presented to the committee
- variety must be tested in several sites at least three seasons

ZAMBIA release procedures are similar

- at least two years of testing required in national variety trials
- minimum amount of seed to be produced
- variety proposed to Varietal Release Committee and acceptance for pre-release
- additional tests on-farm
- end use acceptance tests
- purity tests
- larger increases of basic seed - by breeder.

Latin American experience

A great number of varieties are released but have little impact because:

a) the variety may not become known, i.e. little publicity

b) inadequate quality and quantity of seed is produced

c) seed is not adequately distributed

VARIETAL RELEASE/SEED PRODUCTION

Discussant - M. Dessert

ISSUES

Varietal release

- necessary criteria for release
- critical steps in release process
- number of cultivars to be released

Basic seed production

- responsibility
- location
- quantity
- funding
- seed quality control

Authorized ("certified") seed production

- responsibility - research institute, seed unit, seed company (state or private)
- quantity
- alternative production systems

Distribution

- access
- transportation
- alternative outlets

INTRODUCTION

African experience

There have been many references during this meeting to problems with seed production. For example, colleagues from both ZAMBIA and MALAWI noted that a major constraint is the failure of national seed companies to produce adequate quantities of seed and/or seed prices are so high that farmers will not buy improved seed.

Partially in response to such constraints, colleagues in Burundi are now initiating a system of contract seed production with farmers. Their selection of a region has depended upon the presence of:

1. a development project that can supervise farmer multipliers;

2. an ISABU sub-station in the region which can facilitate continuing close contact; and

g) The zonal nurseries and trials should be similar in design and layout as the Great Lakes PRELAAC and ERGL. The nurseries should have 100-121 bush and up to 49 climbing type entries. The trials should have 16 entries (bush and climbing).

h) The locations for nurseries for Zones B to D and the specific characteristics to be evaluated should be:

ZONE B	ZONE C	ZONE D
Drought - Melkassa	Anth - Mbeya	ALS - Bunda
CBB - Kawanda	HB - Misuku Hills	Beanfly - Msekera
Anth - Mabughai	Scab - Mbala	BCMV - Gwebi/Kadoma
Rust - Awassa	Acid soils - Huambo	HB - Machache
Beanfly - Arusha	Beanfly - Lichinga	Rust - Malkerns
Bruchids - Somalia		HB - Mauritius
BCMV - Morogoro		
Drought - Sudan		

j) Zonal trials should be at the same locations as and be the responsibilities of the centre responsible for the nurseries.

k) The best entries from the zonal trials should be promoted to the AFBYANs (bush and climbing), which should continue to be grown as a single set across regions initially with the aim of stratifying them ecologically in due course.

l) Possible names and acronyms for the nurseries and trials are:

ZONE B

East African Zonal Bean Evaluation Nursery (EAZBEN)
East African Zonal Bean Yield Trial (EAZBYT)

ZONE C

Central African Zonal Bean Evaluation Nursery (CAZBEN)
Central African Zonal Bean Yield Trial (CAZBYT)

ZONE D

Southern African Zonal Bean Evaluation Nursery (SAZBEN)
Southern African Zonal Bean Yield Trial (SAZBYT)

m) These recommendations to be conveyed by participants to their National Programmes and considered at the next meetings of the Steering Committees in each region to seek approval to proceed.

REGIONAL NURSERIES

Discussant - J.B. Smithson

DISCUSSION AND RECOMMENDATIONS

a) It was noted that a system of regional nurseries had been established in the Great Lakes.

b) The system comprises a PRELAAC, equivalent to the CIAT VEF, to which NPs contribute germplasm and advanced breeding lines. It is evaluated in hot spots for specific diseases and pests. There are tests of bush (about 120 entries) and climbing (about 50 entries) types. Both are simple lattices with 2 row x 2.5 m long plots and are organised by Rubona.

c) Regional trials (ERGL) are composed based on the PRELAAC and performance in national programme trials. They are grown at 2-3 locations in each NP. There are trails of bush and climbing types, both of 16 entries, in triple lattice designs with plots of 4 rows, 3 m long. They are organized from Rubona.

d) It was agreed to proceed towards similar systems in eastern and southern Africa but with an ecological rather than regional basis.

e) The ecological divisions proposed were as follows:

ZONE A. S.W. Uganda and W. Tanzania - to participate in Great Lakes system (PRELAAC and ERGL)

ZONE B. Ethiopia, C. Uganda, N. and E. Tanzania, Kenya, Somalia, Sudan.

ZONE C. S. Tanzania, N. Zambia, N. Malawi, N. Mozambique, Angola.

ZONE D. C. and S. Malawi, E. Zambia, Zimbabwe, Swaziland, Lesotho, Mauritius.

f) It was suggested that the following centres should be reponsible for organization of the zonal nurseries and trials.

CIAT,	Rubona, Rwanda	ZONE A	(as at present)
CIAT,	Kawanda, Uganda	ZONE B	
EPAD,	Msekera, Zambia	ZONE C	
CIAT,	Bunda College, Malawi	ZONE D	(when regional position filled)

Regional funds can be made available for organization of zonal trials and nurseries.

6. Because of difficulties of selection and current farmers' poor yields, breeding for yield potential is not justified.

7. Depending on capacity, breeding materials should be grouped to facilitate selection.

them, incorporating required characters successively. Wide adaptation is important in the sense of stability across cropping systems and seasons.

f) Breeding for yield - selection for yield has been shown to be unreliable in many crops. i.e. little correlation has been demonstrated between the yields of single plants and those of their progenies. Possible strategies are to select for specific characters like disease resistance or at random in early generations and evaluate a large number of progenies or families for yield in replicated preliminary trials as early as possible. Yield evaluation can be conducted in hot spots for important diseases to select for yield under prevailing conditions. Ultimately, the aim must be improved yield but the value of breeding directly for yield potential remains in doubt.

g) Farmers' needs. It is vital to evaluate breeding lines on-farm and feed results back into breeding programme. Breeders are responsible for on-farm trials in many countries. Since mixtures vary from farm to farm and are reconstituted by farmers before sowing, the most sensible strategy appears to be the development of pure lines for the farmer to test and include in his own mixtures.

h) Grouping of materials. It is important to group breeding materials for testing according to NP needs (for example by plant habit and seed type) in order to avoid omitting materials appropriate to farmers' needs, but this proliferates trials and may be difficult for NPs with limited capacity.

RECOMMENDATIONS AND CONCLUSIONS

1. Initially emphasis should be on introductions for quick impact which will foster credibility and support. Shift to emphasis on selection in segregating populations later.

2. Establish priorities and determine farmers' needs, existing and future, and establish feasibility of breeding.

3. Where NP capacity is inadequate or for incorporation of specific traits, crossing and early generation selection can be practised at CIAT. Regional sub-projects could generate crosses in Africa.

4. Parents must be properly evaluated. At least one should be adapted to local conditions and preferred by farmers. Best sources of desired traits should be identified.

5. Breeding for specific adaptation is more feasible than for wide adaptation but balance depends on diversity of environments.

SEGREGATING POPULATIONS

Discussant - J.H.C. Davis

DISCUSSIONS

a) Introduction versus hybridization. In general, it was agreed that this should remain an NP decision. It is necessary to develop expertise in crossing at least and it is in progress already in Ethiopia and Zimbabwe, but can only be effective if the programme has necessary capacity. In Lesotho, Uganda and Tanzania emphasis is on introduction to identify promising materials before venturing into hybridization.

b) Establishment of priorities. Important in order not to dissipate resources, especially when employing hybridization programme. Collection missions serve to identify constraints and determine priorities in Uganda. It is also important to determine whether progress is possible by use of hybridization i.e. is there sufficient variability, are there effective selection methods? Collaborative links can help to spread load where constraints are numerous.

c) Selection of parents. The first requirement is evaluation of materials in the environments in which they will be grown. At CIAT, breeding programmes had commenced using diverse parentage and without specific objectives - as knowledge was gained emphasis turned to incorporating specific characters. Also to distinguish between backgrounds (i.e. adapted materials) and sources (lines with desirable characters such as resistance to a disease or diseases). Parents of a cross should complement each other, for example an introduction which is excellent but lacking in a few characters would be crossed with lines possessing the characters. In general, all crosses should involve at least one adapted parent, though this needn't necessarilly be a local material.

d) Crossing at CIAT versus in NPs. Where capacity not present in NP, crosses and early generation selection can be practised at CIAT HQ, especially for incorporation of specific characters by back crossing. Where capacity exists crosses should be practised by NPs. Regional sub-projects will help to spread the load - for example, the drought sub-project (Zimbabwe, Malawi, Tanzania) encompasses hybridization of promising materials. Also, CIAT HQ does not have all the local materials to use as parents and it is important to develop expertise of NPs to conduct crosses if necessary.

e) Breeding for wide adaptation. Though specific adaptation limits wider use of improved cultivars, existing local materials have built up gene complexes adapted to the environments in which they are grown. These can be utilized to develop materials with specific adaptation. One strategy is to define agroecological zones and breed specifically for

Evaluation

- a 1200 sub-set of CIAT germplasm is available for national programmes in Africa, this sub-set represents the variation in the CIAT germplasm collection

- suggested that the 1200 sub-set be first screened at primary locations in a region and superior genotypes from this sub-set then be distributed to secondary locations in region, all the data recorded on the sub-set to be disseminated to national programmes

- screening of the 1200 sub-set in Ethiopia gave very different results at three locations

- Zambia, Zimbabwe, Great Lakes, Lesotho and Tanzania indicated a wish to screen the 1200 sub-set

- it was pointed out that there is considerable variation in the AFBYANs and VEFs and national programmes should consider utilizing these nurseries as alternatives to the 1200 sub-set which will require adequate facilities

- scoring should be done using standard scales (CIAT 1-9) and only more highly heritable characters should be evaluated

RECOMMENDATIONS

1. Identify geographic areas where collection is still required.

2. Obtain relevant data for germplasm accessions from Africa that lack complete passport data.

3. Make available to national programmes details of all CIAT's advanced breeding lines including parental information.

4. Notify CIAT and other agencies distributing germplasm of any change in a country's quarantine and/or phytosanitary regulations.

5. National programmes should inform CIAT once a year of their requirements for nurseries and breeding material with requests channelled through the national coordinator and CIAT regional coordinator.

6. Steering committees to recommend to SADCC on update and easing of present quarantine regulations to at least allow exchange of small quantities of seed.

GENETIC RESOURCES

Discussant - J. Tohme

DISCUSSION

Collection

- suggested that the Nordic Project in Lusaka could be approached to help in future collecting

- mixtures: a general discussion involved the following points:

  - problems of handling components from both a breeding point and possible changes in the frequency of components as a mixture is grown out for rejuvenation
  - the same variety may have different names in different locations and a different variety may have the same name in different locations
  - it could be important to collect samples of a mixture grown on different soil types

- ensure that adequate collections have been made of all local land races

- national governments should be persuaded/encouraged to establish seed storage facilities

- it was questioned whether future collections should be regular or occasional

- CIAT was asked to identify priority areas for collection

Preservation

- agreed that national programmes should be responsible for short term temporary storage and CIAT, Pullman etc. for long term (stressed that accessions for long term storage should be placed at more than one site).

- national programmes should ensure that they undertake collection of local material as in practice this is often given low priority

- medium term storage should be the responsibility of regional organisations (IBPGR)

Training

- national programmes should try and make use of facilities available from IBPGR and germplasm centres at Addis and Lusaka.

much excellent progress lately. And it is reassuring to note that the Uganda NP is yet again up and running after much hardship and self-sacrifice following times of dormancy, albeit based on the solid progress of the 1960s, the impact of which is still being felt in neighbouring countries from Ugandan cultivars.

The presentations from the Great Lakes to me clearly reveal the progress made from very effective regional collaboration, in an area where consumption is highest in the world. There are lessons here for many of us, including the work on mixtures of relevance to parts of SADCC.

The Malawi paper referred to the large germplasm collection held, admitting that more evaluation was required to identify superior materials with disease resistance. Tanzania, where lies the largest number of bean scientists in the continent, has made substantial progress with cultivar releases like Uyole 84 and Lyamungu 85. Two excellent presentations by Mulila-Mitti on Zambia and Olivia Venge on Zimbabwe showed large seed yield increments from introduced lines. In Zambia, Carioca has been released after out-yielding local cultivars, and now some eight materials are in turn outyielding Carioca. In Zimbabwe, since the breeding programme began in 1984, large (188%) improvements over local cultivars are being achieved on station from introductions, with yields in excess of 3 t/ha.

The young programmes becoming established in Mozambique and Angola are emphasising training and introduction of germplasm. Excellent progress is being made in Lesotho and Swaziland, where very large impact seems within reach.

The Future Strategy Session will be rather different from the others. There will be no papers as such. The discussants will set the scene raising ideas for open discussion, from which a set of recommendations will emerge for each topic. Rapporteurs for each topic are: HEG for Tohme, JBS for Davis, HEG for Smithson, and LS for Dessert. Matt Silbernagel will then piece the whole together as the finale.

SESSION IX - FUTURE STRATEGY

OPENING REMARKS

D.J. Allen

We now come to the climax of the workshop, from which we should strive to come up with specific recommendations.

The first day began with Joe Tohme's tracing of the genetic diversity available, and the status of work on centres of origin, including the importance of the Andean Zone in African landraces. He then went on to describe recent progress in breeding, including the use of wild types (eg bruchids) and species (CBB, Ascochyta, BF) as sources of resistance.

Matt Silbernagel described the CRSP contribution to NPs in Africa, and Masaya showed how a mature and highly successful NP in Central America had effectively used both local and introduced germplasm in developing a breeding programme, leading to actual increases in production and productivity in Guatemala and to national self-sufficiency. Dessert described the evolution of NPs within a regional network in Central America and the Caribbean, at first independently through collaboration with PCCMCA, then with input from CIAT, whose role was first in distribution of international nurseries (IBYAN) then to increasing decentralization, more use of segregating populations, as NPs strengthen.

Barry Smithson then drew attention to the need to increase the accurancy of deployment of germplasm, stressing opportunities to define ecological homologues among and between sites. He described a possible structure of primary and secondary locations for the evaluation of materials including regional trials like the AFBYAN. Jeremy Davis went on to describe recent progress and a structure for bean improvement in the regional programmes in Africa, with special reference to the Great Lakes. And finally, Louise Sperling elegantly emphasized the importance of involving farmers in varietal selection, so as to improve breeders' ability to meet farmers' needs.

A day in the lowlands then the foothills showed what potential for large gains there are in Lesotho for improving bean production, albeit from a small and young NP making some bold steps. The uniqueness of these sites (eg. Machache, at 2200 masl with only about 600 mm rainfall and so drought prone), underscores the importance of adaptation in varietal introduction. We also saw the key need to determine a means of seed increase on an appropriate scale and in a system unthreatened by halo blight.

The third day was devoted to country reports, from NPs of substantially differing capacity, age and achievement. Ethiopia again demonstrated the spectacularly heavy yields (more than 5 t/ha) that may be achieved in that country, where the NP has made

Baert: In Burundi, only 10% of the beans are grown for commercial sale and it is therefore imperative to consider consumer acceptance characteristics of consumption.

Massey: In Lesotho, it is difficult for farmers to grasp the concept that excess production can be sold.

Allen: The data from your trials in Swaziland show that you have lines yielding up to three times the local varieties. Are such varieties to be released and how near are you to making an impact on bean production?

Pali-Shikhulu: Last August, 10 lines were multiplied for testing in advanced variety and on-farm trials. We hope to release a variety next August.

Allen: Do you have any problems in seed multiplication?

Pali-Shikhulu: No problems as seed multiplication is handled by the large estates.

Allen: What are the varieties you are considering for release?

Pali-Shikhulu: PV 782 and A 442.

Sperling: I would like to make a few general comments.

a) the discussions have become polarised between what are described as the breeder concerns - yield and disease - and what may be 'farmer' reasons for rejecting a variety - colour, seed size, etc.

b) in between these we should consider a whole range of 'farmer concerns' which determine whether the farmer is going to be able to eat the beans, ie:

- in Uganda a high yielding variety was rejected became it spoiled too quickly.
- in Ethiopia release of a variety was stopped because it had a long cooking time.
- in Lesotho a woman may not have enough fuel to cook a bean (that does not have a short cooking time).

In the above instances the 'theoretical' qualities of yield and disease resistance are useless. I feel we have to distinguish between traits which might be described as 'stylistic' (e.g. colour) and those which represent real constraints.

c) We all agree that yield and disease resistance are primary factors in creating productive varieties, but they are not the sole critical factors.

Massey: The key is to identify what are the viable constraints. But I feel that a farmer will adopt a new variety/agronomic practice once he has been shown that it markedly increases yield.

Pali-Shikhulu: Different constraints may operate for a farmer producing seed 'commercially' for sale compared to one growing seed for home consumption.

Allen: For Lesotho I feel that although the Pinto has proved successful one should keep the options open for testing other 'genetic' types.

Massey: The Pinto is not perfect as it is susceptible to certain diseases and we are examining other material in CIAT's trials.

SESSION VIII - COUNTRY REPORTS - SOUTHERN AFRICA (CONT.)

Camacho: What type of beans are grown in the maize/bean association?

Amane: In northern Mozambique, semi-climbers, and in the south, bush types.

Camarada: In Angola we are in the process of classifying the local varieties by growth habit, but climbing types are not common.

Massaya: In Mozambique, you indicated that you were attempting to purify your local collections. Is this wise as genetic diversity may be very important in cultivars?

Amane: We are not trying to purify but simply sort out and arrange the local collections as poor seed storage and management has resulted in the mixing of accessions.

Allen: The data from Angola indicates that many of the Mulatinho types are considerably heavier yielding than the local varieties. Are these types acceptable to the farmers?

Camarada: Green and creamish types are acceptable and we hope to release a variety in the near future.

Allen: With yield increase of 63% over the local variety such a release could have a dramatic impact on bean production.

Sperling: What is the yield of the Pinto bean with no irrigation?

Massey: Around 500 kg/ha.

Sperling: What percentage of farmers use fertilizer, and is fertilizer use confined to a particular wealth category?

Massey: Most farmers in Lesotho use fertilizer.

Sperling: Is much use made of manure/compost?

Massey: Owing to lack of wood for fuel, manure is largerly used for cooking. However, the 'wood lot' projects is an attempt in provide wood for fuel and allow manure to be used in the fields.

Dessert: Have you tested any Great Northern types?

Massey: Only one has been tested and this yielded poorly.

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Table 5. Seed yields (kg/ha) in National Bean Cultivar Trials in Swaziland in 1987/88.

Entry	Malkerns	Mangcongo	Nhlangano	Mean
Carioca 80	1869	1999	2017	1962
PVBZ 1782	1433	1924	2149	1835
BAT 1514	1617	1960	1600	1726
A 442	1239	2029	1873	1714
Umvoti	845	1490	2135	1490
PVMX 1589	1167	1193	2054	1472
BAT 1713	560	1469	1900	1310
Seminole	908	1385	1568	1237
PVA 781	514	1607	1305	1142
PVA 267	508	1119	1772	1133
PVA 894	794	1325	1179	1100
PVA 1216	639	1067	1041	1016
PVA 262	707	1271	1007	995
Contender	360	944	1020	775
Bonus	336	860	720	639

Source: Pali-Shikhulu (1988)

PROCEDURES FOR TESTING AND SEED RELEASE AND MULTIPLICATION

Testing procedures include:

(i) Introductions are first tested at one location for one season to assess disease resistance and general adaptation.

(ii) At the second stage of testing, the best performing lines are included in a national preliminary yield evaluation trial at two locations (one high-yielding and one low-yielding) for one season.

(iii) The third stage of testing involves evaluation in at least six on-station environments for a period of two years/seasons in National Advanced Cultivar Trials. During the off-season (winter), seeds of the best lines are multiplied to increase seeds for the next stage of evaluation and to provide a source of single plants for selection.

(iv) Prior to cultivar release, data from the Seed Authority's and from the on-station and on-farm trials are considered at an informal seed release committee comprising a rural sociologist, an agronomist and seed certification and multiplication officers and acceptable lines are then released.

(v) Maintenance of the released lines remains the responsibility of the Research Division whilst the production of certified seed becomes the responsibility of the Seed Multiplication Project.

Table 3. Characteristics of entries in the National Bean Cultivar Trial at Mangcongo in 1987/88.

Entry	Seed yield (kg/ha)	Yield/ plant (g)	Disease reactions Rust	CBB	BCMV
PVMX 1589	2054	2.5	R	R	R
A 442	2029	15.9	R	I	I
Carioca 80	1999	20.5	R	R	R
BAT 1514	1960	21.2	R	R	R
PVBZ 1782	1924	14.7	R	R	R
PVA 781	1607	15.3	I	R	I
Umvoti	1490	13.1	R	R	R
BAT 1713	1469	21.7	R	R	R
Seminole	1383	24.4	R	I	I
PVA 894	1325	12.8	R	I	R
PVA 262	1271	10.0	R	S	I
PVA 267	1119	13.1	R	S	I
PVA 1216	1067	9.9	R	S	I
Contender	944	9.0	S	I	S
Bonus	861	9.6	S	S	S
Mean	1500				

Table 4. Characteristics of entries in the National Bean Cultivar Trial at Nhlangano in 1987/88.

Entry	Seed yield (kg/ha)	Yield/ plant (g)	Disease reactions Rust	CBB	BCMV
PVBZ 1782	2149	15.4	I	R	R
Umvoti	2135	15.9	I	I	I
Carioca 80	2017	15.7	R	R	R
BAT 1713	1900	19.7	R	R	R
A 442	1873	14.4	R	R	R
PVA 267	1772	11.9	I	I	R
BAT 1514	1600	12.2	R	R	R
Seminole	1568	14.0	R	R	R
PVA 1216	1341	10.6	S	R	R
PVA 781	1305	10.5	I	R	R
PVmx 1589	1193	10.8	I	I	S
PVA 894	1179	8.5	I	R	R
Contender	1020	10.8	I	S	S
PVA 262	1007	9.1	I	R	R
Bonus	720	9.5	S	S	S
Mean	1519				

Table 2. Characteristics of entries in the National Bean Cultivar Trial at Malkerns in 1987/88.

Entry	Seed yield (kg/ha)	Plant stand	Yield/ plant (g)
Carioca 80	1869	51.3	18.1
BAT 1514	1617	56.3	14.0
PVBZ 1782	1433	54.3	12.7
A 442	1239	52.3	11.6
PVMX 1589	1167	47.3	12.4
Seminole	908	26.7	16.3
Umvoti	845	53.0	7.7
PVA 894	794	52.3	7.4
PVA 262	707	61.0	5.5
PVA 1216	639	53.0	5.8
BAT 1713	560	33.7	7.7
PVA 781	514	53.3	4.8
PVA 267	508	55.7	4.4
Contender	360	49.7	3.5
Bonus	336	41.7	4.1
Mean	900	49.4	9.1

Source: Pali-Shikhulu (1988)

At Nhlangano, seed yields were generally large (trial mean yield 1518 kg/ha) (Table 4). Again the Pintos and Cariocas performed better than Calima types and most entries were significantly better yielding than Bonus. PVBZ 1782 produced the heaviest yield (2149 kg/ha). CBB and, to a smaller extent, rust were the most serious diseases.

In general, introduced materials outyielded the local Speckled Sugar type (Bonus), in some cases by as much as 150 % (Table 5), and were superior in disease reactions, particularly rust. However, the best yielding entries are small-seeded and have indeterminate growth habits, which are neither desired by nor readily acceptable to small producers on SNL.

Six of these cultivars are in tests on farm to monitor their performance and to assess their acceptibility to producers before final release. They include, both small-seeded types like Carioca, PVMX 1589, BAT 1713 and PVBZ 1782 and two Calima types (PVA 781 and PVA 894) which yielded less, but are determinate with large seeds, characteristics more preferred by farmers.

and diseases rust, halo blight and anthracnose, though these appear to be of minor importance.

Limited agronomic inputs. These include: poor plant populations (less than 50 % of recommended); minimal fertilizer use; soil acidity; late weed control; and inappropriate cropping systems.

Lack of adapted bean cultivars and limited seed supply. Available cultivars include Bonus, Seminole and Contender, all of which have high yield potential under good management but perform dismally in poor conditions, because of their susceptibility to diseases and due to moisture stress. The latter arises from their long growth periods and late sowing.

Non-technical constraints

Non-technical constraints include: lack of bean production technology and therefore bean production orientation; lack of capital to purchase inputs; under-developed markets; and farmers' dislike of available cultivars.

BEAN IMPROVEMENT ACTIVITIES

From the results of these surveys it became evident that for increased bean production there is a need to address specific technological contraints in order of priority. The first step was to introduce new germplasm and to identify better cultivars than those in commercial use before undertaking agronomic research. This was felt of particular significance in view of the newly established Seed Multiplication Project which was charged with the responsibility of producing certified seed. The first introductions were nurseries from CIAT, which were evaluated initially in 1982. Bean research is still confined to introductions and selections from these nurseries.

Materials are selected on the basis of: tolerance to rust and BCMV; length of growing season; yield stability; and more recently, through the efforts of a rural sociologist, seed size, seed colour and acceptibility to producers and consumers.

National Bean Cultivar Trials were established in 1987/88, when they were conducted at Malkerns, Mangcongo and Nhlangano. At Malkerns, the best yields were obtained from small-seeded entries (Table 2). Carioca 80 produced the heaviest yields (1869 kg/ha). Several entries were significantly better yielding than Bonus.

Seed yields at Mangcongo were better than at Malkerns (Table 3). The smaller-seeded Pintos and Cariocas were again superior to small-seeded entries. PVMX 1589 produced the heaviest yield (2054 kg/ha). Several entries were better yielding than established cultivars.

Table 1. Area (000 ha) and percentages of area occupied by crops on SNL in a typical farming year.

Crop	Highveld		Middleveld		Lowveld		Lubombo		Total	
	Area	%	Area	%	Area	%	Area	%	Area	%
Maize	15,608	87	28,439	75	10,154	47	4,735	82	58,936	71
Cotton	0	0	3,244	9	8,262	38	69	1	11,575	14
Sorghum	382	2	968	3	750	4	72	1	2,162	3
Dry beans	623	4	986	3	186	1	222	4	2,017	3
Pumpkins	400	2	1,091	3	320	2	201	4	2,012	3
Irish potatoes	26	0.1	115	0.3	0	0	0	0	141	0.2
Tobacco	255	1	160	0.4	2	0	0	0	417	0.5
Others	655	4	3,294	9	1,953	9	471	8	6,373	8
Total	17,949		38,287		21,627		5,770		83,633	

Source: Seubert (1988)

CROPPING SYSTEMS

Three types of cropping systems are commonly employed in bean production:

(i) On SNL, early sown beans are with maize as a food supplement when maize reserves are low. Intercropped beans account for 17 % of the total bean production. Intercropping is most common in the lowveld (34 %) and least in the highveld (10 %).

(ii) Also on SNL, beans are sown late (January-March), as a sole crop after the sowing of the main cereal crop. The practice is evidently designed to avoid diseases and to ensure that the crop matures during dry weather.

(iii) Beans are also grown under irrigation. Such practice tends to be confined to large scale farms in the lowveld, where the crop may be sown in late June, when the risk of frost has receeded, or in February/March, when temperatures have fallen from their summer highs.

CONSTRAINTS

During 1982/83, diagnostic surveys were undertaken to determine farmers circumstances with respect to bean production. These studies identified several bean production constraints, which have classified as "technical" and "non-technical" (Seubert, 1988).

Technical constraints

Biotic factors. The most common are pests including the CMR beetle (*Mylabris* spp) and the bean fly (*Ophiomyia centrosematis*) lies between the 25th and 28th parallels and has a climate which is basically subtropical. Altitude ranges between 100 and 1800 masl. The country is divided into four major agroecological zones on the basis of altitude and rainfall.

The main features of these zones are briefly outlined:

Highveld: Mean altitude is 1300 masl. Annual rainfall ranges between 1000 and 1500 mm, mostly falling during tthe summer, and is both reliable and evenly distributed. Temperatures are mild, ranging during the growing season between 20 and 25°C.

Middleveld: The middleveld is generally hilly but includes large valleys of lower relief. The mean altitude is 700 masl. The climate is warm and sub-humid with summer temperatures of 20-30°C. Mean annual rainfall ranges between 750 and 1000 mm. The east is distinctly drier than the western sector.

Lowveld: The lowveld is gently undulating, with a mean altitude of 200 masl. Summers are dry and hot and rainfall varies markedly. Annual rainfall is about 500 mm and ranges between 400 and 700 mm but is poorly distributed: as a result, the zone has an 80 % drought risk. Temperatures are high, being in the range of 14° during the winter and 30° in the summer.

Lubombo: Located in the extreme west of the country, the zone has altitudes ranging between 250 and 850 masl and a sub-humid climate with annual rainfall in the range of 600-1000 mm.

RELATIVE IMPORTANCE

From Table 1, the following conclusions can be drawn regarding the pattern of land use on SNL:

(i) Maize is by far the most important crop for smallholders.

(ii) Dry beans occupy a minor proportion of the total arable land mass (3 %) which amounts to 2,000 ha.

(iii) They are an important component of the crop mix in the highveld and Lubombo but much less so in the lowveld.

(iv) The middleveld is the most important bean producing zone of the country in terms of area, not unexpected considering temperatures and rainfall.

During the past three years, large scale commercial farmers and sugar estates have taken to bean production and it is estimated up to 500 ha may already be under the crop. It is anticipated that this trend will continue and acreage expand.

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SWAZILAND

Mr. John Pali-Shikhulu

ABSTRACT

The dry bean is the most important legume grown in Swaziland. Area has varied between 2,167 ha in 1976 to 1500 ha in 1983, accounting for only 3 % of the total arable land. Average yields are poor (200 kg/ha). Four agroecological zones are distinguished - highveld, middleveld, lowveld and Lubombo - of which the middleveld is the most important for bean production. Beans are usually grown in intercrop with maize when sown early and as sole crops when sown late or irrigated. The main constraints are: pests and diseases; and lack of inputs (including seeds of suitable cultivars), production technology, capital and markets. CIAT materials have exhibited substantial yield improvements over the recommended cultivars, Bonus and Contender, and six are being tested on farm. Systematic testing and seed release and multiplication procedures have been established.

INTRODUCTION

The dry bean *Phaseolus vulgaris* is the most important legume grown in Swaziland. The area under production varies from year to year (Anon,1976; Anon, 1985). On Swazi Nation Land (SNL) in 1976, it was estimated at 2,167 ha. In 1983, it was 1,500 ha. Total production has shown an even greater decline, from 1,000 tonnes in 1976 to only 500 tonnes in 1983. Average yields in general are low and are estimated at about 200 kg/ha, ranging from 40 kg/ha in the lowveld to 500 kg/ha in the highveld. These yields represent about 25% of potential bean yields. Despite the importance attached to beans, national production still lags far behind consumption and large quantities of beans are imported to satisfy demand.

The importance of beans as a food crop cannot be over emphasized. Nutritionally, they are rich in vegetable proteins which are invaluable in preventing malnutrition, particularly in rural areas. The protein is more economic than that from animal sources and is rich in lysine and tryptophane which complement the amino acids of high-energy cereal-based diets.

It is for these and other reasons that Swaziland considers bean research crucial in the overall agricultural development of the country. An increase in production will not only improve the human diet, but also provide farm income and help reduce the volume of imports.

AREAS OF PRODUCTION

Swaziland has a total land mass of 1,736 thousand hectares, lies

4. Planting early in October with the first rains. Delaying planting reduces yield (Table 7) and very late planting (after 15 January) can result in crop loss from frost.

5. Sowing seed at a depth of 1.5 to 2.5 cm.

6. A plant population of 200 to 300 thousand plants/ha, which can be achieved with rows 0.5 to 1m apart and an intra-row spacing of 0.05 m.

7. Control of weeds either by timely hand hoeing or herbicide application. The two herbicides that are registered and available in Lesotho and effective are Eptam (EPTC) and Dual (Metolachlor). Eptam should be applied at 4 l/ha and soil incorporated immediately after application. Dual should be applied at 2 l/ha and can be physically incorporated with the soil or allowed to soak in with the rain. Both herbicides control weeds up to about sixty days and have no phytotoxic effect on beans.

8. Pollen beetles and American bollworm are the main insect pests which, if present in large numbers, cause economic damage. Both can be controlled by the application of the synthetic pyrethoids, Ambush and Cymbush.

9. The main disease problem is common bacterial blight, for which there is no economic chemical control. The recommended cultivars are resistant to BCMV, which is rarely a problem except in high rainfall years.

10. The relative short life cycle of the Pinto cultivars allows double cropping (hence maximising the return per unit area) by immediately planting a bean crop after completion of the winter wheat harvest. Beans should also improve soil fertility through nitrogen fixation.

In the same year, the three Pinto types, a further ten introduced cultivars and the local check, Speckled Sugar, were evaluated at Maseru Experimental Station. The Pinto genotypes confirmed their superiority by out-yielding the check in the range of 55 to 128% (Table 6).

Table 6. Seed yields (kg/ha) of introduced cultivars in early sown (28 October) trial at Maseru experiment station in 1987/88.

Cultivar	Seed type	Seed yield
Nodak	Pinto	2313
Harold	Pink	2294
NW 410	Pinto	2201
NW 590	Pinto	2150
Red Mex 59	Pink	2047
UI 126	Pinto	2036
UI 129	Pinto	1957
Wyo 166	Pinto	1821
Olathe	Pinto	1792
Pindac	Pinto	1718
GH 196-2	Pinto	1631
Cahone	Pinto	1596
UI III	Pinto	1568
Umvoti	Pinto	1086
Bonus	Speckled Sugar	1014
White	Tepary	813[1]

[1] Herbicide injury (Dual @ 2 l/ha)

ACCEPTIBILITY

Aside from the promising yield results, surveys, field days and seminars in the three Agricultural Research prototype areas, have shown that the Pinto bean is very acceptable to the local population. Farmers prefer to grow the Pintos rather than local cultivars and in nutritional studies cooked Pinto beans were an acceptable food dish.

RECOMMENDED AGRONOMIC PRACTICES

The following practices are recommended to achieve maximum yields:

1. Good seedbed preparation by deep ploughing followed by disking and harrowing to produce a fine tilth.

2. Use of the recommended cultivars, NW 590 and Olathe.

3. Application of 150 to 250 kg/ha of the fertilizer 2:3:2: Additional amounts do not improve seed yields (Table 6).

Table 3. Seed yields (kg/ha) of large-scale sowings of Pinto beans on research substations and farmers' fields in Lesotho in 1987/88.

Cultivar	Location	Area (ha)	Seed yield
UI 126	Teyateyaneng	1.3	532
Olathe	Machache	3.0	1190
UI 126	Mafateng	1.5	70[1]
Olathe	Matsieng	3.0	735
Olathe, NW 590, UI 126	Mohale's Hoek	4.3	812

[1]Excessive rain
All at spacings of 1 m between and 2.5 cm within rows

Table 4. Effect of fertilizer application on the seed yields (kg/ha) of Pintos and local cultivars at Maseru Research Station in 1987/88

	Rate of 2:3:2 fertilizer (kg/ha)					
Cultivars	0	2.5	5.0	7.5	10.0	Mean
Olathe	2031	2293	2365	2320	1758	2153
NW 590	1461	2562	2154	2077	1943	2039
Bonus	766	714	524	752	445	640
Small White Haricot	521	628	410	828	316	541
Mean	1195	1549	1363	1494	1116	

Table 5 Effect of sowing date on seed yields (kg/ha) of Pintos and Bonus at Maseru Research Station in 1987/88.

	Dates of sowing				
Cultivar	15 Oct	16 Nov[1]	6 Dec[2]	11 Jan[3]	Mean
NW 590	2664	37	149	97	737
Olathe	1878	47	261	246	608
UI 126	2048	20	73	115	563
Bonus	1313	4	72	68	364
Mean	1976	27	139	132	568

[1] Drought
[2] Excessive rain
[3] Excessive rain/late sown

5. poor seed yield (an average of 210 kg/ha in on-station tests over the last six seasons).

In an attempt to overcome these problems a range of new bean genotypes has been introduced for evaluation.

EXPERIMENTAL RESULTS

In an initial yield trial conducted at five locations in 1986/87, the introduced Pinto genotypes, NW 590, UI 126 and Olathe, were considerably heavier yielding than the two local check cultivars, Small White Haricot and Speckled Sugar (Table 1). NW 590 gave very acceptable yields on research sub-stations (525 kg/ha at Teyateyaneng and 805 kg/ha at Matsieng) and on farmers' fields in 1986/87 (Table 2) and 1987/88 (Table 3).

Table 1. Seed yields (kg/ha) at locations in Lesotho in 1986/87.

Cultivar	Seed type	Mas-eru	Mas-eru	Ler-ibe	Mas-eru	Mas-eru	Mean	Gross return (M/ha)[2]
Olathe	Pinto	1498	np[1]	np	np	np	1498	2996
UI 126	Pinto	1057	np	np	np	np	1057	2114
NW 590	Pinto	623	1036	812	504	651	728	1456
Bonus	Speckled sugar	553	497	np	252	448	441	882
Small White Haricot	White	378	343	280	245	56	259	518

[1] np = not planted
[2] at M 2.00/kg (M 1.00 = US$ 0.40)

Table 2. Seed yields (kg/ha) of NW 590 obtained by farmers of the LAPIS Project at Pela Ts'oeu in 1986-1987.

Farmer	Area (ha)	Seed yield	Gross[1] return (M/ha)
M. Nkhasi	0.003	1659	2272
M. Nkhasi	0.067	1253	1750
M. Roto	0.044	819	1148
Ms. Lesia	0.050	1050	1470

[1] at 1.37 Maluti/kg (1986/87 price)

In 1987/88 the three Pinto genotypes again showed marked yield advantages over the two checks in fertilizer and date of sowing trials (Tables 4 and 5).