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PREFACE

This volume reports the proceedings of a working group meeting of breeders from the Eastern Africa region.

This document is the 33rd in a series of workshop documents that serves research on bean (*Phaseolus vulgaris*) in Africa. This publication, and the workshop from which it arises, were made possible through support provided by the Office of Agriculture, Bureau for Research and Development, U.S. Agency for International Development, under grant No. LAG-4111-G-00-2026-00, and the Canadian International Development Agency (CIDA). Activities of the bean research networks in Africa are further supported by the Swiss Agency for Development and Cooperation (SDC). The opinions expressed herein are those of the authors and do not necessarily reflect the views of these contributing donor organizations, nor of CIAT.

Further information of regional research activities on bean in Africa that are part of these projects is available from:

Pan-African Coordinator, CIAT, P.O. Box 6247, Kampala, Uganda.

Coordinator, SADC Bean Network, P.O. Box 2704, Arusha, Tanzania

Coordinator, Eastern and Central Africa Bean Research Network (ECABREN), P.O. Box 2704, Arusha, Tanzania

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O.Z. Mukoko and N.W. Galwey. 1995. Breeding the Common Bean (*Phaseolus vulgaris* L.) for Resistance to Bean Common Mosaic Virus: Alternatives to Backcrossing. Euphytica 82:91-104.

INTRODUCTION

Bean (*Phaseolus vulgaris* L.) is a major source of protein and calories in Eastern, Central and Southern Africa and in many bean producing areas productivity is constrained by diseases (fungi, bacteria and virus), insect pests and low fertility.

Small-scale farmers, who are the principal producers of beans, have few or no resources to purchase chemical inputs to combat these constraints and improve productivity. Genetic improvement of the crop, through the development and dissemination of improved cultivars with a heavier yield and/or better tolerance to biotic and abiotic factors, therefore has a key role in increasing productivity. New cultivars allow the farmer to attain increased productivity without recourse to inputs and are easily integrated into his or her production system.

Specialist Working Groups on pathology, entomology and low fertility meet to discuss and advise the Network Steering Committee on the priority areas for research. The first Working Group Meeting of Bean Breeders in Eastern Africa brought together breeders from the national programmes in the region to review and discuss:

- the mechanisms for dissemination of elite breeding material between NARS programmes in the region and in Africa;
- variety development and dissemination;
- breeding and selection strategies;
- development of material with resistance to important biotic constraints;
- the current status and needs of NARS bean breeding programmes.

BEAN VARIETY DEVELOPMENT IN SOUTH WESTERN ETHIOPIA

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ABSTRACT

Two experiments were conducted in 1993 in South West Ethiopia, each comprising three trials in a randomized block design of three seed types, namely, white pea bean (WPB) large seeded bean (LSB) and medium seeded bean (MSB). The first experiment evaluated the yield of advanced lines on-farm and on-station and the second the yield of preliminary lines on-station.

Amongst the advanced lines only the LSB line, A 410, significantly outyielded its appropriate check and although liked by the farmers for its high yield was rated second to the LSB line ICA 1554 for consumer characters. Amongst the MSB lines the released cultivar, Roba 1, and A 265 were preferred. Farmers preferred larger seeded types. Only genotypes in the LSB group were inconsistent in their relative yield performance over sites.

In the second experiment there were significant differences amongst lines in all three groups for seed yield at each location and a significant line by location interaction in the WSP and MSB groups. Ten LSB and four WPB lines were significantly outyielded the appropriate check. A significant negative correlation was observed between yield and angular leaf.

INTRODUCTION

The food bean (*Phaseolus vulgaris* L.) is among the five most important food legumes produced in Ethiopia and is mainly grown at an altitude of 1400 to 1800 masl (1). The crop is important in South Western (SW) Ethiopia where it accounts for 15% of the total area under legumes excluding that under intercropping. Helo-Bore and Nada-Dedo Awrajas in Illubabor province and Gojeb, Gimbo and Shishinda from Keffa province are the main production areas. Farmers' yield is currently around 590 kg/ha (4) which is low compared to that on-station and largely reflects the low yield potential of locally available cultivars. To alleviate this problem nationally coordinated bean research in Ethiopia started in 1972 (5).

In the first ten years only local lines were collected and evaluated from markets and bean traders (5 and 6), whereas from 1983 introduced lines from CIAT (Centro International de Agriculture Tropical) in Colombia, dominated in trial evaluations. From testing conducted from 1972 to 1982 the national programme recommended following local lines for cultivation: the medium seeded Black Dessie, Red Wolaita, Canadian Wonder, Ethiopia Red, Negrome Central and 15 R-52; the white pea bean lines Mexican-142, Tengru-16 and Ethiopia-10 and the large seeded Brown speckled. Some of these are still in production (1, 2, 6). Though there was no detailed adoption studies, cultivars such as Red Wolaita, Black Dessie and Mexican 142 were widely disseminated and continue to be grown by many farmers.

The majority of these lines also yielded well at locations in the SW Region where the top yielders of this period were Black Dessie and Red Wolaita, Mexican 142 and Brown Speckled, outyielding the local cultivar Jima-Limu local by 169%, 162%, 99% and 77% respectively (Table 1). This represented a large increase in yield and production potential for the region.

From 1983 the national programme introduced and evaluated annually many lines from CIAT at Nazreth Research Station with adapted lines passed to different regions in Ethiopia to initiate regional testing; those with superior yield at Jimma are presented in Table 2. In 1989 introduced lines approved for national release as new cultivars were, namely, the white pea bean, Awash 1, and the medium seeded, Roba 1.

This paper reviews past research activities and the performance of advanced and preliminary lines tested in on-station and on-farm trials in the SW Region in 1993 and recommends a strategy to alleviate the current lack of new cultivars available to farmers for this region.

MATERIALS AND METHODS

Two sets of experiments were conducted in 1993.

1. Evaluation of advanced lines

Four medium seeded (MSB), five white pea bean (WPB) and four large seeded (LSB) advanced breeding lines were tested in three separate trials in a randomized block design with two replicates, at Jimma Research Center, representing the medium altitude (1750 masl), and on a farmer's field at Shishanda, representing the high altitude (2050 masl). Plot size was 8.0m^2 with a within and between spacing of 0.10m and 0.40m respectively. The released cultivars, Roba 1 and Awash1 and the local cultivar, Brown Speckled, were the checks for MSB, WPB and LSB trials respectively. Only a local WPB check could be obtained from the market.

Before planting, one hand cultivation and two harrowings by tractor were done at Jimma, while two oxen plowings and one time hand cultivation were done at Shishinda. Weeds were controlled by hand hoeing. At Jimma 100 kg/ha of DAP (18% N and 46% $P_2 0_5$) was applied at planting and 50 kg/ha Urea (46% N) three weeks after emergence; no fertilizer was added to the farmer's field at Shishinda as farmers do not use fertilizer.

Seed yield was recorded for each plot and analyses of variance conducted at and over locations; locations and varieties were taken as fixed effects. Farmers around Shishanda ranked lines and cultivars for seed color and size and taste.

2. Evaluation of preliminary lines

Seventeen WPB, eighteen LSB and twenty-four preliminary breeding lines were tested in three separate trials in a randomized block design with three replicates, at Jimma and Mettu with the same checks as above. Plot size was 1.60m x 4.0m with 3.2m^2 harvested. Spacing, land preparation and weeding practices at Jimma and Mettu were as above for the advanced trials at Jimma and Shishinda respectively.

One hundred kg/ha of DAP (18% N and 46% $P_2 0_5$) was applied at planting and 50 kg/ha urea (46%N) three weeks after emergence at Jimma; no fertilizer was applied at Mettu. Seed yield and disease ratings (on a 1-9 scale; where 1 was resistant and 9 highly susceptible) for angular leaf spot, common bacterial blight and flowery leaf spot data were recorded, with the analyses of variance undertaken as for the advanced lines. Correlations between disease scores and yield were calculated for each location.

RESULT AND DISCUSSION

1. Evaluation of advanced lines

Roba 1 at 2215 kg/ha, PAN 134 at 1960 kg/ha and A 410 at 2203 kg/ha were the top yielders across locations from the MSB, WPB and LSB groups respectively, but only A 410 exhibited a significant increase over standard or local check (Tables 3, 4, 5). A significant line by location interaction was detected only amongst the LSB lines (Table 6).

In the LSB group the Shishanda farmers preferred the brown-white spotted color and relatively large seeded line ICA 1554 to A 410, which has a smaller seed with a light green color (Table 7) but were highly attracted by the heavy yield of A 410. In the MSB group farmers selected the recently released cultivar, Roba 1, as best for seed size and color, whereas for taste A 265 was preferred (Table 7). Generally farmers showed a greater preference for large seeded types.

In most bean growing areas of the SW region red or black colored local cultivars with a medium seed size and indeterminate prostate growth habit predominate with WPB and LSB types grown only on a small scale. The major complaints of the farmers regarding low productivity are firstly, diseases, particularly angular leaf spot, common bacterial blight, anthracnose and rust.

And secondly, lack of alternative cultivars; little genetic variation was found in the farmers' fields as a LSB local cultivar was difficult to find at Jimma and none could be found at Shishinda. WPB local cultivars, however, were more readily available.

2. Evaluation of preliminary lines

The MSB, WPB and LSB preliminary lines differed significantly for seed yield at the two locations of Jimma and Mettu and across locations four WPB and ten LSB lines significantly outyielded the standard checks, namely, Awash 1 and Roba 1, respectively; no similar increases were detected amongst MSB lines (Table 8). There was a significant line by location interaction in all groups (Table 9).

Leaf diseases are considered an important yield constraint SW Ethiopia and across the two locations and three groups seed yield was negatively correlated with angular leaf spot on four occasions and common bacterial on one occasion (Table 10). This finding was in agreement with previous findings (6).

CONCLUSION

The following recommendations are made to solve the current varietal problem of farmers and formulate a future research strategy in variety development.

- Brown speckled, Awash 1 and Roba1 showed 140%, 28% and 47% yield advantage over the local check of their respective group and should be exploited by disseminating these to farmers. In addition the varieties will broaden the germplasm base of the farmers.

- The large seeded line, A410, significantly outyielded the local and standard check variety Brown speckled and will thus be submitted for release in the region to the variety release committee.

- Lines combining large seed with the colours brown, red or brown with white spots, good taste and fast cooking are much preferred for local consumption. So future research on beans should focus on these quality parameters in addition to seed yield.

- Farmers also much like growing WPB types for the market but fear low production and poor quality seed due to diseases. So, an effort should be breed disease resistant and high yielding WPB cultivars.

- The lines that significantly outyielded the standard check in the WPB and LSB groups will be tested further in the region for potential release.

- A large number of medium seeded lines should be introduced from CIAT to identify lines superior to Roba-1. Selection of lines resistant to angular leaf spot should be given priority.

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Table 1. Seed yield (kg/ha) of selected lines, released cultivars and local checks at three locations in South Western Ethiopia, 1972-1982.

Line/cultivar	Group[2]	Location[3]			Mean
		Jimma	Mettu	Gojeb	
Mexican-142[1]	WPB	2340(5)	1460(5)	1560(3)	1787
Black Dessie[1]	MSB	2930(5)	1600(5)	2720(3)	2417
Negro mecentral[1]	MSB	2810(5)	1560(5)	1530(1)	1967
Brown speckled[1]	LSB	1770(5)	1120(4)	1890(3)	1593
W-95-02		1920(4)	1430(1)	-	1675
ISR-52[1]		2510(3)	1460(2)	-	1985
ISR-42		2340(3)	1080(2)	-	1710
Epid sample		2170(4)	1080(2)	-	1625
Ethiopia-10[1]	WPB	1850(5)	1560(2)	1500(2)	1637
Ethiopian red[1]	MSB	2010(5)	-	1940(3)	1975
Red Wolaita[1]	MSB	2180(4)	1900(1)	2990(2)	2357
Mexican-142-R	WPB	2530(5)	1360(4)	1220(2)	1703
Tenggeru-16[1]	WPB	1260(2)	1480(1)	1690(1)	1477
ISR-66		1810(5)	810(2)	2900(1)	1840
ISR-57		2050(5)	950(3)	2780(1)	1927
Jimma (Limu) local Check.		900(1)	-	-	900
Jimma (Asendabo) local check.		240(1)	-	-	240

1. Recommended cultivars.
2. MSB: medium seeded; WPB: white pea bean; LSB: large seeded.
3. Number of years of testing in brackets; '-' not tested at the location. Source: Progress report of Jimma Research Center 1972-82.

Table 2. Seed yield (kg/ha) over five seasons of released cultivars and advanced lines at Jimma in Ethiopia.

Line/cultivar	Group[1]	Year					Mean
		1986	1987	1989	1990	1992	
A 265	MSB	2100	4662	3760	3503	1494	3104
A 445	MSB	1475	4096	3750	3447	1709	2895
Roba 1[2]	MSB	2471	4180	3610	3227	1427	2983
BAT 338-1-C	WPB	2412	3986	2280	2248	-	3006
BAT 1198	WPB	2781	3816	2110	3001	2156	2773
PAN 134	WPB	-[3]	-	2330	3512	2313	2718
Awash 1[2]	WPB	2567	4335	1710	3428	1906	2789
A 410	LSB	958	4043	1650	2974	2469	2419
ICA 15541	LSB	-	-	1470	2585	1375	1810
Brown speckled[2]	LSB	-	2624	1150	1643	906	1581

1. MSB: medium seeded; WPB: white pea bean; LSB: large seeded.
2. Released cultivars.
3. '-': not tested in this season.

Source: Progress report of Jimma research center of 1986-1992.

Table 3, 4, 5. Mean seed yield (kg/ha) across two locations of three groups of advanced lines, standard[1] and local checks 1993.

Table 3. Medium seeded lines.

Line/cultivar	Seed yield
A-265	2156
A-445	2137
Roba-1[1]	2215
Local check	1732
Mean	2060
CV (SP) %	14.4
LSD (5%)	NS

Table 4. White pea bean lines.

Line/cultivar	Seed yield
BAT 338-1-C	1650
BAT 1198	1390
PAN 134	1960
Awash 1[1]	1843
Local check	1094
Mean	1587
CV %	36.9
LSD (5%)	ns

Table 5. Large seeded lines.

Line/cultivar	Seed yield
A 410	2203
ICA 15541	1665
Brown speckled[1]	1396
Local check	581
C.V %	5.4
LSD (5%)	519

Table 6. Mean squares from anovar for seed yield across two locations of advanced WPB, MSB and LSB lines in 1993.

Source of variation	Group[1]/statistic[2]					
	WSB		MSB		LSB	
	df	mean square	df	mean square	df	mean square
Location (L)	1	54.501	1	214.769	1	296.311*
Variety (V)	3	10.866	3	9.494	2	27.646*
V x L	3	1.071	3	1.610	2	2.6177
Error	6	2.501	6	3.588	4	2.8646

1. MSB: medium seeded; WPB: white pea bean; LSB: large seeded.
2. *: significant at P=0.05.

Table 7. Ranks for lines and cultivars by farmers for three consumer characteristics at Shishinda.

Line/cultivar	Seed color	Seed size	Taste
Large seeded			
A 410	3	3	2
ICA 15541	1	1	1
Brown speckled	2	2	3
Medium seeded			
A 265	3	3	1
A 445	4	4	4
Roba	1	1	2
Local check	2	2	3

Table 8. Mean seed yield (kg/ha) of preliminary WPB and LSB lines that significantly outyielded the standard check of the respective group over two locations in 1993.

Line/cultivar	Group[1]	Seed yield
PAN 112	WPB	2844
EMP 175	WPB	2688
G 18330	WPB	1938
Awash 1[2]	WPB	1469
LRK 27	LSB	1734
SUG 49	LSB	1656
A 262	LSB	1656
AFR 372	LSB	1594
AND 635	LSB	1562
997 CH 173	LSB	1560
AFR 302	LSB	1515
ARF 406	LSB	1469
DRK 34	LSB	1468
A 195	LSB	1422

1. MSB: medium seeded; WPB: white pea bean; LSB: large seeded.
2. Released varieties used as standard checks.

Table 9. Mean squares from anovar for seed yield across locations for preliminary WPB, MSB and LSB lines in 1993.

Source of variation	White pea bean		Medium seeded		Large seeded	
	df	mean square[2]	df	mean square	df	mean square
Location (L)	1	0.828	1	0.6574	1	3.9254*
Variety (V)	16	0.1311**	23	0.0441**	17	0.0229
V x L	16	0.0722*	23	0.0339**	17	0.0578**
Error 6	64	0.0146	92	0.0131	68	0.0187
CV %		22.6		22.6		29.5
LSD 5%)		436		410		492

1. MSB: medium seeded; WPB: white pea bean; LSB: large seeded.
2. *, **: significant at P=0.05 and P=.01 respectively.

Table 10. Correlation coefficients[1] between seed yield and three leaf diseases[2] at Jimma and Mettu in 1993.

Group		Jimma			Mettu		
	df	ALS	CBB	FLS	ALS	CBB	FLS
Large seeded	16	ns	-0.62**	ns	-0.66**	-[3]	ns
Medium seeded	22	-0.52*	ns	ns	0.50*	-	ns
White pea bean	15	ns	ns	ns	-0.65**	ns	ns

1. *, **: significant at P=0.05 and P=0.01 respectively.
2. ALS: Angular leaf spot, CBB: Common bacterial blight, FLS: Flowery leaf spot.
3. No CBB ratings taken.

IMPORTANCE OF A ZONAL APPROACH IN BEAN BREEDING STRATEGY IN ETHIOPIA

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ABSTRACT

In Ethiopia beans (Phaseolus vulgaris L.) are grown in areas where there is great variation in climatic conditions, cropping systems and growers preferences' for specific bean types. Such variation does not justify the development and release of varieties based on general performance and a zonal approach to variety development is considered to be the best alternative, particularly for the food beans. When this strategy is effectively applied varieties with adaptation to specific agroecological zones can be released more quickly than the relatively longer time required to release a variety with wider adaptation. In some zones using two growing seasons per year for evaluation will also accelerate the release of varieties. These advantages will result in more efficient utilization of human, financial and genetic resources.

INTRODUCTION

It is often suggested that wide adaptation is obtained at the expense of high yield at specific sites. Because of diverse environmental conditions there is a growing tendency for decentralization of breeding activities to capitalize on specific adaptation for maximum yield (Singh 1991).

Although beans in Ethiopia are produced under a wide range of climatic conditions and cropping systems and there is variation in growers preferences' for specific seed types, varieties have been developed and released based on wide adaptation. As bean lines are usually inconsistent in yield over environments, high mean yield can reflect superiority in a few environments (Table 1 and 2). For example DRK 34 showed the heaviest mean yield over locations but was the fourth at Alemaya and Melkassa. Whereas AFR 302 exhibited the lightest mean yield over all locations but was the heaviest yielder at Alemaya (and among the poorest yielders at all other locations). Inevitably selection for wide adaptation has neglected specific adaptation and to rectify this the bean breeding program is giving currently more attention to decentralizing of the breeding activities.

The remainder this paper discusses aspects of bean production and research in Ethiopia that stress the need for zonal approach to variety development and mention some of the advantages which will be expected from this strategy.

PRODUCTION ENVIRONMENTS

Production in Ethiopia is concentrated in the four warmer zones of the country which are diverse in altitude and rainfall. Beans are grown in the Western zone at a low altitude in the range of 1000-1700 masl and high rainfall and in the central and southern part of the country at altitudes ranging from 1500-1900 masl. The southern zone has medium to high rainfall received in two rainy seasons. The Eastern zone is characterized by high altitude ranging from 1700 to 2200 masl and low to medium rainfall.

PRODUCTION SYSTEMS

Beans are produced under both monocropping and intercropping (Table 3). Almost all beans in the central zone are grown as a monocrop whereas intercropping with maize and sorghum is common practice in the Eastern, Western and Southern part of Ethiopia. Around 80% of beans grown are intercropped in Eastern zone (Shimelis and Hawariat, 1990).

GROWERS' PREFERENCES

Growers preferences' vary widely between zones (Table 3). In the central zone white pea beans predominate although a small amount of coloured beans are grown for home consumption, whereas in the Eastern zone these and red types are equally important. White pea beans are the main source of income for the farmer and a major export commodity of the country. In the southern and western zones coloured types are the most preferred with small red types dominant in the Southern zone but types with greater variation in grain size and colour are cultivated in the Western zone.

POSSIBLE ADVANTAGES

A zonal approach to variety development especially for food types is considered the most appropriate bean breeding strategy in Ethiopia. Although this approach is accepted it needs strengthening by providing each zone with necessary facilities including a breeder, seed storage facilities and sufficient funds. An intermediate step would consist of a period during which zonal selections are made by the national coordinating breeder, using data from zonal trials (IAR, 1990).

The national coordinating center based at Nazret will continue to cooperate with each zone in germplasm introduction based on the need of each zone, making requested crosses and off-season seed increases. After the zonal approach is implemented it is expected that varieties specifically adapted to individual zones will be developed and in a shorter time than required for widely adapted variety. Using two seasons for evaluation in the Southern zone will help to speed up the release of new varieties. Furthermore it will enable zonal researchers to test lines in trials that accommodate the dominant production systems.

EXPECTED RESULTS

Adoption of the zonal approach is expected to result in a faster release of a greater number of varieties adapted to local production environments, thus providing farmers a greater chance of identifying and growing a variety tailored to meet his specific production needs. Overall these advantages will result in more efficient utilization of human, financial and genetic resources.

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Table 1. Yield (kg/ha) of selected lines at different locations (1989-1992).

Variety	Location[1]					
	Alm	Awa	Jim	Mel	Mean	Rank
AFR 396	1770	4583	2396	3861	3153	2
DRK 34	2290	4641	2827	3593	3339	1
COS 7	2552	2362	2008	4195	2776	4
AFR 302	2878	2498	1383	3569	2582	5
G 7602	2493	2987	1963	4667	3028	3
Mean	2398	3414	2115	3977		
Altitude (mals)	1980	1700	1730	1550		
Rainfall (mm)	NA[2]	976	1534	722		

1. Alm: Alemaya, Awa: Awasa, Jim: Jima, Mel: Melkassa.
Yield at a location can be for one, two or three years.
2. NA = Not available.
Source: Progress Reports (1989-92).

Table 2. Yield ranks at four locations for five lines in over 1989-1992.

Variety	Location[1]			
	Alm	Awa	Jim	Mel
AFR 396	5	2	2	3
DRK 34	4	1	1	4
COS 7	2	5	3	2
AFR 302	1	4	5	5
G 7602	3	3	4	1

1. Alm: Alemaya, Awa: Awasa, Jim: Jima, Mel: Melkassa.

Table 3. Characteristics of production systems in four zones.

Zone (Station)	Production System	Purpose	Constraints	Preferred Types
Central (Melkassa)	Monocrop, one season	Mainly cash	Weeds, labour	Small white, prostrate bush, early maturing
Eastern (Awasa/Areka)	Intercrop, two seasons	Food/cash	Disease, shattering	White, red, shade tolerant, bush types
Southern (Awasa/Areka)	Intercrop (1st season) Monocrop (2nd season)	Mostly food	Bean fly, weeds	Small, red, early types
Western (Jima/Bako)	Intercrop	Food	Wild animals, diseases	Bush/climbing, range seed sizes/colour

PROFILE OF BEAN BREEDING RESEARCH IN ETHIOPIA

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INTRODUCTION

Beans (*Phaseolus vulgaris L.*) is one of the major crops in Ethiopian agricultural system. It has been grown as a food crop for a long time and also as an export commodity for more than four decades. It is believed to have been introduced by the Portuguese in 16th century.

Official statistics estimate the bean production area at 85,000 hectares. Farm surveys, however, conducted by Institute of Agricultural Research and Alemaya University of Agriculture from 1986 to 1989 consistently indicate this an underestimate, probably reflecting the failure to include beans in intercrop, especially in eastern Hararge highlands, western and southern parts of the country, where intercropping beans with sorghum, maize, ensete and coffee is dominant. From these surveys the area is estimated as approximately 300,000 hectares.

At the beginning of 1970's research on beans was conducted at Awasa and Nazareth and within the Chilalo Agricultural Development Unit (CADU). In 1972 nationally coordinated research started under the Nazareth Research Center of the Institute of Agricultural Research. Initially the Program focused upon variety trials and agronomic research to improve the production of white pea beans (for food and export) in the Rift Valley in the central part of the country. Varietal improvement of food beans received less attention than the export type until 1986.

Now a strong national network of bean research exists, with testing sites in different agroecological zones, which caters for both regional and national needs.

THRUST OF VARIETAL IMPROVEMENT

Food Bean

Introductions of fixed lines of this type have shown marked yield improvements over local cultivars and seem likely to continue this trend for some years. To supplement this source of genetic variation, segregating populations were introduced in 1992 and local crosses made in the off season of 1994 (under irrigation); these are expected to gradually to assume greater importance in the breeding programme.

The principle of organizing food bean trials on zonal basis has been adopted and now gradually implemented, with four zones - central, south, western and eastern - now conducting their own regional nurseries and variety trials.

Export type bean

White pea beans are important as food beans and a major export of the country. This category of bean has two major constrains: the relative scarcity of germplasm available (for introduction and evaluation) and export quality demands. For example in 1993 only 19 (4.5%) of the 415 of the introduced lines screened were white pea bean types.

To tackle the problem several segregation populations were introduced in 1993 from CIAT and local crosses initiated to generate lines with desirable varietal characteristics for the market.

BREEDING SEQUENCE

The steps in evaluation of food and white pea beans are as follows.

1. Acquisition and Generation of Germplasm

All introductions from the Centro International de Agricultura International (CIAT) in Colombia, other research institutes and local collections (made in the early stage of the Program) are screened at Nazret for general adaptation and reaction to local biotic constraints. Those poorly adapted or very susceptible are discarded.

Necrotic strains of Bean common Mosaic Virus (BCMV) do not occur in Ethiopia and to avoid introducing these strains there is a voluntarily freeze on the introduction of material from other African countries. This will cease when the equipment for ELISA screening of introduced material for BCMV is operational.

Crossing has been initiated to improve existing varieties.

2. Evaluation

Introduced and locally generated lines are evaluated in a sequence of breeding nurseries and trials. Initially, several hundred to a thousand lines are screened in a Nursery I in a non-replicated design of single row plots with standard checks included alternatively for every 10 test entries. Each zonal program receives this trial to initiate regional varietal selection. After this stage selected lines are divided into three groups for testing: coloured large seeded food beans (LSB); different coloured, medium and small seeded food types (DCB) and white pea beans (WPB) for food and export.

Seventy-five to 100 selected lines from Nursery I in the first two groups, but usually far less in the WPB group (due to shortage of germplasm of this type of bean) are tested in a Nursery II trial which is a replicated yield trial with two or more rows per plot.

Selected lines from Nursery II enter Preliminary Variety Trials which are conducted at several locations; lines with the best performance are promoted to the next stage of National Variety Trials which are again conducted at several locations.

The lines which perform best in National Variety Trial are then tested on-farm before being presented for release to the National Variety Release Committee.

PRESENT STATUS OF BREEDING PROGRAM

In 1993 477 coloured beans were introduced from CIAT and Cambridge, England of which 294 lines were selected for distribution to the four regions in Nursery I in the 1994 rainy season (June-August).

In 1994 748 bush lines have been received from CIAT and 25 superior climbing lines from the Great Lakes Region are also expected.

Several F_2 populations were introduced in 1992 and 1993 which are now at F_5.

Due to decision to initiate regionalization of the breeding programme, which is progressing well, all zonal programmes now have their own regional nursery II of the three bean groups.

Yield data over locations on the three heaviest yielding lines in the three groups and the appropriate checks in preliminary and national variety trials in 1993 are given in Tables 1 and 2 respectively. Yield increases over the control checks were large ranging from 39% (PVA 1076) to 96% (TY 3396-1) in the preliminary and 41% (G 17450) to 112% (MX 2500-19) in the national trials. It is intended to test these lines on-farm in 1995.

ON-FARM VERIFICATION TRIALS

In 1986 the on-farm verification trial comprised four black seeded lines, namely, W-108(0177-2), W-95-08, WR-375-08 and W-117 (01504) but these proved unacceptable to farmers and therefore none were released.

In 1990 and 1992, two large seeded beans, namely, A 410 and A 262, were tested on-farm and due to their good performance and acceptance by the farmers have been submitted for release by the National Program.

On-farm trials provide information on the preferences of farmers and consumers which is taken into account when requesting germplasm for introduction and advancing lines in the breeding sequence.

VARIETAL RELEASE PROCEDURE

The National Variety release Committee has guidelines for crop release, the most important of which are as follows.

a) The variety should be tested for yield, disease reaction and other important characteristics for minimum of two to three years in regional or national variety trials at least three to five locations.

b) A complete description of varieties is submitted.

c) Appropriate data is provided to support recommendations on yield and associated agronomic data, disease reaction from individual locations over years and any other relevant data on important characteristics such as canning quality and cooking time.

d) In any one season no more than three varieties per crop should be proposed for release.

e) A new variety should be assigned a permanent designation by the breeding team after it has been approved for release.

f) The breeder or institution responsible for developing varieties that have been approved for release are expected to maintain an appropriate quantity of breeder and basic seed.

The National Bean Program has recommended and released several varieties since its existence which this year includes a proposal for the release of A 410 and A 262 (Table 3).

CONCLUSIONS

Since the mid 1980s when the Program began collaboration with the CIAT Bean Network for Eastern Africa several thousand lines (local and introduced) have been tested. The Program has released several varieties and to continue the momentum in variety development greater use is now being made of introduced and locally generated segregating populations.

Table 1. Yield (kg/ha) of the three heaviest yielding lines in preliminary variety trials at four or five locations in 1993 in Ethiopia.

Group[1]/line	Location[2]						
	Al	Aw	Ji	Mel	Sir	Mean	% Check
WPB							
Awash 1	4114	3567	-[3]	2653	2216	3145	157
PAN 182	4248	3386	-	2139	1921	2924	146
PAC 17	3929	3156	-	2450	1822	2839	142
Check: Mexican 142	3826	431	-	1967	1770	1990	100
DCB							
TY 3396-1	4555	3065	3531	2238	1707	3019	196
BZ 1289-9	3952	3555	2762	2235	1719	2845	184
G 01805	4668	2569	3865	1132	1454	2738	177
Roba 1	4019	2473	2467	2582	1742	2657	172
Check: Red Wolaita	2288	1000	2412	1465	535	1540	100
LSB							
AND 661	4396	2754	-	2187	1397	2684	146
A 197	3877	2801	-	2513	1123	2579	140
PVA 1076	3866	2853	-	2026	1525	2579	139
Check: Brown Speckled	3372	1643	-	1306	1023	1836	100

1. WPB: white pea bean; DCB: medium and small coloured; LSB: large seeded coloured.
2. Al: Alemaya, Aw: Awasa, Bk: Bako, Ji: Jima, Mel: Melkassa, Sir: Sirinka.
3. Line not tested at this site.

Table 2. Yield (kg/ha) of the three heaviest yielding lines in national variety trials at six locations in 1993 in Ethiopia.

Group[1]/line	Location[2]							
	Al	Aw	Bk	Ji	Mel	Sir	Mean	% Check
WPB								
EMP 175	3236	3546	1735	2379	2600	2294	2632	155
Awash 1	4316	3248	1041	1620	3252	1634	2519	148
G 17450	3796	3056	880	1612	2909	2092	2391	141
Check: Mexican 142	3783	565	500	1383	1932	1994	1693	100
DCB								
GX 1175-3	4797	3184	1715	1966	2740	1716	2686	191
A 445	4120	3453	1885	2080	2320	1824	2614	186
TY 3396-8	5055	3228	1366	1722	2494	1779	2607	185
Roba 1	3653	2515	1834	1348	2045	1392	2131	151
Check: Red Wolaita	1783	1292	1135	1522	1288	1398	1403	100
LSB								
MX 2500-19	4771	3965	1968	2026	2324	2812	2978	212
G 2816	4314	3778	1653	2265	2422	1954	2731	194
A 410	3394	3836	1979	1911	3381	1807	2718	193
Check: Brown Speckled	2656	830	1508	1357	1392	682	1404	100

1. WPB: white pea bean; DCB: medium and small coloured; LSB: large seeded coloured.
2. Al: Alemaya, Aw: Awasa, Bk: Bako, Ji: Jima, Mel: Melkassa, Sir: Sirinka.

Table 3. Lines released and proposed for release by the National Bean Program.

Line	Year	Seed Colour	Yield Range (kg/ha)
Released			
Mexican 142	1974	White	1400 - 1800
Red Wolaita	1974	Red	1000 - 1400
Black Dessie	1974	Black	1800 - 2200
Brown Speckled	1974	Brown	1000 - 1600
Roba 1	1989	Beige	2000 - 2400
Awash 1	1990	White	2000 - 2400
Proposed			
A 410	1994	Cream	2000 - 2500
A 262	1994	Brown/Cream	2000 - 2500

SNAP BEAN BREEDING IN KENYA

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SUMMARY

In most developing countries, fertilizers and pesticides constitute 13-53% of total snap bean production costs (2). Rust and angular leaf spot are some of the major biotic constraints in the production of snap beans. Fifteen snap bean lines and 61 F_2 derived F_4 segregating snap bean populations were evaluated for disease resistance and some important agronomic traits. The lines with a higher disease resistance than Monel were: S2, S3 and S10 for rust, S2, S3, S7 and S11 for angular leaf spots and S2 and S11 for common bacterial blight than Monel. The populations with a higher disease resistance than Monel were: BC 2.1, BC 2.2 and BC 5.5 for rust, BC 5.5 for angular leaf spot and BC 1.7, BC 2.9, BC 4.4, BC 6.6 and BC 7.5 for common bacterial blight.

INTRODUCTION

In the developing world, snap beans are cultivated in different climatic zones, at varying altitudes and under a variety of management practices. Among and within countries, they may differ in size, shape, taste and colour ranging from white to black pods. The common denominator is that snap beans are invariably produced by small scale farmers as a "high input", "high-output" market oriented crop, close to urban centers(3).

A cup serving of green snap beans contributes very significantly to vitamin A (11%) requirements and can be a moderate contributor of riboflavin (55%), thiamine (9%), calcium (6.9%) and iron (6.7%). It also contributes exceptionally well to the ascorbic acid requirements (60%) but less than 5% of the requirements for niacin, protein and phosphorus and the calorie contribution is less than 2%(4).

Snap bean production in developing countries is estimated at 4.0-4.5 million metric tonnes (MT). Latin America produce 250,000-300,000 tons, America 40,000 MT, the Middle East and Northern Africa, 600,000 MT, while the total Asian snap bean production is 3.6-3.5 million MT.

Production of snap beans in Kenya has expanded rapidly in recent years. In 1986 snap cultivation of the variety, Monel, had increased to 10,000 ha. It is grown in areas receiving 500-1500mm of rainfall per annum at an altitude of up to 2,000m(1). Irrigation is, however, required in the drier areas in off season production. The beans are grown in a wide range of soils although deep well drained loam soils give the best results. The varieties commonly grown in Kenya and other African countries are exclusively of European origin. Most of them are not adapted to the climatic conditions of the tropics and this results in low yields and high production costs. Disease and insect pest control are major financial and labour constraints. Major production reducing diseases are rust, anthracnose, root rots and various blights. The major snap bean insect pests are bean stem maggot, whitefly, leaf miner, pod borer, aphids and mites(3). To generate the potentially high returns on investment the crop requires large amounts of fertilizers and pesticides. In addition, irrigation has been shown to have a significantly positive effect in production in several countries(2). In most developing countries, fertilizers and pesticides constitute 13-53% of total costs.

The objective of this study were to:

- evaluate and characterise local snap bean genotypes;
- develop lines resistant to rust (*Uromyces phaseoli*) from selection in segregating populations generated from crosses between Monel and rust resistance sources.

MATERIALS AND METHODS

1. Characterization of local snap bean genotypes

Fifteen locally collected snap bean genotypes from farmers and seed merchants in Central and Eastern Kenya and Monel were characterized in the screen house at the National Horticultural Research Centre, Thika. Every genotype was planted in five pots. DAP was applied at the rate of 20gms/20kg soil at planting. CAN was added at the rate of 3gms/plot at flowering. Data was collected on the parameters: plant type, growth vigour, days to 50% flowering, colour of standard, wings, leaf shape, leaf persistence, plant height, pod length, colour, shape, taste and ability to snap, seed colour, pod clearance, pods/plant, seeds/pod and seed weight and disease reaction to rust, angular leaf spot and common bacterial blight.

2. Evaluation of F_4 segregating progenies

Seventy segregating F_2 derived F_4 populations were evaluated at Thika during the long rains season of 1993 in non-replicated plots of 5m x 4m. DAP was applied at the rate of 100 kg/ha at planting. Diazinon was sprayed once at the primary leaf stage to reduce bean stem maggot damage. Data was taken on the parameters: plant type, growth vigour, days to 50% flowering, leaf persistence, plant height, pod length, colour, shape, taste and ability to snap, position of pods, seed colour, pods/plant and resistance to rust, angular leaf spots and common bacterial blight.

The scales used in the evaluation of the above parameters are illustrated in Table 1.

RESULTS AND DISCUSSION

Data in Table 2 shows that most of snap bean genotypes had the determinate growth habit which is preferred by most farmers in Kenya because of the ease of management in weeding, chemical application and harvesting.

The growth vigour of most of the genotypes was similar to Monel. Days to 50% flowering ranged from 39-54. Most of the genotypes had triangular leaf shapes. At senescence, most of the genotypes retained their leaves like in Monel but the genotypes S7, S11 and S13 showed a high degree of defoliation. The plant height ranged from 31-80cm, the tallest being indeterminate. Pod length at maturity ranged from 7-17cm. The current pod packaging for export requires the pods to have a size similar to that of Monel. Some genotypes did not have straight pods like Monel and therefore would not be preferred for the export market. Most of the genotypes had pod colour similar to Monel but S13 had a deep purple coloration. Most of the lines had a taste similar to Monel but S5 and S7 had a bitter taste and therefore are of low preference by the market. The ability of the pods to snap differed depending on the amount of strings in the pods; S5 and S9 did not snap as easily as Monel. The two genotypes, S6 and S13 showed a higher ground clearance than that of Monel and are therefore more adapted for mechanical harvesting.

The number of pods/plant ranged from 9-50 with the genotypes having more pods/plant bearing shorter pods. Most of the genotypes had roundish pods with the less rounded ones being more stringy and therefore less favourable for export market. Seeds/pod ranged from 3-7. Most of the genotypes were black seeded like Monel while S6, S12 and S15 were white, S5, S10 and S13 were cream and S14 variegated purple on cream. Most of the genotypes had kidney shaped seeds like Monel but one was oval (S12) and two cuboid (S1 and S7).

Some of the genotypes were a lot more susceptible to rust than Monel but S2, S3 and S10 showed the highest resistance. Angular leaf spot resistance was similar in most genotypes but S2, S3, S7 and S11 showed the highest resistance. There was generally low common bacterial blight infection but S2 and S11 showed a higher resistance than Monel.

Table 3 shows characteristics of 61 F4 segregating populations (labelled with 'BC' and an identifying number). All, except BC 2.3 and 2.5 had the determinate growth habit, which is the currently more preferred growth habit by Kenyan farmers. Flowering period ranged from 39-48 days with Monel flowering in 42 days and plant height from 39-95cm while Monel had a height of 45cm. Most populations had a pod colour and pod length similar to that of Monel, whilst the number of pods/plant ranged from 18-32.

BC1.6, BC2.10 and BC3.1 had a more bitter taste and therefore are not preferred and 1.6, 2.10, 3.1, 4.5, 4.7, 6.8, 6.9, 7.8, 7.9 a sweeter taste than Monel. BC1.4, BC1.5, BC2.4 and BC2.9 were more vigorous and BC 3.6 less vigorous in vegetative growth than Monel.

Lowest disease ratings were recorded by BC2.1, BC2.2 and BC5.5 for rust, BC4.8 and BC5.5 for angular leaf spot and BC1.7, BC2.9, BC4.4, BC6.6 and BC7.5 for common bacterial blight.

The single plants that combined a high level of favourable agronomic characters and disease resistance were selected for further evaluation at F_5.

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Table 1. Evaluation scales for parameters used in describing F_4 snap bean populations.

Parameter	Ratings[1]	Descriptions
Growth habit	D	Determinate
	ID	Indeterminate
Growth vigour	+	More than Monel
	-	Less than Monel
Leaf shape	1	Triangular
	2	Quadrangular
	3	Round
Leaf persistence at	1,2,3	Most leaves persistent
	4,5,6	Intermediate
	7,8,9	Most leaves dropped
Plant height	+	Taller than Monel
	-	Shorter than Monel
Pod length	+	Longer than Monel
	-	Shorter than Monel
Pod colour	+	Darker than Monel
	-	Lighter than Monel
Shape	+	Straighter than Monel
	-	More curved than Monel
Taste	+	Bitterer than Monel
	-	Sweeter than Monel
Snapability	+	More strings than Monel
	-	Less strings than Monel
Pod ground clearance	+	Higher clearance than Monel
	-	Less clearance than Monel
Disease resistance	1..3	Resistant
	4..6	Intermediate
	7..9	Susceptible
Pod cross-section	+	Round
	-	Flat
Seed shape	1	Round
	2	Oval
	3	Cuboid
	4	Kidney
Seed colour	B	Black
	C	Cream
	W	White
	P	Purple

1. Characters similar to those of Monel were rated as '0'

Table 2. Characterization of Monel and 16 snap bean genotypes collected from farmers in Eastern and Central Kenya.

Character	Snap Bean Genotypes[1,2]															
	M	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Growth habit	D	D	ID	D	D	D	D	D	ID	D	ID	D	ID	ID	D	D
Growth vigour		-	0	+	0	0	-	0	0	+	+	0	+	0	0	-
Days to 50% Flowering	40	40	40	41	44	39	41	42	40	39	40	47	46	43	41	54
Colour of standard	pu	pu	pu	pu	pu	wh	pu	pu	pu	wh	pu	pu	wh	pu	wh	cr
Colour of wings	pu	pu	pu	pu	pu	wh	pu	pu	pu	wh	pu	pu	wh	pu	wh	cr
Leaf shape	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Leaf persistence	3	3	5	3	5	5	3	7	3	3	3	7	5	7	5	3
Plant height (cm)	45	43	50	45	36	35	45	33	38	60	80	55	39	40	33	31
Pod length (cm)	13	7	12	12	13	13	9	15	16	17	11	13	13	10	11	11
Pod shape	0	+	+	0	0	-	-	-	-	+	-	0	0	-	-	-
Pod colour	0	-	0	0	0	0	-	-	-	0	-	0	-	+	-	-
Pod taste	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0
Ability to snap	0	0	0	0	0	+	0	0	0	+	0	0	+	-	-	-
Pod ground clearance	0	0	0	-	-	0	+	0	-	-	-	-	0	+	0	0
Pods/plant	18	9	10	18	12	14	14	22	15	20	22	16	29	8	26	50
Pods cross-section	+	+	+	+	+	-	+	+	+	-	+	+	-	+	+	+
Seeds/pod	4	3	5	5	3	3	5	7	7	6	5	5	7	5	4	5
Seed colour	B	B	B	B	B	C	W	B	B	B	C	B	W	C	P/C	W
Seed shape	4	3	4	4	4	4	4	3	4	4	4	4	2	4	4	4
Rust resistance	3	7	2	2	5	9	8	2	7	8	2	2	9	8	7	9
ALS resistance	3	3	2	2	3	5	3	2	4	5	3	2	8	3	5	4
CBB resistance	3	5	2	3	3	4	3	3	5	5	3	2	5	4	5	4

1. M = Monel, S = local genotype 2. Evaluation scales given in Table 1.

Table 3. Characteristic of 61 F snap bean segregating populations.

Progenies	Characters[12]									
	GH	GV	DF	PH	PT	PC	PL	P/P	RU	ALS	CBB
BC 1.1	D	0	40	45	0	0	10	20	3	3	2
BC 1.2	D	0	42	45	0	0	10	18	2	3	3
BC 1.3	D	0	40	40	0	+	12	24	2	3	3
BC 1.4	D	+	40	40	0	0	13	26	2	3	3
BC 1.5	D	+	39	45	0	0	14	26	2	3	2
BC 1.6	D	0	42	44	+	0	14	27	2	3	2
BC 1.7	D	0	42	43	0	0	15	28	2	3	1
BC 1.8	D	0	42	46	0	-	9	24	2	4	3
BC 1.9	D	0	42	46	0	+	10	22	2	3	2
BC 2.1	D	0	40	48	0	+	12	20	1	3	2
BC 2.2	D	0	41	48	0	0	12	18	1	2	3
BC 2.3	ID	0	45	80	-	0	14	22	2	2	2
BC 2.4	D	+	42	46	0	0	13	24	2	3	2
BC 2.5	ID	0	46	85	0	0	14	22	2	3	2
BC 2.6	D	0	42	45	0	0	14	20	2	3	3
BC 2.7	D	0	42	45	0	+	15	18	2	2	3
BC 2.8	D	0	42	46	0	0	16	26	2	2	2
BC 2.9	D	+	42	46	0	0	13	28	2	2	1
BC 2.10	D	0	43	45	+	0	13	30	2	3	3
BC 3.1	D	0	42	46	+	0	12	31	2	2	3
BC 3.2	D	0	43	46	0	0	10	28	2	2	3
BC 3.3	D	0	43	46	0	-	10	24	2	2	4
BC 3.4	D	0	43	44	0	0	11	22	3	2	4
BC 3.5	D	0	44	44	0	0	12	20	3	2	2
BC 3.6	D	-	44	42	0	0	13	20	3	2	2
BC 4.1	D	0	40	45	0	+	14	18	3	2	3
BC 4.2	D	0	44	45	0	+	14	20	3	2	3
BC 4.3	D	0	44	43	-	0	13	22	3	2	2
BC 4.4	D	0	42	48	0	0	12	24	3	2	1
BC 4.5	D	0	42	50	+	0	10	20	4	2	2
BC 4.6	D	0	42	48	0	0	14	18	2	3	3
BC 4.7	D	0	43	48	+	+	14	22	2	3	3
BC 4.8	D	0	42	50	0	0	15	22	3	1	4

Table 3. (continued)

Progenies	Characters[1,2]										
	GH	GV	DF	PH	PT	PC	PL	P/P	RU	ALS	CBB
BC 5.1	D	0	42	50	0	0	13	24	2	2	4
BC 5.2	ID	0	48	75	0	0	13	26	2	3	3
BC 5.3	D	0	40	44	0	-	12	20	2	3	2
BC 5.4	D	0	40	44	0	-	12	22	2	3	2
BC 5.5	D	0	42	48	0	0	13	18	1	1	2
BC 5.6	D	0	42	47	0	0	14	20	2	3	2
BC 5.7	D	0	43	48	0	0	14	20	2	3	2
BC 5.8	D	0	42	48	0	0	12	18	2	2	3
BC 5.9	D	0	44	46	0	+	10	22	3	3	2
BC 5.10	D	0	44	46	-	0	10	22	2	3	2
BC 6.1	D	0	42	45	0	0	13	24	2	2	3
BC 6.2	D	0	43	48	0	+	13	26	3	3	3
BC 6.3	D	0	43	43	0	0	14	28	3	3	2
BC 6.4	ID	0	47	90	-	0	16	25	3	3	4
BC 6.5	ID	0	47	95	0	0	16	23	2	3	4
BC 6.6	D	0	44	50	0	0	15	24	2	3	1
BC 6.7	D	0	44	55	0	0	15	27	4	3	2
BC 6.8	D	0	44	55	+	0	14	29	3	3	2
BC 6.9	ID	0	48	90	+	0	13	30	3	3	2
BC 6.10	D	0	40	46	0	0	13	32	3	3	3
BC 7.1	D	0	40	46	0	0	12	28	3	3	2
BC 7.2	D	0	42	47	0	+	12	29	4	3	2
BC 7.3	D	0	41	48	0	0	14	26	3	3	2
BC 7.4	ID	0	46	95	0	+	12	24	2	2	2
BC 7.5	D	0	42	50	0	0	12	22	3	2	1
BC 7.8	D	0	42	50	+	0	14	20	2	2	2
BC 7.9	ID	0	47	95	+	+	14	18	2	2	2
BC 7.10	D	0	42	44	0	0	15	18	2	2	3

1. GH = Growth habit
DF = Days to 50% flowering
PT = Pod taste (cm)
PL = Pod length
RU = Rust ratings
CBB = Common bacterial blight ratings

GV = Growth vigour
PH = Plant height (cm)
PC = Pod colour
P/P = No. of pods/plant
ALS = Angular leaf spot ratings

PERFORMANCE OF BEAN LINES SELECTED FOR MULTIPLE RESISTANCE ACROSS ENVIRONMENTS IN KENYA

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INTRODUCTION

In Kenya beans are grown over a wide range of agro-ecological zones varying from the hot and semi-arid zones in Eastern province, cool and humid highlands in Taita-Taveta district, moderately warm to humid high potential zones in the central highlands to the warm and high rainfall zones in western and parts of Nyanza provinces. Because of the diverse climatic and soil conditions, the performance of bean cultivars differ with seasons and locations (Kimani et al., 1993). Disease incidence and severity also tend to vary with locations and also with seasons. Cultivars with wide adaptability and with resistance to the major diseases can stabilize yields in a wide range of environments. Evaluation of promising beans lines across environments is therefore necessary in breeding cultivars with wide adaptability and yield stability.

Such evaluations provide for the estimation of the magnitude of environmental (E) influences and their interactions with genotypes (G). Large G x E interactions impede progress from selection and have important implications for testing and cultivar release programmes (Smithson and Grisley, 1992). Few studies have been conducted to determine the magnitude and nature of G x E interactions for beans in Eastern Africa. Smithson and Grisley (1992) reported significant genotypic and environmental effects and genotype x environments interactions for most of the characters measured on bean cultivars grown in 14 environments, in six Eastern African countries. They attributed most of the G x E interactions to responses to soil fertility and reproductive rainfall period.

A bean improvement program was initiated in 1986 at the Department of Crop Science, University of Nairobi (Kimani et al., 1990). Several promising lines were selected with improved disease resistance and grain yield. The purpose of this paper is to describe the performance of these promising bean lines across environments in Kenya.

Fifty-one advanced generation bean lines (F10 and F11) were evaluated in up to 19 environments in Kenya between 1992 and 1994. They were grown for two seasons each year in the long rains from March to June and in the short rains from October to December.

Plant Material

The 51 lines were selected for a multiple resistance to diseases (rust, anthracnose, angular leaf spot, common bacterial blight, halo blight and bean common mosaic virus), maturity, seed characteristics and grain yield in a breeding programme at the Department of Crop Science, University of Nairobi between 1986 and 1991 (Kimani et al.; 1990, 1993). Ten lines were classified as early (80-85 days), 21 as medium (86-90) and 20 late maturity (96-105). Four local cultivars (GLP2, GLP24, GLP92 and GLP585) were used as checks.

Environments

The genotypes were grown at ten locations representing the main agro-ecological zones of bean growing areas in Kenya and were: Kebete, Katumani, Nyeri Kisii, Kakamega, Embu, Taita, Tigoni, Thika and Ol'Jorok. Table 1 shows the altitude, temperature, rainfall and soils at the experimental sites. All the sites except Kakamega have a bimodal rainfall with peaks in March/April and October/November. At Kakamega there is no distinct dry season between two rainy seasons.

Experimental design and layout

At each experimental site lines in the early, medium and late maturity groups were each tested in a randomized complete block design with four replicates. The four local checks were included in each experiment. A plot consisted of four 5m rows. Spacing was 0.50m between rows and 0.10m within rows. A basal rate of 100 kg/ ha diammonium phosphate (18% N and 45% P_2O_5) was applied at planting. Plots were kept weed free by hand cultivation.

Inoculation and disease assessment

Plants were rated for their reaction to common bacterial blight, rust, angular leaf spot, anthracnose, and halo blight. The 1993 evaluations were based on natural epiphytotics. In 1992 plants were artificially inoculated with all five pathogens. To ensure that the materials were subjected to a wide variety of races that exist, isolates were collected from different bean growing areas in Kenya. The isolates were multiplied separately and then mixed before inoculation. Procedures for pathogen isolation, multiplication and inoculation and assessment were described previously (Kimani et al., 1990). Rating for common bacterial blight (CBB) was based on natural epiphytotics.

A 1-9 disease severity scale was used, where 1-3 is resistant, 4-6 moderately resistant and 7-9 is susceptible. Disease assessment on pods and leaf was done 21 days after inoculation (R6) and also at mid-pod filling stage (R8) on 10 randomly selected plants in each plot. The higher of the two ratings was taken as the final rating. Data on duration to 50% flowering, maturity, and grain yield was recorded for the two inner rows. A random sample of 100 seeds from each plot was used to determine seed weight.

Data analysis

Each location in a given season was considered a distinct environment. Data from each environment was subjected to analysis of variance followed by a combined analysis for all environments. Genotypes were considered fixed and environments random. Least significant difference method was used for mean separation.

RESULTS AND DISCUSSION

Analysis of variance

Table 2 shows there were significant genotypic effects for all traits recorded among the early, medium and late maturity lines except for yield among the early maturity lines and days to maturity among the medium maturity lines; data on the traits for the three maturity groups are given in Tables 3, 4 and 5 respectively. Environments significantly influenced all the traits measured and were the largest source of variability. There were highly significant ($P < 0.01$) genotype x environment interactions for all traits in all maturity groups. The significant environmental influences were attributed to differences in altitude, temperature, rainfall and soil characteristics (Table 1). In addition, seasonal differences in temperature and rainfall affected the performance of these genotypes.

Days to flowering and maturity

Among the early maturing lines, duration to flowering varied from 45.3 to 46.2 days with a mean of 45.8 days compared to 46.4 to 51.3 days for the checks; the lines matured in 95 to 97 days compared to 97 to 104 days for the checks. Among the medium and late maturity lines flowering occurred between 50 to 54 days with a mean of 52 and 53 days, respectively. The lines matured in 91 to 103 days with the latest checks (GLP 24 and GLP 92) maturing in 104 days.

Both the duration to flowering and maturity were considerably affected by the environment. For example the shortest duration to flowering for early maturity lines at 38 days was recorded at Katumani during the 1992 and 1993 short rains and matured latest in 147 days at Ol Jorok during the first season in 1993. The results indicated that the new lines mature within the same range as the existing commercial cultivar in most environments. Since the growing season in many bean growing areas in Kenya is 2-3 months long, it would appear that the duration to maturity of the new lines should not be a constraint since they all mature within 103 days except at high altitude sites such as Ol Jorok. The early maturing group can be produced in areas with short growing season especially the second (short) rainy season, while the medium and late group can be grown in the long rainy season.

Seed size

The early maturing group had the highest average 100 seed weight of 50.0g compared to 38.5g for medium and 39.6 for the late maturity group. Within the early maturity group, seed weight varied 45.7 to 53.9g and nine of the ten lines had heavier seeds than the largest seeded local check GLP 2. However, only two of the medium maturity and one late maturity line significantly exceeded GLP 2. Overall GLP 585 had the smallest seeds with an average of 26 g/100 seeds.

According to the classification of seed size by Kimani et al. (1993) all the ten early maturity lines, seven medium maturity and eight late maturing lines are large seeded (greater than 40 g/100 seeds), 25 medium/late lines are medium sized (39 to 30g/100 seeds) and one line is small seeded (less than 29g/100 seeds). Among the checks GLP 2 is large seeded, GLP 24 and GLP 92 are medium while GLP 585 is small seeded (less than 29 g/100 seeds). The results also indicated that seed size was significantly influenced by the environment and its interaction with the genotype. For example, for the early maturity lines average seed size was highest (57.1 g/100 seeds) at Ol Jorok during the 1993 long rainy season and smallest at Kakamega during the 1993 long rainy season (34.1 g/100 seeds). For the medium maturity group average seed size was highest (47.9 g/100 seeds) at Taita during the 1993 long rainy season and lowest (30.7 g/100 seeds) during the 1993 long rainy season at Kakamega. The late maturing lines also had the highest average seed weight (49.6 g/100 seeds) at Ol Jorok during the 1993 long rainy season and the lowest at Kakamega same season (28.3 g/100 seeds).

Yield

Mean yield was 1650 kg/ha for early maturity group compared to 1850 and 1683 kg/ha for medium and late maturing groups, respectively. The yield of the lines and controls in the early maturity group did not differ significantly (Table 2). However, five out of 19 and two out of 11 lines outyielding the heaviest yielding check in the medium and late maturity groups, respectively, did so significantly.

Grain yield was significantly influenced by the environment and significant genotype x environment interactions also were detected. The lowest yields for all lines was recorded at Kisii Regional Research Centre during the 1993 long rainy season with average yields of 313, 167 and 189 kg/ha for the early, medium and late maturity groups respectively. Low yields were also recorded at Nyeri in both long and short rainy seasons in 1993. The low yields at Kisii were due to severe bean stem maggot infestation, hail damage and couch grass which proved very difficult to control. The low yields at Nyeri were attributed to soils with very low nutrient concentration and severe moisture stress during flowering and filling stages. This resulted in poor crop growth and serious flower and young pod abscission. The highest average mean yield for all groups was recorded at Kabete and Katumani in 1992 short rains. Average yields at Kabete were 4683, 6381 and 5699 kg/ha and at Katumani 3271, 3525 and 2535 kg/ha for the early, medium and late maturity groups, respectively. These high yields were attributed to the very favourable, long growing season and adequate rainfall in November, December and January, decreasing gradually in February 1993. This caused some rotting especially among the late maturity groups which matured while it was still wet. Excessive rainfall also caused rotting and depressed yield at Kakamega during the 1993 short rainy season. In this area the long and short rainy seasons overlap without any distinct dry season unlike other sites with distinct bimodal rainfall pattern separated by a dry spell (Jaetzold and Schimdt, 1983).

Disease ratings

Disease pressure was low at many sites for the those rated, namely; halo blight, common bacterial blight, anthracnose, rust and angular leaf spot. Consequently the majority of lines in each maturity group and checks had mean ratings over sites of three or less for these diseases.

- **Halo blight and common bacterial blight**

All lines and checks had mean disease ratings of less than three for halo blight and common bacterial blight. The former was most severe at Ol Jorok experimental site during the 1993 long rainy season with average ratings of 1.3, 3.8 and 3.1 for the early, medium and late maturity groups, suggesting that the early maturity lines may have matured before maximum disease development. The latter was most severe at Kakamega during the 1993 long rainy season where mean ratings were 3.8, 3.8, and 3.5 for early, medium and late maturity groups, respectively.

- **Anthracnose**

All lines except E9 and L50 and all checks except GLP 585 had mean ratings of less than 3; these three rated less than four. Anthracnose was most severe at Kakamega during the 1993 long rainy season, followed by Taita in both seasons in the same year; ratings at Kakamega were 5.6, 4.6 and 4.7 for early medium and late maturing lines respectively.

- **Rust**

All lines except M31 and all checks except GLP 92 had mean ratings of less than three; the former rated 3.4 and the latter 4.3 to 5.1. Rust severity was significantly influenced by the environment and interacted with genotypes. The highest mean incidence of rust was recorded at Nyeri (4.5) during the 1993 short rainy season followed by Taita (4.0), Tigoni (3.71) and Kakamega (3.7) in the same season. As expected GLP 92 was the most susceptible check.

- **Angular leaf spot**

All lines except M31 at 3.1 and all checks had mean ratings of less than three. Angular leaf spot was most severe at Taita (4.93) in both seasons in 1993, followed by Kabete (4.6) during the long rainy season.

CONCLUSION

The significant genotype x environment interactions for all traits indicated the performance of the genotypes was influenced by the environments where they were grown. Both plant characteristics and disease incidence varied with environments. Smithson and Grisley (1992) also reported significant environmental effects on all traits in trials conducted in 14 environments in Africa. In the present study environment was the main source of observed variation, followed by genotypic effects and genotype x environment interaction for all characters measured. The primary objective of this work was to develop new bean cultivars with resistance to the major bean diseases in Kenya and with desirable seed characteristics and high yield potential. The results indicate this has been achieved to a large extent. The lines have shown adequate variability in maturity to fit areas with different growing seasons, yet they are not later than the existing commercial cultivars. These lines also have a wide range of seed characteristics for both colour and size. For example nine of the ten early maturity lines not only have the preferred Rosecoco type but also have significantly larger seeds.

Although disease levels were generally low, the reaction of lines at sites where it was high showed that they combined resistance to all the five major diseases in Kenya. Such sites can be used as 'hot spots' in evaluating for resistance. The new lines also showed considerable yield advantage over the best commercial checks. For example 18 medium maturity and 10 late maturity lines had better yields than the best check cultivar. The yield advantage over the best check was 19.5% to 27.2 % for the best medium and late maturity lines respectively.

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Table 1. Altitude, mean annual temperature and rainfall and soil characteristics at the experimental sites[1].

Site	Altitude (m)	Temp(°C) (min/max)	Rainfall (mm)	Soil characteristics
Kabete	1820	12.0/23	1046	Well drained, very deep, dark reddish brown, friable clays (NITOSOLS).
Katumani	1600	24.7/19.3	717	Complex of somewhat excessively drained to well drained, deep to very deep dark red to brown sandy loam to clay. (ACRISOLS, undifferentiated with ARENOSOLS).
Embu	1494	25/19.5	1230	Well drained, extremely deep, dusk red to darkish brown, friable clay with acid humic top soil (humic NITOSOLS).
Taita	1675	1.2/16.4	1415	Well drained, shallow, black to very dark (Wandanyi) brown, in places rocky, acid humic, very friable loam (Cambisols acrisols with ferrasols).
Nyeri	1829	23.3/16.5	904	Well drained extremely deep, dusk red to darkish brown, friable clay with acid top soil (humic NITOSOLS).
Tigoni	2237	20.9/15.8	1016	Well drained, extremely deep, dusk red to reddish brown, friable clays (entric NITOSOLS with nichromic CAMBISOLS and Chromic ACRISOLS).
Thika	1600	25.1/19.2	1018	Well drained, extremely dark red to dark reddish brown, friable clay (entric NITOSOLS, with nitochromic CAMBISOLS and chromic ACRISOLS).
Ol Jorok	2371	21.2/13.8	977	Well drained, deep to very deep, very dark grayish brown to dark brown, friable and slightly smeary clay, loam (ando-luvic PHAEOZEMS).
Kakamega	1585	25.9/20.6	1918	Well drained, extremely deep, dark reddish, friable clay with humic topsoil (mollic NITOSOLS).
Kisii	1680	24.1/19.2	2677	Well drained, deep to extremely deep, reddish brown, friable clay with thick humic topsoils (mollic NITOSOLS and cromo-luvic PHAEOSEMS).

1. Source: Jaetzold and Schimdt, 1983

Table 2. Mean squares[1] for days to flowering and maturity, seed weight, grain yield, and disease rating of bean lines grown in up to 19 environments in Kenya.

Mean Squares

Source	Df	Days to flowering	Days to maturity	100-seed weight (g)	Grain yield (kg/ha)	HB	CBB	ANT	Rust	ALS
						Disease Ratings[2]				
(a) Early Maturity Lines										
Replications	3	3.81	15.66	45.27	2275482	0.02	0.10	0.04	6.78	2.48
Genotypes (G)	13	103.38**	157.16**	328.15**	853838ns	0.14**	0.49**	8.24**	47.91**	4.86**
Environment (E)	18	9072.32**	23349.35**	2227.58**	574406**	45.12**	20.69**	123.90**	60.09**	87.52**
GxE	234	9.93**	31.12**	71.14**	696367**	0.14**	0.30**	2.92**	4.23**	2.79**
Pooled error	795	2.53	5.54	20.47	533287	0.04	0.13	0.75	0.86	0.71
(b) Medium Maturing Lines										
Replications	3	17.61	207.3	20.65	3656834	0.16	0.94	10.98	3.09	8.53
Genotypes (G)	24	195.27**	155.58	1584.34**	171196**	1.52**	0.63**	13.63**	24.90**	3.90**
Environment (E)	17	18673.67**	938.22**	2547.84**	191349315**	60.88**	43.89**	146.96**	110.56**	188.85**
GxE	408	8.79**	159.28	63.29**	954497**	1.39**	0.55**	2.82**	3.42**	2.36**
Pooled error	1347	3.2	145.82	17.23	549220	0.10	0.14	0.86	0.72	0.72
(c) Late Maturing Lines										
Replications	3	1.67	81.34	41.68	8216916	0.16	1.07	2.84	1.46	1.25
Genotypes	23	192.52**	209.36**	1504.92**	1612456**	0.80**	0.36**	9.89**	31.04**	4.04**
Environment (E)	18	17600.67**	297.39**	3521.97**	132188053**	35.83**	39.87**	2135.58**	94.63**	175.62**
GxE	414	8.48**	12.28**	61.67**	744834**	0.67**	0.26**	2.71**	3.88**	2.42**
Pooled error	1365	3.05	5.56	15.98	579683	0.12	0.15	0.79	0.72	0.78

1. *, **: significant at 5 and 1% probability levels, respectively.
2. HB-halo blight, CBB-common bacterial blight, ANT-anthracnose, ALS-angular leaf spot.

Table 3. Mean days to flower and maturity, yield and disease ratings over 19 environments and seed characteristics of ten early maturing bean lines in Kenya, 1992-1994

Line/Cultivar	Source Population	Days to		Seed type[1]	100-seed weight	Disease ratings[2]					Yield (kg/ha)
		flowering	maturity			HB	CBB	ANT	Rust	ALS	
E1	K7/6A	46	95	RC	53.9	1.0	1.0	2.4	1.9	2.3	1753
E2	K7/9A	46	96	RC	49.7	1.0	1.1	2.3	2.4	2.2	1702
E3	K7/12A/2	46	96	RC	52.2	1.0	1.3	2.9	2.2	2.4	1528
E4	K7/13A	45	96	RC	46.6	1.0	1.2	2.3	2.2	2.5	1590
E5	III	45	95	RC	51.6	1.0	1.1	2.8	1.8	2.6	1660
E6	K7/26B	45	95	RC	51.8	1.0	1.1	2.9	1.6	2.5	1587
E7	K7/27A/1	45	95	RC	49.1	1.0	1.3	2.7	2.5	2.4	1651
E8	K15/1A1	46	97	RC	45.7	1.0	1.0	2.6	2.0	2.3	1834
E9	K15/2A/1	45	97	RC	49.7	1.0	1.2	3.4	1.7	2.5	1610
E10	K15/6C I	45	96	RC	49.5	1.0	1.2	2.8	2.3	1.8	1590
Mean		45	96		50.02	1.0	1.1	2.7	2.1	2.4	1650
Checks[3]:											
GLP 2		46	97	RC	45.8	1.1	1.2	2.4	2.1	2.7	1610
GLP 24		48	103	CW	36.7	1.0	1.2	2.9	2.4	2.4	1777
GLP 92		46	99	MW	36.6	1.0	1.1	2.2	5.1	2.8	1582
GLP 585		51	100	MM	26.9	1.0	1.4	3.3	2.4	2.9	1417
LSD(0.05)		0.	0.9		1.67	0.04	0.12	0.32	0.31	0.29	ns

1. RC-Resecoco, CW-Canadian Wonder, MW-Mwitemania and MM-Mwezi moja seed types.
2. HB-halo blight, CBB-common bacterial blight, ANT-anthracnose, ALS-angular leaf spot.
3. Commercial check cultivars: GLP2/24/92.

Table 4. Mean days to flower and maturity, yield and disease ratings over 18 environments and seed characteristics of 21 medium maturing bean lines in Kenya, 1992-1994

Line/Cultivar	Source Population	Days to		Seed type[1]	100-seed weight	Disease ratings[2]					Yield (kg/ha)
		flowering	maturity			HB	CBB	ANT	Rust	ALS	
M11	K1/2B/1	52	94	CW	37.5	1.2	1.1	2.8	1.6	2.7	2026
M12	K6/6B II	52	94	RC	37.6	1.3	1.2	2.8	1.8	2.5	1938
M13	K6/10B	53	95	CW	40.5	1.1	1.1	3.0	1.0	2.6	1787
M14	K7/6B I	47	92	RC	50.3	1.4	1.3	2.8	1.8	2.6	1877
M15	K7/26B/1	51	95	RC	39.3	1.1	1.1	2.2	2.0	2.1	1792
M16	K8/24B	52	97	MW	34.4	1.4	1.4	2.4	2.0	2.4	1581
M17	K13/A II	51	93	CW	36.7	1.3	1.2	2.5	2.3	2.7	1993
M18	K13/9B	54	97	MM	45.8	1.0	1.2	1.7	1.9	2.1	2027
M19	K15/1A	53	96	MW	35.2	1.1	1.1	2.0	1.8	2.6	1728
M20	K19/4A	53	97	CW	38.3	1.0	1.3	1.8	1.8	2.4	1717
M21	K19/4C	53	95	MM	42.9	1.0	1.0	1.5	1.7	2.4	2055
M22	K19/22A I	52	96	RC	43.9	0.9	1.2	1.7	2.9	2.5	1819
M23	K19/38A	51	96	RC	42.3	1.1	1.0	1.8	1.7	2.4	1834
M24	K21/46A II	52	95	CW	42.3	1.2	1.1	2.2	1.9	2.5	1973
M25	K25/13A	52	95	RC	36.7	1.1	1.3	1.7	2.3	2.4	1705
M26	K33/38A	51	96	RH	37.1	1.1	1.1	2.9	2.0	2.3	1734
M27	K33/38B	52	95	RH	37.8	0.9	1.1	2.7	1.9	1.9	1734
M28	M262/16	52	95	CW	33.2	1.1	1.2	2.0	2.3	2.5	1823
M29	M355/1	51	95	CW	35.1	1.2	1.1	2.5	1.7	2.3	1892
M30	M355/27	51	95	CW	36.4	1.2	1.2	2.3	1.7	3.1	1932
M31	Unknown	50	91	RH	24.4	0.9	1.1	2.4	3.4	2.7	1875
Mean		52	95		38.5	1.1	1.16	2.3	2.0	2.2	1850
Checks:[3]											
GLP 2		47	90	RC	44.8	1.1	1.2	2.4	2	2.6	1623
GLP 24		48	94	CW	35.9	0.9	1.2	2.9	2.3	2.4	1718
GLP 92		46	102	MW	36.6	1.0	1.1	2.2	4.3	2.6	1621
GLP 585		52	91	MM	27.1	0.9	1.3	3.2	2.3	2.9	1437
LSD(0.05)		0.7	6.3		1.6	0.11	0.13		0.28	0.29	242

1. RC-Rosecoco, CW-Canadian Wonder, MW-Mwitemania, MM-Mwezi moja seed types.
2. HB-halo blight, CBB-common bacterial blight, ANT-anthracnose, ALS-angular leaf spot.
3. Commercial check cultivars: GLP2/24/92.

Table 5. Mean days to flower and maturity, yield and disease ratings over 19 environments and seed characteristics of 20 late maturing bean lines in Kenya, 1992-1994

Line/Cultivar	Source Population	Days to		Seed type[1]	100-seed weight	Disease ratings[2]					Yield (kg/ha)
		flowering	maturity			HB	CBB	ANT	Rust	ALS	
L31	K3/2B/1	53	101	CW	31.9	1.1	1.1	2.1	2.2	2.3	1505
L32	K13/5BI	54	97	RC	45.6	1.2	1.1	2.6	1.6	2.2	1572
L33	K13/26B	52	97	RC	38.7	1.2	1.2	2.8	2.2	2.7	1547
L34	K13/26C	51	96	RC	39.6	1.2	1.1	2.4	2.2	2.2	1537
L35	K13/27A	54	97	RC	50.0	1.1	1.2	2.3	2.6	2.6	1706
L36	K13/27A	53	96	CW	44.3	1.1	1.1	2.7	2.7	2.8	1759
L37	K21/24A	52	97	RC	45.3	0.9	1.1	2.5	2.2	2.6	1576
L38	K21/46A	52	98	CW	43.2	1.1	1.1	2.1	2.4	2.2	1696
L39	K23/19C	54	97	RC	40.9	0.9	1.1	1.8	2.0	2.1	1593
L40	K23/21	53	97	CW	40.5	1.0	1.1	1.9	2.1	2.3	2134
L41	K23/28C	53	98	RC	43.6	1.0	1.1	2.1	1.9	2.1	1933
L42	K28/29A	53	97	CW	36.4	1.2	1.0	2.5	2.9	2.5	1654
L43	K28/33BI	52	103	CW	35.5	1.0	1.0	2.8	2.1	2.2	1686
L44	K29/6CI	52	97	MM	38.0	0.9	1.0	2.2	1.9	2	1755
L45	K29/36D	53	97	CW	39.3	1.0	1.1	2.9	2.0	2.7	1721
L46	K33/28C	52	103	RH	33.2	1.0	1.0	1.8	1.8	2.3	1667
L47	M262/13	53	99	CW	34.9	0.9	1.1	2.6	1.7	2.6	1538
L48	M262/35	53	99	CW	36.5	1.2	1.0	2.3	2.2	2.4	1640
L49	M355/21	50	96	CW	36.8	1.1	1.2	2.5	1.6	2.4	1697
L50	M355/22	51	96	CW	37.3	1.2	1.1	3.1	2.2	2.7	1740
Mean		52	98		39.6	1.0	1.1	2.4	2.1	2.39	1683
Checks:[3]											
GLP 2		46	90	RC	45.8	1.1	1.1	2.4	2.1	2.7	1610
GLP 24		48	94	CW	36.8	0.9	1.2	2.9	2.4	2.4	1679
GLP 92		46	99	MW	36.6	1.0	1.1	2.2	5.1	2.8	1582
GLP 585		52	91	RH	26.9	0.9	1.3	3.3	2.4	2.9	1417
LSD (0.05)		0.7	1.2		1.5	0.12	0.13	0.32	0.29	0.31	242

1. RC-Rosecoco, CW-Canadian Wonder, MW-Mwitemania, MM-Mwezi moja seed types.
2. HB-halo blight, CBB-common bacterial blight, ANT-anthracnose, ALS-angular leaf spot.
3. Commercial check cultivars: GLP2/24/92.

DEVELOPMENT OF AN INTEGRATED BEAN ROOT ROT CONTROL STRATEGY FOR WESTERN KENYA

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INTRODUCTION

Bean production in Western Kenya is severely constrained by a root rot complex, especially where soil fertility levels are low and bean production intensity is high. Roots rots have been observed to be serious under similar conditions in parts of Central Kenya, Uganda, Rwanda, Burundi and Zaire (CIAT, 1992). In Western Kenya the complex is composed primarily of *Fusarium spp. phaseoli*, *Rhizoctonia solani*, and *Pythium spp.* (R. Buruchara, pers. comm.). Root rot pathogens attack beans at all growth stages causing damping off at the seedling stage, yellowing of the leaves, stunted growth and death, if severe.

In Africa, root rot problems tend to be associated with intensive, near-continuous bean production and a subsequent build-up of inoculum in the soil, together with low soil fertility which results in less plant tolerance to root rot infection. The bean is a major food crop in Western Kenya and small-scale farmers are reluctant to adopt a crop rotation involving a decrease in the frequency of sowing beans that would help maintain soil pathogens at low levels (Hall and Phillips, 1992).

The ability of a bean crop to tolerate root rots is related to soil nutrient supply. With high soil fertility, the crop grows vigorously and tolerates root rots and the application of fertilizers or readily decomposed organic manures has been shown to improve tolerance to root rots (CIAT, 1992; Mutitu et al., 1985 and 1989). This effect appears to be primarily due to the plants improved ability to obtain adequate nutrient supply rather than an effect on the pathogens *per se*.

The effectiveness of other cultural practices in contributing to the control of root rots has been demonstrated in Central Africa: planting on ridges can be useful where soils are not well aerated (Buruchara and Rusuku, 1992; Miller and Burke, 1985; Pieczark and Abawi, 1978), fungicides can give effective control and hilling-up soil around the stems of seedlings encourages growth of adventitious roots. Varietal tolerance, expressed as ability to produce adventitious roots and recover from attack, and resistance, expressed as low levels of infection, has been found in bean germplasm (CIAT, 1992). The effectiveness of individual practices varies with environmental conditions and positive additive effects often result from combining two or more of the cultural practices (Abawi and Pastor-Corrales, 1990; CIAT, 1992). Hence an integrated root rot management approach is preferred.

Applying available information on root rot management, an adaptive research program was initiated in 1993 to develop alternative components for integrated management of bean root rots. The objectives were to identify resistant or tolerant genotypes acceptable to the farmer and consumer and to evaluate the effectiveness of different cultural practices in the control of the root rot complex.

MATERIALS AND METHODS

Root rot 'hot-spot' sites were identified in farmers' fields in Vihiga District in Western Kenya in 1992. The physical and climatic characteristics of the Western Agricultural Research Station (WARS) of the Kenya Agricultural Research Organization are considered to be typical of the research sites:

altitude 1530 m; latitude 0°18'N; longitude 34°45'E; a bi-modal rainfall with an 60% reliability of at least 800-900 mm during the first season and 600-700 mm during the second season and little variation from the mean maximum of 28.6°C and minimum of 12.8°C temperatures.

The red soils of the farm sites were not characterized in detail but are well drained, deep, and of sandy clay to clay texture (humic/ferralo-chromic/orthic Acrisols). The soil of the research station has been classified as a mollic Nitosol (Jaetzold and Schmidt, 1982). Low available soil N and P are typical for the soils in this area. Experimentation to develop solutions to the root rot problem commenced in 1993 and was initiated with a sequence of genotypic evaluations for resistance to the root rot complex and an experiment to test the effectiveness of cultural practices.

Observations typically made on these trials covered: plant survival at harvest, percent of the taproot covered by root rot lesions, growth of adventitious roots and grain yield. All trials were sown at a spacing of 50 x 10 cm between and within rows respectively.

GENOTYPE EVALUATION FOR RESISTANCE TO ROOT ROTS

In the 1993a season, 374 entries from the Kenyan germplasm collection and 26 introductions which were previously identified as resistant in Rwanda were tested on two farms with the root rot 'hot spot' sites. Single row plots of 3 m length of each genotype were sown with one replicate per farm. GLP 2, a local well-adapted but susceptible Calima-type variety, was sown every five rows to evaluate variation in severity of the disease throughout the fields. Based on plant survival forty two genotypes, comprising 16 accessions and the 26 introductions, were selected for further testing.

In the 1994a season, these 42 genotypes and the susceptible GLP 2 were evaluated in trials conducted at the same sites but with two replicates per farm. Based on plant survival sixteen genotypes have been selected for testing in 1994b (Table 1).

EVALUATION OF CULTURAL PRACTICES FOR ROOT ROT CONTROL

Seven cultural practices were evaluated, using the local variety GLP 2, in a randomized complete block design with three replications and a plot size of 6 rows x 3 m, during the 1993a and b seasons on the two farms with root rot 'hot-spot' sites. The cultural treatments comprised:

- seed dressing with Benlate at a rate of 28 g/kg of seed,
- KCl applied at 100 kg/ha;,
- urea applied at 87 kg/ha;
- diammonium phosphate (DAP) applied at 150 kg/ha,
- certified seed (assumed to be free of root rot inoculum),
- green manure (either sesbania or luceana) applied 14 days before planting at 10 t/ha fresh material,
- ridging with bean sown on the top of the ridges.

and the the farmers' practice as control.

The outer two rows of the plots were used for destructive sampling and the inner four rows were used to determine yield. Root rot infection levels were high in all plots on both farms. The application of DAP and green manure and ridging produced the highest plant survival and numbers of adventitious roots, and gave large and significant ($P \leq 0.05$) yield increases over the control (farmers' practice) (Table 2). Other practices showed no significant yield increase over the control.

The application of DAP and green manure were further evaluated in the 1994b season using two local varieties, the susceptible GLP 2 and the tolerant, but not resistant, GLPX92, in a split plot design with main plots as variety and sub plots as soil amendments and the farmers' practice as the control. The trial was conducted on four farms with root rot 'hot-spot' sites, each farm representing one replication. The plots were 10 rows of five metres with the outer two rows used for destructive sampling and the inner four rows to estimate yield.

Under the farmers' practice, GLPX92 was significantly superior to GLP 2 for yield and number of plants surviving at harvest and had fewer lesions on the tap root (Table 3). Both soil application treatments with both varieties significantly exceeded the farmers' practice; DAP + GLP 2 giving the heaviest yield (Table 3).

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Table 1. Characteristics of 16 genotypes found to be resistant or tolerant to root rots in Western Kenya.

Variety	Source	Seed type	Maturity
Resistant[1]:			
RWR 719	Rwanda	Red (small)	Late
MLB 40-89A	Zaire	Black	Early
Ihumure	(unknown)	Grey	Medium
SCAM-80-CM/1	Burundi	Calima	Early
RWR 1092	Rwanda	Canadian Wonder	Early
RWR 40-89A	Rwanda	Chocolate-yellow	Late
RWR 10-59	Rwanda	Calima	Early
RWR 432	Rwanda	Calima	Medium
MLB 48-89A	Zaire	Grey (small)	Late
Tolerant[1]:			
GLPX92	Kenya	Pinto	Medium
MLB 17-89A	Zaire	Calima	Early
SCAM 50-CM/5	Burundi	Calima	Early
RWR 39-89A	Rwanda	Chocolate-yellow	Medium
MCD 221	CIAT	Calima	Medium
RWR 86	Rwanda	Calima	Medium

1. Resistant: $<10\%$ of taproot covered with lesions.
Tolerant: 10-30% of taproot covered with lesions.

Table 2. Effect of cultural practices on yield (kg/ha) and root rot severity in Western Kenya (mean of two farms over seasons 1993 a and b).

Practice	Grain yield[1]	% stand at harvest	No. adventitious roots (visual score)
DAP	1077 A	78	70
Green manure	828 A	66	50
Ridging	602 B	70	30
Urea	452 C	8	<10
KCl	422 C	10	<10
Clean seed	394 C	7	<10
Seed dressing	353 C	7	<10
Control	216 C	5	<10

1. Means followed by the same letter are not significantly (P=0.05) different based on Duncan's Multiple Range Test.

Table 3. Effect of DAP and green manure on crop tolerance to root rots and yield for a susceptible (GLP 2) and tolerant (GLPX92) variety in Western Kenya (mean of four farms in season 1994b).

Variety-practice[1]	Grain yield[-1]		% stand at harvest	Area (%) tap root with lesions	No. adventitious roots (visual score)
GLP 2 - DAP	1109	A	67	>70 *	>50
GLP2/ - GM	951	AB	72	* 50	>50
GLPX92 - DAP	946	AB	73	<30	30
GLPX92 - GM	852	B	73	<30	30
GLPX92 - FM	458	C	45	<30	<10
GLP 2 - FM	110	D	12	50	<10
LSD (0.01)	06.8		4.6		

1. Means followed by the same letter are not significantly (P=0.05) different based on Duncan's Multiple Range Test.
2. DAP, GM, and FM: diammonium phosphate, green manure and farmers' practice (control) respectively.

DEVELOPMENT OF DRY BEAN (*PHASEOLUS VULGARIS* L.) LINES ADAPTED TO HIGH SEMI-ARID CONDITIONS IN KENYA

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INTRODUCTION

Dry beans in Kenya are often produced on small farms in association with other crops such as maize, sorghum, vegetables, young fruit trees and recently coffee. A field survey in 1980 found 94% of the bean area to be intercropped and the remaining 6% under sole crop. Beans are produced for both home consumption and income generation. Although there is a minor differential preference in bean colours and sizes in Kenya, the major preferred seed colours are red (Canadian Wonder type) in Western Kenya, and mostly pinto, zebra and mixtures in Eastern and Central Kenya. Rose Coco types are preferred across the country mainly due to the attractive market price.

The climatic conditions of the Eastern African countries range from high potential areas in the cool highlands to medium and low potential areas at lower altitudes. In the central and cool highlands of Kenya, Ethiopia, Uganda, Swaziland and Lesotho are found small semi-arid areas, characterized by low bimodal rainfall of 500 to 700mm, which is erratic and received in four to six weeks with mean daily temperatures ranging from 15 to 20°C. These areas are traditionally ranch lands and in Kenya bean production research has neglected such areas but farmers are increasingly acquiring land in these semi-arid cool highland areas.

Although many cultivars of beans achieve high yields over a wide range of environments, both temperature and photoperiod have strong effects on crop growth and development (Masaya and White, 1991). Research was needed therefore to identify lines with tolerance to constraints in the semi-arid cool highlands. Selection was made therefore to identify lines which have evolved adaptive mechanisms that were temperature regulated and drought tolerant.

MATERIALS AND METHODS

Dry bean nurseries were obtained from the Centro International de Agricultura Tropical (CIAT) headquarters in Colombia. These nurseries were coded as cold medium climate with 47 lines and warm medium climate with 50 lines. Other nurseries obtained were the International Bean Common Mosaic Virus (46 lines) and African bean drought nursery (74 lines).

These materials, together with the local check cultivars, Kat MM, GLP2, 3330 and 3334 were screened under field conditions for adaptation to drought and cool conditions. The experiments were conducted in a triple lattice design at Matanya Experimental Farm over four seasons from the long rainy (LR) season of 1992 to the short rainy (SR) season of 1993.

Matanya is situated 12 km south west of Nanyuki town in Laikipia district. This site represents LH5 and UM5 agro-ecological zones (Jaetzold and Schmidt, 1983). At an altitude of 1840 masl, it receives 500-700 mm annually. The mean minimum and mean maximum temperatures are 12°C and 25°C, respectively, with daily mean of around 18°C. Using data from the first three seasons of testing the lines were classified into early (up to 90 days), medium (85-100 days) and late (85-115 days) maturity groups. This grouping is flexible and serves only as a guide.

RESULTS AND DISCUSSIONS

Table 1 presents results of 14 lines in the early maturity group. Days to emergence were 6 and 8 days for MCM 2002 and GLP 2 (check), respectively, with the majority of the lines emerging seven days after planting.

Days to flower ranged between 36 and 49 days. Except for MCR 2205A, MCR 2205B and MCR2510, all the other lines were significantly later to flower than the earlier check (Kat MM).

Days to maturity varied from 78 days for Kat MM (check) to 90 days for G4272, AFR 404 and MCM2002. It is important to note that during the short rains of 1993, AFR 461 and MCR 2514 wilted and died before reaching flowering. The drought during this period was extremely severe with less than 100mm of rainfall received during the growth period. About 60mm was received during the first 30 days with 57mm received in one day.

One hundred seed weight varied from 18g for MCM 2002 to 49g for G4272. Small seeded beans are preferred in Ethiopia while the large seeded types in Eastern, Central and Southern African regions. Seed colours of the lines are likely to be acceptable in most areas except for MCM 2002 which is black.

MCR 2514, AFR 504 and AND 736 significantly ($P \leq 0.05$) outyielded the lower yielding check, GLP 2, whilst MCM 2002 significantly outyielded both checks.

Table 2 gives data for lines in the medium maturity group. Days to emergence was generally later than in the early maturity group. Days to flower varied from 37 to 63 days for Kat MM (check) and AND 773, respectively and days to maturity from 78 to 99 days for Kat MM and DRK 24, respectively. During the most severe drought season of short rains of 1993, AND 740, AND 814 OBN 48 and OBN 42 reached the flowering stage but did not produce any seed. Only the checks Kat MM, GLP2 and 3330 flowered and produced some seeds at maturity.

Only the lines OBN42 (1948 kg/ha) and CAL 89 (1869 kg/ha) significantly outyielded the highest yielding check (3330). Although OBN 42 is a high yielder, the seed colour may detract from its use in a hybridization programme.

Table 3 gives data for lines in the late maturity group. Lines LAS 294 and CAL 104 were significantly later in emergence than the earliest check (GLP2). In general, days to emergence were later than for early and medium maturity groups with days to flower and days to maturity varying from 61 to 66 and 99 to 112 days respectively.

The lines AND 817 (1787 kg/ha) and CAL 104 (1842 kg/ha) yielded significantly higher than the higher check 3330. During the short rains of 1993 all the lines in this group wilted before flowering.

CONCLUSION

These results suggest that the early maturity group can produce a crop with less than 100mm of rainfall. Furthermore, the line MCM 2002 (1518 kg/ha) yielded significantly more than the best check Kat MM (1243 kg/ha.).

All the lines are now being multiplied and will be available for distribution upon request in October 1994.

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Table 1. Means of agronomic characters for advanced early maturity lines at Matanya over four seasons.

Entry	Days to emergence	Days to 50% flower	Days to maturity	100 seed Wt.(g)	Yield kg/ha
G4272	7	42	90	49	1013
AFR461	6	44	87*[1]	43	940
BAT 1297	7	51	89	23	1145
MCR 2205A	7	36	82	28	1354
MCR 2205B	7	38	85	48	1368
MCR 2209	7	43	80	38	969
MCR 2510	7	39	86	42	1298
MCR 2514	6	42	89*	20	1423
AFR 404	7	41	90	23	1415
MCM 2002	6	49	90	18	1517
AND 759	7	45	87	22	1069
AND 749	7	45	88	41	984
AND 735	7	45	89	43	849
AND 736	7	44	88	42	1453
GLP2	8	44	83	45	1120
Kat MM	7	37	78	44	1243
LSD (P=0.05)	1.0	3.4	4.6	8.4	251.5

1. Lines that did not attain maturity during the short rains of 1993.

Table 2. Means of agronomic characters for advanced medium maturity lines at Matanya over four seasons.

Entry	Days to emergence	Days to 50% flower	Days to maturity	100 seed wt.(g)	Yield kg/ha
AND 822	8	59*[1]	91*[1]	44.4	1581
OBN42	8	51	87*	26.3	1949
OBN48	10	52	87*	40.4	1167
AND 814	10	51	92*	36.4	1175
AND 733	8	63*	91*	41.4	988
AND 739	9	57*	98*	38.7	1014
AND 740	8	53	95*	40.5	856
AND 759	10	55*	89*	43.1	1140
AFR 346	10	56*	93*	45.2	1350
DRK24	9	58*	99*	46.5	1562
CAL89	10	57*	84*	44.3	1869
Kat MM	7	37	78	44.3	1243
GLP2	8	44	83	45.7	1120
3330	10	44	89	46.1	1272
LSD P=0.05	2.0	5.8	8.7	9.83	439.7

1. Lines did not flower or attain maturity during the short rains of 1993.

Table 3. Means of agronomic characters for advanced late maturity lines at Matanya over four seasons.

Entry	Days to emergence	Days to 50% flower	Days to maturity	100 seed wt. (g)	Yield kg/ha
A74	10	61	98	26.5	987
AND 824	9	62	101	41.0	763
LAS 294	11	59	112	36.8	1474
CAL 104	11	64	99	39.3	1842
AND 817	9	66	102	36.9	1787
3330	10	44	89	46.1	1272
GLP2	8	44	83	45.7	1120
LSD (P=0.05)	2	10.9	7.7	3.74	408.0

BEAN IMPROVEMENT RESEARCH AT THE NATIONAL CENTRE FOR APPLIED RESEARCH FOR RURAL DEVELOPMENT (FOFIFA) IN MADAGASCAR

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ABSTRACT

Bean research at FOFIFA was initiated during the 1970s with the introduction and maintenance of 42 varieties. From 1984 to 1990, four collecting missions throughout the country contributed to increasing the number of accessions in the bean germplasm collection. Meanwhile, more lines were added to the collection from the involvement with the Centro International de Agricultura Tropical (CIAT) through the Eastern Africa Bean Research Network since 1988.

Through introduction and selection, high yielding lines with resistance to the prevalent diseases have been identified. The selected lines G 13671, GLPX92, Nain de Kyondo and 997-CH-173 are being tested under farmers' conditions. Screening for rust resistance has led to the identification of highly resistant lines Ikinimba and Goiano Precoce, and highly susceptible varieties Gallaroy and Gratiot. Commercial bean varieties are being multiplied for prebasic seed production.

INTRODUCTION

The common bean (*Phaseolus vulgaris L.*) is the second most important legume crop grown in Madagascar after groundnuts (*Arachis hypogea L.*). It covers an area of about 46,000 ha, mostly located in the highlands of the country. It is grown over a wide range of environments under different copping systems. The national average yield of 860 kg/ha recorded by the Agricultural Statistics Service may be an overestimate not taking into account yields in farmers' fields which are lower due to various constraints including disease and pests, environmental stresses and lack of appropriate varieties.

The common bean is primarily a source of food and income for the small farmer, but also a source of foreign exchange for the country. Despite its economic importance at the national level beans remained for many years a second priority crop at the National Center Applied Research for Rural Development (FOFIFA).

When the "Programme legumineuse" was established in 1986 within the Department of Agronomic Research (DRA) as a multidisciplinary research program it focused on groundnuts and soybeans which were considered industrial crops. Research on beans became important only since 1988 when contact with CIAT was established. Areas of research in beans include agronomy, physiology, plant pathology and breeding. This paper reports the recent achievements in breeding.

OBJECTIVES AND METHODS OF THE BREEDING PROGRAM

The primary objectives of the Legume Programme at FOFIFA are to achieve food self-sufficiency and to produce for export. In view of these national objectives major efforts in breeding are directed toward the search for higher yielding cultivars with resistance or tolerance to the prevalent diseases and pests, to adverse environmental stresses and with improved commercial seed characteristics. To attain these objectives, with the scientific personnel available, the bean improvement program is carried out through introduction and selection of varieties and lines. This process is started with the characterization and evaluation of introduced or locally collected material. All introduced material is grown in observation trials where it is characterized for morphological, agronomic and physiological traits and evaluated for general adaptation and reaction to diseases and pests. This work is usually conducted for one season in the Antananarivo area where soil fertility is generally poor due to acidity and where most of the serious bean diseases' occur.

Any material with the desired characteristics is multiplied and included in a series of yield trials replicated over time and space to evaluate yield potential. In the last step of evaluation promising material is tested under farmers' conditions and the best adapted and most accepted by farmers proposed for official release as new improved varieties.

BEAN GERMPLASM COLLECTION AND INTRODUCTIONS

The first bean collection at FOFIFA was constituted in the 1970s and comprised 42 accessions, five of which were local varieties and the others introduced from different countries in America, Africa and Australia. This collection was maintained in the field at the Complexe Agronomique du Lac Alaotra (CALA)) in Ambatondrazaka. Poor harvesting methods and inadequate storage conditions of this collection caused the loss of several varieties.

From 1984 to 1990, four collecting missions throughout the country were undertaken with the support and collaboration of the International Board of Plant Genetic Resources (IBPGR) to collect local rice and legume varieties. A total of 194 local bean varieties were collected and to date 129 of them remain in collection at CALA (Table 1).

With the involvement of CIAT in the Legume Program since 1988 through the Eastern Africa Region Bean Programme, additional lines were received regularly from 1988 to 1993 (Table 2).

The red seeded lines which were received from CIAT in 1988 were multiplied for two seasons to get an adequate amount of seed. Their evaluation led to the selection of lines to compose a multilocation trial which led to on-farm testing of AND 208 and multiplication for commercial seed production of DRK 6, ZAA 64, DRK 4 and AND 429. A number of them are retained in collection (Table 2).

In 1988 and 1989 a total of 22 varieties introduced from Rwanda and Ethiopia were evaluated with other varieties of the collection. Five of them, namely, G 2005, G 4017, XAN 78, BAT 1432-1 and Argentina were selected for multiplication and rust screening in 1991.

The 25 varieties of the African Bean Yield Adaptation Nursery II (AFBYAN II) received in 1989 were planted during the season of 1990-1991 to form a replicated trial at one location. The best lines were: GLPX92, XAN 76, Ikinimba, Carioca, K20 and 997-CH-173. In subsequent evaluation, as many as ten varieties were selected for the 1991-1993 multilocation trials and rust screening. To date 17 lines exist in the collection.

The lines from the first Eastern African Zone Bean Yield Trial (EAZBYT-I) and the AFBYAN-III were received in 1992 and planted in 1993. Most were lost due to drought at the early vegetative stage and therefore could not be evaluated. Regeneration of the original seed set resulted in the recovery of 16 lines.

The same year, 80 lines for various purposes (Table 2) were received from CIAT; 67 of them remain in collection. The most recent introductions were made in 1993 of 76 lines of the Bean Rust Nursery from CIAT in Colombia and 5 climbing bean lines from Rwanda. They were evaluated during the season of 1993-1994 at Ambatobe. Promising lines were identified and will be tested in a preliminary yield trial next season.

A set of 132 lines from CIAT has just been released from quarantine.

VARIETAL SELECTION

In the search for higher yielding varieties for a given location, one cycle of varietal selection has been completed. Two series of multilocation trials were conducted since 1990 to compare the best varieties from observation trials of both local cultivars and CIAT introductions. In the first series, four experimental sites were chosen on the basis of their being representative of the main bean growing zones. Three of them were on-station (Arivonimamo, Kianjasoa, Ambatondrazaka) and the other one with a development project (FANALAMANGA) at Moramanga. Results of trial showed that introduced varieties outyielded all local cultivars. The three black seeded lines, namely, BAT 1432-1, G 2005 and XAN 76 were identified as best yielders at three out of four sites.

Other lines yielding better than the local check at one or two sites were: Bico de Ouro, G 4017, Rosinha G2, which, in addition, were found to be tolerant to the prevalent diseases of the region.

In the second series of multilocation trial started in 1992, ten lines of varying growth habit were tested at the three previous on-station sites and at two additional sites in 1993 (Ankazobe and Finarantsoa).

Results from three locations showed that the type IV and late maturing line G 13671, type III GLPX92, and type II 997-CH-173 were high yielders at all three locations. The black seeded variety XAN 78 performed well in Kianjasoa and Ankazobe but not in Arivonimamo. Conversely, the line Nain de Kyondo was second best yielder in Arivonimamo, while it ranked 6th and 8th respectively in Antsirabe and Kianjasoa.

ON-FARM TRIAL

The ten best lines from the multilocation trials were tested on shared fields, under farmers' management practice in 1992-1993. Results from two sites showed the lines GLPX92, G 13671, BTZ 3, XAN 78, and G 2005 outyielded the local check, with site mean yields of 1100 and 1800 kg/ha. Farmers showed great interest in the black-seeded variety XAN 78. During the season of 1993-1994, the number of testing sites was increased to six and the trial included the five best lines from the previous year's trial. This on-farm trial was carried out simultaneously with the on-station multilocation trial.

VARIETAL SCREENING FOR RUST RESISTANCE

Rust is the most widespread bean disease in Madagascar and one method of control is through resistant varieties. To this end, upon approval of the Steering Committee, a collaborative sub-project involving the disciplines of plant pathology and plant breeding was initiated in 1991. One of the objectives of the project was to identify sources of resistance to rust among the introduced and local lines available. Selected bean lines were evaluated for their reaction to rust at different locations. A wide range of variation was found among the 25 lines tested. The black seeded line Ikinimba was highly resistant, showing no rust symptoms at all locations over three years. The line Goiano Precoce from Brazil was resistant in some locations whereas at others showed mild symptoms. Two navy bean lines Gallaroy and Gratiot were highly susceptible at several locations. Other lines were variable in their reaction over locations.

SEED PRODUCTION OF COMMERCIAL VARIETIES

Because of the presently increasing demand of beans for export, FOFIFA was solicited to provide improved seed of commercial varieties. Therefore the bean improvement program undertook the multiplication of these varieties in order to produce high quality pre-basic seed. Seed multiplication was conducted on station under protected conditions. At present four commercial classes of bean are being produced for export: large white ("lingot blanc"), large red speckled ("rouge marble"), large purple ("rouge sang de boeuf") and small white. Evaluation of commercial types existing in the germplasm collection is being carried out and their improvement is a part of our long term objectives.

FUTURE PROSPECTS AND CONCLUSIONS

Lines superior in many characters to the local varieties were identified among the introduced materials as a result collaboration with CIAT, and it seems that further improvements can be obtained with more efficient selection methods, using appropriate checks and experimental sites. This will only be achieved with a better knowledge of prevalent biotic and abiotic constraints, rainfall and temperature regime at experimental sites, requiring close collaboration between different disciplines. A long term objective is to develop improved materials by combining the desirable seed characteristics of local cultivars with the resistance and high yielding characteristics of introduced lines, to satisfy the need of exporters and local consumers. More introductions are needed in order to acquire adequate genetic variation. The proper use of the available germplasm in the bean collection will contribute to increasing productivity of crop and therefore achieve the primary objective of the breeding programme.

Table 1. Local bean varieties collected in the IBPGR/FOFIFA collecting missions.

Year	Number collected	Number currently existing
1984	67	41
1985	31	13
1986	22	1
1990	74	74
Total	194	129

Table 2. CIAT lines and nurseries received from 1988 to 1993.

Year received	Nurseries/lines characteristics	Number received	Number existing
1988	Red seeded lines.	83	24
1988	Tolerance to acid soils. Resistant to anthracnose.	13 9	10 7
1989	AFBYAN-II.	25	17
1992	AFBYAN-III. EAZBYT I.	25 25	2 14
1992	- Tolerance to drought and low P. - Superior yielding CIAT lines in Africa. - Lines with resistance to BCMV black-root and anthracnose.	total: 80	67
1993	Bean rust nursery. Climbing beans.	76 5	76
Total		361	223

BEAN BREEDING PROGRAMME IN THE SUDAN

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The area of common bean in the southern Sudan used to be about 2,500 ha. but due to the civil troubles in the South the area (and agricultural production in general) has declined. In the north where most of the bean research is conducted at Hudeiba Research Station since the 1960s, the area under bean is about 5,000 ha.

The objectives of the breeding program are:

1. To breed for high yielding stable cultivars.

2. To screen for tolerance to soil salinity and/or alkalinity.

3. To breed for resistance to the prevailing diseases.

The consumers prefer the white medium to large seeded (25 - 30g/100 seeds) types and thus the program ha been directed to breed such genotypes.

One of the most important constraints is soil salinity and alkalinity and now there is a sub-project financed by East African Bean Research Network to screen for tolerant genotypes.

The most important disease of bean are the so-called curly top disease and *Macrophomina* blight. The misnamed curly top disease was identified be the cowpea mild mottle virus (CMMV) which is transmitted by the white fly (*Bemisia tabaci*).

To meet the above objectives a number of bean genotypes were imported in nurseries from:

- the United States (Great Northern types),

- the Centro International de Agricultura Tropical (CIAT) in the West and North African Bean Adaptation Nursery (WANABAN) and International Bean Adaptation Nursery (IBYAN),

- countries in Africa in the African Bean Yield and Adaptation Nursery (AFBYAN) and the East African Zonal Bean Yield Trial (EAZBYT),

- from Egypt.

Table 1 shows seed yields of elite genotypes, some of which are to be released in the near future. Table 2 shows the performance of genotypes in the EAZBYT in 1992/93 season.

In the screening for tolerance to salinity/alkalinity a number of promising genotypes were identified. Also some promising genotypes were identified for tolerance to CMMV but not for *Macrophomina*.

Table 1. Seed yield (kg/ha) of lines in the bean national variety trial.

Genotype	Seed yield
Red Mexican	2470
Giza 3	2436
Basabeer	1833
RO/2/1 (check)	1816
Baladi	1813
HRS 518	1783
HRS 531	1595
HRS 545	1577
HRS 516	1560
HRS 560	1536
PI	1530
8R	1355
HRS 519	1308
Mean	1739
S.E. ±	160
'F' test for genotypes: P=0.001	

Table 2. Seed yield (kg/ha) of lines in the EAZBYT in 1992/93.

Genotype	Seed yield
GLPX92	1372
RAO 55	1302
RO/2/1 (check)	1297
AND 661	1128
PEF 7	1096
GLP 2	1073
AFR 478	1072
RIZ 111	1069
ICM 2525-25	1032
AND 667	1014
RIZ 113	926
ARA 4	911
AFR 541	911
PEF 2	892
PAI 129	887
RAB 485	885
AND 618	873
RWR 109	872
MARENGUE	860
PEF 9	815
NIC 145	809
GLP 1127	732
SHE MEKO	640
RWK 3	509
SUG 50	479
Mean	938
S.E. +/-	162

COUNTRY REPORT: UGANDA

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ABSTRACT

Beans are the major grain legume grown in Uganda. Bean breeding work aims at the identification of high yielding genotypes with multiple disease resistance. Genetic variability assembled through germplasm introductions and collections on a regular basis is evaluated through a selection sequence that eventually leads to the release of new varieties. Interactions between breeders and pathologists, socio-economists, soil scientists and agronomists lead to addressing most of the production constraints realistically. Impact of on-farm trials on new variety dissemination is well established. Gains attained from evaluation of introduced germplasm is indicative of benefits likely to be obtained from zonal network activities in variety testing.

INTRODUCTION

It is assumed that beans (*Phaseolus vulgaris L.*) were introduced to Uganda by the Portuguese in the eighteenth century and presently beans are the major grain legume grown in regard to acreage and production.

Beans assumed major importance when malnutrition due to consumption of insufficient protein was widespread in the banana based diets in Uganda. A research programme on beans was initiated in 1960 to address the need for provision of a cheap plant protein. The yields realised on the farmers' fields then was below 500 kg/ha (Rubaihayo et al., 1980).

At this time bean production was poor because of use of low yielding varieties which were susceptible to disease as well as to edaphic constraints, especially poor soil fertility. Anthracnose was recognised as the major disease affecting yield and the variety K20 released in 1968 was resistant to this disease. This variety and related lines are the most extensively grown in the country.

Though yield realised on farmers' fields is still below 1000 kg/ha (on average 700 kg/ha) there has been a steady increase in yield per unit area among beans of bush habit in on-station trials in the 1990s, with yields of over 2000 kg/ha registered at Bukalasa and Ikulwe. A National Bean Programme was set up after consultative meetings held with the Centro International de Agricultura Tropical (CIAT) in Malawi and Colombia in early 1980 (Kirkby, 1990).

The Uganda National Bean Programme, based at Namulonge Agricultural and Animal Production Research Institute, comprises a team of scientists in the following disciplines: two pathologists, two breeders, three agronomists, a post- harvest entomologist and a socio-economist. Collaborative work is carried out with the soil scientists and microbiologists based at Kawanda Agricultural Research Institute and Makerere University. The team works collectively with the aim of solving the major constraints to bean production.

The major production constraints include the diseases floury leaf spot (FLS), angular leaf spot (ALS), common bacterial blight (CBB), bean common mosaic virus (BCMV) (especially necrotic strains) in the warm lowland zones below 1500 masl whilst in the highland zone the major diseases include halo blight, ascochyta (phoma) blight and anthracnose (Sengooba, 1987). The pests of major importance include the bean stem maggot, aphids and storage pest bruchids, *Zabrotes subfasciatus* and *Acanthocelides obtectus*, with the latter the more important (Silim, 1990). Production is also affected by soil mineral deficiency factors of Nitrogen and Phosphorus as well as toxic levels of Aluminium and Manganese. Besides the above problems cultivar acceptability for consumers and producers has to be considered in recommending a new variety. Characters include yield, seed colour and size, maturity period, growth habit, cooking time, taste and marketability.

Breeding work is therefore geared to address as many of the constraints as possible simultaneously, though more emphasis is placed on improved yield. Obviously not all desired characteristics can be incorporated in one genotype but in on-farm testing farmers have the chance to select from among the best yielders those with the preferred characters. Final variety release takes into consideration performance of the candidate variety in different ecological zones as well as comments from on-farm evaluation with emphasis on farmers criteria for variety acceptance.

SOURCE OF GENETIC VARIABILITY

Crop improvement is a result of manipulation of the genetic variability to satisfy set goals. Much importance is attached to acquiring as many new genotypes as possible either through introductions, hybridisation or germplasm collection.

Germplasm collection within Uganda is carried out regularly in collaboration with agricultural extensionists and non-governmental organisations (NGO) operating in rural farming areas. The assembled collection, facilitated through use of standard passport data forms, consists mainly of landraces which are morphologically characterised, multiplied, dried to low moisture content (6.0 - 6.5% MC) using the low cost silica gel method (Fischler, 1992) and stored in sealed glass bottles. This germplasm of over 300 accessions is now partially documented in Dbase III+ computer filing system and is available for supply in small quantities of specified genotypes for research purposes. There is a wealth of genotypic variation realised from sorting mixtures grown by farmers. The sorting of mixtures has been done on beans of Type I and Type II and is currently on-going for climbing bean mixtures from Kisoro District.

The other source of genetic variability is homozygous lines in breeders' and disease nurseries from CIAT in Colombia. In addition CIAT also has available F_2 segregating populations from crosses to combine multiple disease resistance and high yield. Non-I gene material is preferred but in some cases superior I-gene lines are handled by the CIAT regional breeder, based at Kawanda, to incorporate resistance to necrotic strains of BCMV.

A limited number of crosses have been made within the regional breeding projects on common bacterial blight and ascochyta blight. No new varieties have been developed from these as the populations are still segregating and undergoing selection.

BREEDING SEQUENCE

Introduced lines are first screened at Namulonge, where the National Bean Programme is based, to eliminate poorly adapted material. Up to 2000 entries, depending on the number of nurseries received, can be planted in any one season. Records on disease and pest reaction, vigour, pod load and a range of agronomic characters are taken with the best entries selected for advancement to preliminary yield trials (PYTs). The F_2 segregating populations undergo similar screening with the single plant selections taken in the best yielding populations following testing at F_3 and F_4.

The PYTs usually comprise 25, 36 or 49 lines in a lattice design with two replicates grown at two to three sites depending on the available seed quantity. Two or three PYTs may be run in a season depending on the number of selected entries.

The intermediate yield trial (IYT) comprises selections from the PYTs and those lines in a previous IYT which need confirmatory testing before further advancement. The number of entries vary from 25 upward and these too are laid out in a lattice design with three replicates at 3-4 sites in any one season. Seed multiplication of the most promising lines is also carried out to cater for seed demand for on-farm trials. Selections for inclusion in on-farm variety trials are made from IYT and advanced yield trials (AYT).

The advanced yield trials (AYT) consists of entries selected from IYT and usually comprise 25 entries planted in 5 x 5 lattice design with three replicates at 5-8 sites located in different ecological zones. Provision of performance data from multilocation testing for three or more seasons is one of the prerequisites for variety release. In April 1994 two new varieties K131 (MCM 5001) and K132 (CAL 96), which were introductions from CIAT and had gone through the above evaluation sequence, were officially released. Earlier in 1989 three varieties namely; G 13671, Rubona 5 and White Haricot were released after systematic evaluation through the breeding sequence. The problems encountered with these released varieties were susceptibility to bean common mosaic virus (BCMV) and common bacterial blight (CBB).

Maintenance breeding of the released varieties is the responsibility of breeders as subsequent breeders seed has to be provided. In addition description of the new varieties is undertaken to facilitate work on DUS (Distinctness, Uniformity and Stability) tests required by the seed project. Single plant selections (200 and above) are made from the new variety and progeny rows planted and observed for uniformity and conforming to the described characteristics of the new variety. The variety description is a combined modified version of UPOV, CIAT and IBPGR common bean descriptors. Uniform progeny rows are selected and further replanted for observation and seed multiplication. Progenies are rogued for BCMV. A sample of seed of the candidate variety is provided to the seed project prior to application for release so that the project can countercheck the variety description and performance. Collaborative visits are also made by the seed project personnel to multilocation yield trials. The breeder is required to submit 15 kg of breeders to the Uganda Seed Project at the time of variety release.

ON-FARM TESTING AND SEED DISSEMINATION

Since 1987 on-farm variety trials have been conducted in collaboration with the agronomists in the districts of Rakai, Masaka, Mpigi, Kabale, Rukungiri, Luwero, Iganga, Kampala and Bushenyi. In these trials lines which are outstanding in the IYTs and AYTs are tested on farmers' fields. This farmer participatory research was aimed at identifying farmers' criteria for acceptance or rejection of a variety with the farmer assessing varieties under their own conditions. A follow-up study was undertaken in 1990 to determine whether farmers kept or distributed seed or varieties tested on-farm in 1987 (Kisakye, 1991). The results of the study indicated that on-farm trials can be used as a means of disseminating new cultivars since farmers give or sell new seed to their counterparts (Table 1). Farmers continued to grow some of the entries and their choice was mainly based on high yield, good taste, short cooking time, disease resistance, drought tolerance and growth habit. The characters noted as disadvantageous were indeterminate growth habit, tough testa, long maturity period, susceptibility to pest and diseases, small seed size, undesirable taste and long cooking time.

It was concluded that the greater the number of participating farmers in on-farm variety trials, the greater the probability of seed spreading to more farmers. However, follow-up studies are complicated by the fact that lines of similar seed phenotype tend to get mixed by the farmers.

In 1992 another method for seed dissemination was devised whereby small packets of 1 kg of varieties, CAL 96, MCM 5001 and RWR 136 were distributed in several bean growing areas. Due to interest shown by the farmers in 1993, more packets of 0.5 kg of each of the varieties CAL 96 and MCM 5001 were sold in various urban shops at a higher price than bean grain on the open market. Still farmers showed interest in acquiring the new varieties, especially the large seeded CAL 96. A follow-up survey is currently in progress to assess the impact of this dissemination method.

INTERACTION WITH OTHER DISCIPLINES

Pathologists work in close collaboration with the breeders in assessment of resistance, providing the methodology and appropriate inoculum. The agronomist's input is mainly on assessment of varieties in on-farm trials taking into account factors and characteristics that affect production and acceptability of new cultivars. The information so gained is useful to breeders in defending a new variety in the variety release committee. The interactions with the soil scientist also helps identify genotypes tolerant to edaphic stress especially manganese toxicity and nitrogen and phosphorus stress. Marketability and socio-economic factors related to bean production are studied by the economists and information gained is taken into account by the breeders when recommending a new variety for release.

GERMPLASM EXCHANGE

Since 1987 regional nurseries for CBB, and rust have been tested as well as international CIAT disease nurseries for haloblight, ascochyta blight, ALS and BCMV. F_2 segregating populations have also been received from CIAT annually since 1987. The only problem encountered is exchange of material with countries where the necrotic strain of BCMV is absent. This has led to withholding some of the crosses made for CBB resistance which were to be forwarded to Ethiopia. The evaluation of AFBYAN entries led to identification of Rubona 5 and G 13671 which were eventually released in Uganda. Rwanda continues to be the source of elite climbing bean varieties. Continued testing in zonal variety trials could result in identification of yet more lines with good adaptation and high yield in Uganda.

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Table 1. Summary of dissemination of seeds of new entries in on-farm variety trials between 1987 and 1989[1].

	Districts			
	Mpigi	Rakai	Luwero	Kabale
No. of season of trials	4	2	3	5
No. of farmers interviewed	17	11	8	14
Percentage farmers that multiplied new seed	100	64	88	86
Percentage farmers that gave or sold new seed	82	54	75	50
No. of farmers receiving new seed from others	50	15	33	76

1. Source: Kisakye J. (1990)

BREEDING FOR RESISTANCE TO NECROSIS INDUCING STRAINS OF BEAN COMMON MOSAIC VIRUS

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ABSTRACT

Bean common mosaic virus (BCMV) is seed transmitted and the most important virus disease of beans in Africa. A breeding programme was initiated in 1990 in Uganda to develop lines with resistance to necrotic strains that predominate in the continent. Evaluation of field layout on infection level showed increased within row spacing gave a significantly higher level and is used for all resistance screening. Multisite yield testing of lines derived from introductions and selection in introduced populations has identified resistant material, differing for seed size and growth habit, with seed yields markedly exceeding the released cultivars. Small seeded lines exhibited the heaviest yield and their adoption could significantly contribute to increased production. Genotype x environment interactions for seed yield were frequent in the multisite yield trials. A breakdown of these interactions suggested that cross-over or qualitative interactions predominated and indicated means to refine yield testing strategies.

1. INTRODUCTION

Bean common mosaic virus (BCMV) is a seed transmitted disease and the most important virus disease of beans in Africa. Although often sporadic, its prevalence depending of the aphid vector, it can cause severe crop loss ranging from 35-98% (Galvez, 1980).

Ten pathogenicity strains have been identified with resistance conditioned by a dominant 'necrosis' I gene, the non-specific recessive gene, bc-u and the strain specific recessive genes, bc1 to 3 (Drijfhout, 1978). The dominant I gene prevents the establishment of a chronic systemic infection (mosaic) by any of the known strains of BCMV and has been routinely incorporated into many breeding lines at CIAT. However, infection of plants carrying the I gene with the temperature insensitive BCMV strains NL3, NL5 and NL8 result in a hypersensitive reaction resulting in systemic necrosis or the so called 'black root' symptom, leading to early death. Recent surveys show that the necrotic strain NL3 predominates in East, Central and Southern Africa, thus limiting the usefulness in Africa of the many breeding lines from CIAT carrying the I gene.

Of the recessive genes bc3 alone confers immunity to all strains of BCMV and has been incorporated at the Centro International de Agricultura Tropical (CIAT) in Colombia into a range of breeding lines mainly targeted for consumers in Latin America. In 1990 a breeding programme was initiated in Uganda to develop a range of lines carrying this gene with seed characteristics acceptable to consumers in Africa, utilizing homozygous breeding lines and segregating populations introduced from CIAT. A screening method was developed that ensures a high level of infection in field screening which is essential in achieving rapid progress in the development of resistant lines from the populations.

2. MATERIALS AND METHODS

2.1 Resistance screening

To determine the field arrangement of plots and plant spacing that optimize infection levels in the field two trials were conducted in 1991 using the local cultivar, White Haricot, at Bukalasa Experiment Station, a 'hot spot' for BCMV infection by the necrotic strain, NL3. As White Haricot carries the I gene infection levels can be accurately recorded through counts of plants with black root symptoms.

The first trial was a split plot design with three replications:

- the main plot treatments comprised two within row plant spacings of 0.10m (the one commonly used in trials) and 0.50m (with a between row spacing of 0.60m.);

- the sub-plots treatments comprised plots of 2, 4 and 6 rows of 5m.

Two rows of a BCMV 'infector' line G13671, with a high level of BCMV, were sown between all plots (figure 1).

The second trial was a randomized block with three replications of two treatments comprising the same two within row spacings used in the first trial. Each plot had twenty rows of 5m. with between row spacings of 0.60m.. In contrast to the first trial the infector rows of G13671 sown in a two metre band between the plots (figure 1).

2.2 Breeding for resistance and yield

The development of resistant material was initiated with the introduction and yield/disease evaluation of 122 homozygous breeding lines from CIAT (no data is given is presented on these lines). Of the ten superior yielding lines passed to the National Programme in Uganda for country-wide screening three were selected for pre-release, namely, MCM 5001, MCM 2001 and MCM 1015.

Seventy-four small seeded, indeterminate lines from a second introduction in the first season of 1992 (92a) were yield tested in two preliminary (international) yield trials (PIBR-1 and -2) in 92b at three sites; the term 'BR' referring to trials testing black root resistant lines.

The screening of populations segregating for BCMV-black root resistance was initiated in 1990a. Figure 2 outlines the selection scheme applied to segregating populations in Uganda between 90a and 93a to develop well adapted, BCMV black root resistant lines. Selection of symptomless (no mosaic or black root) single plants commences in early generations, usually the F2, with all populations grown at Bukalasa Experimental Farm which is a hot spot for NL3. Symptomless F3 (single plant) progenies, after screening in a like fashion, are bulked with the resulting lines undergoing a further generation of screening, before potentially resistant lines are tested in multisite yield trials.

Three such phases have been initiated in different years.

- In the first, following selection and testing, 45 F8 and F9 large seeded and 40 F7 small seeded bush lines were tested in 92b in an advanced (ABR) and intermediate (IBR) yield trial, respectively, at five sites. Superior yielding lines from the IBR of 92a are being tested by the Ugandan national programme and lines in the ABR of 92b have been distributed to national programmes in Rwanda, Tanzania and Malawi.

- In the second, 405 F5 lines are currently being yield tested with a further 551 F5 lines still being screened for resistance.

- In the third, 2325 F3 progenies have undergone a first screening.

All trials were simple lattices with plot sizes of three rows by three metres or four rows of four metres, between and within row spacing of 0.50m and 0.10m, respectively, and compromised test lines plus the following controls:

- K20: a widely grown large seeded, bush cultivar, released in 1968;

- CAL 96: a large seeded, bush cultivar, a pre-release line with a yield potential around 30% greater than K20;

- MCM 5001, a small seeded, bush cultivar, a pre-release BCMV resistant with a yield potential around 80% greater than K20.

Across site anovas were undertaken for sites common to trials grown in 92a and 92b, using actual and transformed (weighted by the reciprocal of the error mean square) plot data, following the form of Johnson, Robinson and Comstock (1955a). Simple (rp) and rank (rs) correlations over sites were derived from the appropriate variance and covariance terms. The term significant applies to a probability level equal to or less than 0.05.

3. RESULTS AND DISCUSSION

3.1 Resistance screening

In the first trial variation in plot size had no significant effect on infection level, with an average 67% over all plots and spacings (figure 1). Thus plot size can be adjusted without fear of confounding infection levels to meet the varied seed supplies of progenies selected early generations.

The difference in infection level between within row spacings, however, was very large and significant with 88% in the wider spacing at 0.50m nearly double that at the closer spacing of 0.10m.

In the second trial the difference in infection level between spacings was also large and significant, with 83% in the wider spacing 2.6 times greater than that of 31% at the closer spacing (figure 1). Other data not reported here showed that the infection level with spacing increased further to 1.0m. was similar to that at O.50m.

The dramatic increase in infection level from increased within row spacing in both trials indicates that screening for resistance should be conducted at the wider spacing. Also little difference between the two trials in infection level at the wider spacing, shows that the simpler field layout of sowing the infector line in bands between test plots can be utilized.

3.2 Yield improvement

Introduced lines in the PIBR-1 and -2 and lines from the first phase of selection in the IBR and ABR of 92b differed significantly for seed yield in all trials at all sites aside from two for the ABR where coefficients of variation were in excess of 40%; data from these sites was excluded from calculating mean yield over sites.

Seventy-five, fifty-one and eleven percent of the 159 lines in the PIBR-1 and -2, IBR, and ABR of 92b exceeded, respectively, the mean yield over sites of the control cultivars K20, CAL 96 and MCM 5001 (Table 1). The small seeded lines in the PIBRs and the IBR had the larger increases over the large seeded controls, K20 and CAL 96, with 43 and 26 lines outyielding these respectively by 50% or more; six lines recorded double the yield of K20. In contrast, no yield increase of the large seeded lines over these controls exceeded 50% (Table 1). Although such lines are normally considered the more readily adopted, the small seeded cultivar, MCM 5001, has proven acceptable to farmers, due to its yield potential, and expansion of the area sown to small seeded types could significantly increase bean production.

Potential for releasing heavier yielding, BCMV resistant small seeded cultivars is evident, with 15 lines in the PIBRs and the IBR outyielding MCM 5001 by up to 25% (Table 1) and the best two recording increases of 27 and 31%. Moreover, with the F5 small seeded lines in the IBR derived from F2 single plants (figure 1), exploitation of genetic variation through selection in superior yielding lines may achieve further yield increases.

With BCMV resistance controlled by a recessive gene only 25% of the plants in an F2 population are homozygous for this gene and thus resistant. The yield advances were thus achieved in spite of a severe reduction in genetic variation in the source populations due to the selection of resistant single plants and the concomitant promotion of resistant progenies and lines. To counter this a diverse range of populations were screened and the number of genotypes handled maximized within available resources; between 90a and 92b 7041 single plant progenies were screened, of which 769 derived lines entered preliminary yield trials (figure 2).

3.3 Yield performance over sites

Across-site analysis with the actual and transformed data for sites common to trials in 92a and 92b detected interactions for the same nine trials, whilst the PBR 5 of 92a showed an additional interaction with the transformed data (Tables 2 and 3). A 'breakdown' of these 10 three-way site interactions into their (three) two-way site combinations showed that whilst the majority of simple correlations (rp) between line yields were significant there was, aside from one instance, no similar concordance in rankings (Tables 2 and 3), suggesting that cross-over or qualitative, rather than quantitative interactions (Baker, 1988a) predominated. For eight of the 10 trials no significant interaction occurred for one of the three two-way combinations, which was consistently Kawanda/Ikulwe for the 92a PBRs and Kawanda/Namulonge - on three out of four occasions - for the 92b trials (Tables 2 and 3), suggesting possible redundancy in testing lines at both sites for these two combinations.

Interactions involving changes in rank order, as indicated in this study, are those of particular consequence in selection (Baker 1988b), which was shown by the variation between sites within trials in the number of lines identified common to the top 10 yielding over sites (Tables 2 and 3). However, the magnitude of this within trial variation in "identification/selection ability" differed between trials and was matched by that between sites across trials, further emphasizing the complex interplay between genotypes and environments. In addition, neither the absence of significant three-way interactions in the IBR 2 and PBR 1 of 92a, nor fewer significant two-way interactions in other trials, was reflected in the sites identifying more of the 10 superior lines.

Although the results were obtained from a relatively small sample of genotypes and test environments, they illustrate that whilst the derivation of statistical parameters related to genotype x environment interaction can assist in warning of inconsistency in line performance, careful observation of the data is required to evaluate their practical effect on selection. The extension of such studies over more seasons, involving all the sites used in the national breeding programmes, could help refine testing strategies by defining homogeneous agrozones that minimize genotype x environment interactions, identifying sites that best predict across site performance of particular importance in preliminary yield testing and eliminating sites redundant to selection.

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Trial 1: Evaluation of plant spacing and number of rows per plot on infection level with two infector rows between plots (plot length of 5m, 3 replicates).

```
Sub-Plot         Field Layout[1]

No. Rows/        Spacing Between Plants
Plot               in main plots
                   0.10m      0.50m
                 I<----Infector--->I
                 I<----Infector--->I
   2             xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 I<----Infector--->I
                 I<----Infector--->I
   4             xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 I<----Infector--->I
                 I<----Infector--->I
   6             xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 xxxxxxxx  x x x x x
                 I<----Infector--->I
                 I<----Infector--->I
```

% Infection

Sub-Plot	Main Plot 0.10m	Main Plot 0.50m	Mean
2 rows	45	86	66
4 rows	47	89	68
6 rows	43	88	66
Mean	45	88	67

SE main plot +/- 4.5 (F P=0.001)
SE sub-plot +/- 2.7 (F ns)

Trial 2: Evaluation of spacing on infection level with infector rows banded between plots (plot length 5m, 3 replicates, 20 rows/plot).

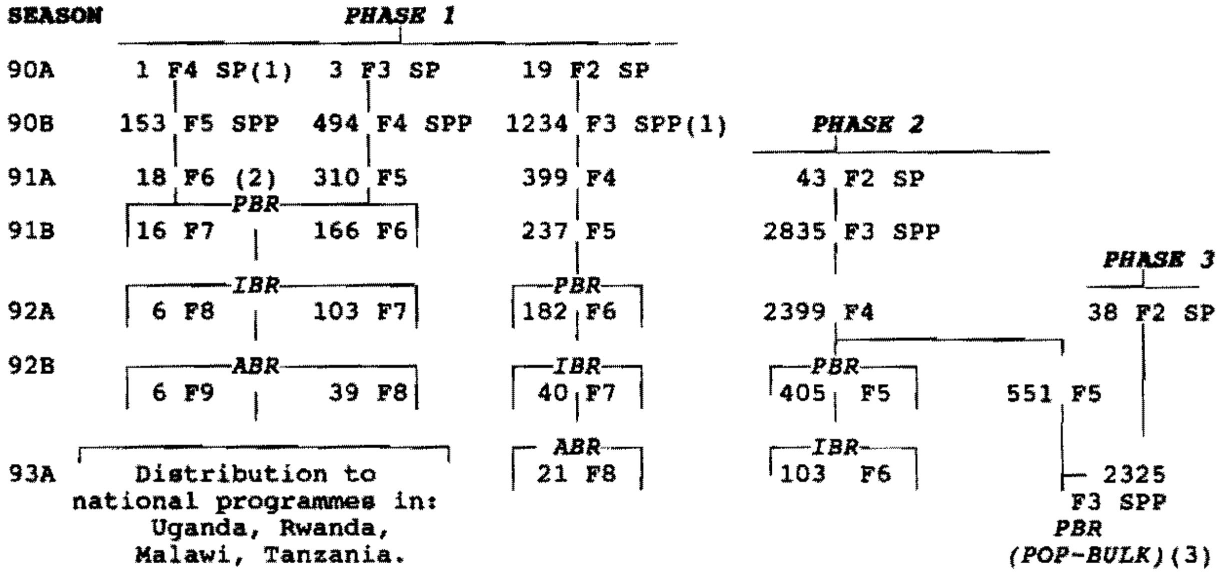
```
                         Field layout[1]

                          Plot length
      2m          5m          2m          5m           2m
                              spacing
                 0.10m                   0.50m
 Infector    xxxxxxxx    Infector  x x x x x    Infector
 Infector    xxxxxxxx    Infector  x x x x x    Infector
    ↓            ↓           ↓          ↓           ↓
 <--------------- 20 rows/plot ---------------->
 Infector    xxxxxxxx    Infector  x x x x x    Infector

% infection      31%                     83%     SE ± 1.50
             F test significant at P=0.01
```

1. x - Plants of the indicator line carrying the I gene.

Figure 1. Evaluation of field layout on level of BCMV infection using the line, White Haricot, that carries the I gene.



1. SP: segregating population. SPP: single plant progeny. Genotypes in succeeding generations referred to as lines.
2. Yield trials: PBR-preliminary, IBR-intermediate, ABR -advanced.
3. PBR of F5 lines and F3 SPP bulked within populations.

Figure 2. Selection for BCMV black root resistance in segregating populations in Uganda from 1990a to 1993a.

Table 1. Mean yield over sites[1], classified as a % of control cultivars, of BCMV black root resistant lines in preliminary (PIBR), intermediate (IBR) and advanced (ABR) trials conducted in the second season of 1992 (92b) in Uganda.

	Number of lines											
Yield[2] class	PIBR 1/2			ABR			IBR			All trials, %		
as % of control	K20	CAL 96	MCM 5001	K20	CAL 96	MCM 5001	K20	CAL 96	MCM 5001	K20	CAL 96	MCM 5001
<100	28	34	67	6	36	45	6	8	30	25	49	89
100-124	8	10	7	28	9	-	6	10	8	26	29	15
125-149	11	14	-	11	-	-	12	12	2	21	16	1
150-174	16	13	-	-	-	-	11	7	-	17	13	-
175-199	8	3	-	-	-	-	2	3	-	6	6	-
>200	3	-	-	-	-	-	3	-	-	4	-	-
No. lines/ trial		74			45			40			159	

1. Number of sites: PIBR 1/2-three, ABR-three, IBR-five.
2. Yield of control cultivar taken as 100%.

Table 2. Genotype x environment parameters for seed yield from breeding trials testing BCMV black root resistant lines in Uganda in the first season of 1992 (1992A).

TRIAL (1)	ALL SITES (2,3)				TWO WAY SITE COMBINATIONS (2,3,4,5)						
	Number of: sites	lines	LSI Raw	Trs	Sites	LSI (Raw)	Correlation rp	rs	No. of lines common to 10 heaviest yielding over sites at:		
									KA	BK	NG
IBR 1	3	49	0.001	0.001	KA/BK	**	ns	ns	5	3	8
					KA/NG	***	**	ns			
					BK/NG	***	***	ns			
IBR 2	3	36	ns	ns	KA/BK	-	ns	ns	7	5	9
					KA/NG	-	***	ns			
					BK/NG	-	ns	ns			
IBR 3	3	36	0.01	0.01	KA/BK	ns	*	ns	7	5	6
					KA/NG	**	**	ns			
					BK/NG	**	ns	ns	*(Total 19*	*13*	*23)*
									KA	BK	IK
PBR 1	3	49	ns	ns	KA/BK	-	***	ns	9	7	6
					KA/IK	-	***	ns			
					BK/IK	-	***	ns			
PBR 2	3	49	0.01	0.001	KA/BK	***	***	*	7	5	6
					KA/IK	ns	***	ns			
					BK/IK	*	***	***			
PBR 3	3	49	0.001	0.001	KA/BK	***	***	ns	8	6	6
					KA/IK	ns	**	ns			
					BK/IK	**	**	ns			
PBR 4	3	36	0.01	0.001	KA/BK	***	*	ns	8	4	5
					KA/IK	ns	**	ns			
					BK/IK	**	ns	ns			
PBR 5	3	25	ns	0.001	KA/BK	***	***	ns	10	8	8
					KA/IK	ns	***	ns			
					BK/IK	**	***	ns	*(Total 42*	*30*	*31)*

1. IBR/PBR: intermediate and preliminary yield trials respectively.
2. LSI: significance level of line x site interaction.
3. Raw/Trs: raw and transformed (/error mean square) data respectively.
4. KA: Kawanda, BK: Bukalasa, NG: Nakabango, IK: Ikulwe.
5. rp and rs: simple and rank correlations for seed yield respectively; ns: non-significant at P=0.05;
   *, **, ***: significant at P<0.05, P<0.01 and P<0.001 respectively.

Table 3. Genotype x environment parameters for seed yield from breeding trials testing BCMV black root resistant lines in Uganda in the second season of 1992 (92b).

TRIAL (1)	ALL SITES (2,3)				TWO WAY SITE COMBINATIONS (2,3,4,5)						
	Number of:		LSI		Sites	LSI (Raw)	Correlation		No. of lines common to 10 heaviest yielding over sites at:		
	sites	lines	Raw	Trs			rp	rs	KA	BK	NM
ABR	3	49	0.001	0.001	KA/BK	***	ns	ns	5	5	5
					KA/NM	*	ns	ns			
					BK/NM	***	**	ns			
IBR	3	49	0.001	0.05	KA/BK	***	***	ns	6	7	5
					KA/NM	ns	***	ns			
					BK/NM	***	***	ns			
PIBR 1	3	49	0.001	0.01	KA/BK	***	***	ns	6	7	6
					KA/NM	ns	***	ns			
					BK/NM	***	***	*			
PIBR 2	3	36	0.05	0.01	KA/BK	**	***	ns	9	8	7
					KA/NM	ns	***	ns			
					BK/NM	**	***	ns			
								Total	*26*	*27*	*23*

1. IBR/PBR: intermediate and preliminary yield trials respectively.
2. LSI: significance level of line x site interaction.
3. Raw/Trs: raw and transformed (/error mean square) data respectively.
4. KA: Kawanda, BK: Bukalasa, NG: Nakabango, IK: Ikulwe.
5. rp and rs: simple and rank correlations for seed yield respectively; ns: non-significant at P=0.05
   *, **, ***: significance at P<0.05, P< 0.01 and P<0.001 respectively.

A SUMMARY OF YIELD RESULTS FROM THE FIRST EAST AFRICAN ZONAL YIELD TRIAL

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INTRODUCTION

The East African Zonal Yield Trial (EAZBYT) was conceived as a means of disseminating elite breeding material amongst national programmes in the region. Of the 24 lines submitted by national programmes 18 were introductions from CIAT; of the other six the three GLP lines were developed in Kenya, the lines Marengue and Shemeko in Sudan and RWK 3 in Rwanda. These lines together with a local check were tested in a 5x5 triple lattice with yield results received from six sites covering four countries (Table 1).

YIELD PERFORMANCE

The yield of the lines and the local checks at the six sites is given in Table 1 with the lines ranked in ascending order for yield at each site and the mean (over sites) in Table 2. In all countries aside from Sudan five or more lines significantly ($P \leq 0.05$) outyielded the local check. The most frequent was in Uganda where over half the lines did so at both sites with many lines showing over double the yield of the check.

This first zonal trial has thus provided all programmes except Sudan with material having improved yield potential over the local check.

Table 1. Seed yield (kg/ha or g/plot) of lines in the EAZBYT over six sites in four countries; (note that treatments 10, 13, 17 are the local control at Karama in season 1 and that the local check differs for each country).

Treatment #	Line code	Country/Site						
		Uganda		Rwanda		Tanzania	Sudan	
		Namulonge	Kawanda	Karama		Selian	Ed-Damer	
				Season				
		kg/ha	kg/ha	1 g/plot	2 g/plot	g/plot	g/plot	Mean
1	AND 667	513	1080	336	181	1750	1271	855
2	AND 618	313	826	345	120	1899	1201	784
3	GLP2 (K20)	233	606	416	161	2194	1254	811
4	GLP 1127	253	813	385	125	2169	1449	865
5	NIC 145	460	773	323	156	1696	853	710
6	AFR 541	233	666	428	141	2171	1248	814
7	PAI 129	480	1086	506	143	1615	1148	830
8	RIZ 113	560	1013	248	86	1269	1508	781
9	PEF 9	380	1106	646	103	2792	1113	1023
10	PEF 7	326	833	338	115	2166	1389	966[a]
11	RAO 55	433	1026	528	166	1796	1642	932
12	RWK 3	266	840	571	96	2199	1226	866
13	GLPX92	320	1206	505	108	2585	1352	1114[a]
14	Marengue	393	980	423	81	1550	1056	747
15	AFR478	563	1106	498	118	1638	1362	881
16	RWR 109	573	853	453	136	1481	1233	788
17	SUG 50	306	713	315	153	1732	908	762[a]
18	RAB 445	646	613	483	235	2326	955	876
19	PEF 2	440	953	700	118	2588	1653	1075
20	ICM2525-25	613	906	431	195	1917	1160	870
21	AND 661	446	1060	636	223	2380	1281	1004
22	SHEMEKO	566	753	305	163	1301	1225	719
23	ARA4	486	1400	451	175	1901	1448	977
24	RIZ111	753	913	466	190	1625	682	771
25	L. check	233	553	410	178	1879	1200	
Mean		432	907	446	146	1945	1232	8522
CV%		27.3	11.4	13.5	32.5	16.9	19.4	28.4
LSD (P=0.05)		137.0	116.2	69.8	55.2	381.4	ns	

(a) Mean yield excluding season 1 at Karama.

Table 2. Rank order (ascending) of treatments (numbers as in Table 1) for seed yield in Table 1 at six sites for lines in the EAZBYT.

Rank(1) order (ascending)	Country/Site						
	Uganda		Rwanda		Tanzania	Sudan	Mean
	Namulonge	Kawanda	Karama		Selian	Ed-Damer	
			1	2			
	Treatment number						
1	3	**25**	8	14	8	24	5
2	6	3	22	8	22	5	22
3	**25**(2)	18	17	12	16	17	14
4	4	6	5	9	14	18	17
5	12	17*	1	13	7	14	24
6	17	22*	10	10	24	9	8
7	2	5*	2	15	15	7	2
8	13	4*	4	19	5	20	16
9	10	2*	**25**	2	17	**25**	3
10	9*(3)	10*	3	4	1	2	6
11	14*	12*	14	16	11	22	7
12	11*	16*	6	6	**25**	12	1
13	19*	20*	20	7	2	16	4
14	21*	24*	23	17	23	6	12
15	5*	19*	16	5	20	3	20
16	7*	14*	24	3	10	1	18
17	23*	8*	18*	22	4	21	15
18	1*	11*	15*	11	6	13	11
19	8*	21*	13*	23	3	15	10
20	15*	1*	7*	**25**	12	10	23
21	22*	7*	11*	1	18*	23	21
22	16*	9*	12*	24	21*	4	9
23	20*	15*	21*	20	13*	8	19
24	18*	13*	9*	21	19*	11	13
25	24*	23*	19*	18*	9*	19	

1. 1 = lowest and 25 = highest yielding.
2. Treatment 25 is the local check at each site.
3. '*': lines significantly outyielding the local check (treatment 25).

DISCUSSION OF PAPERS

Paper: CONTROL STRATEGY FOR BEAN ROOT ROT - R. M. Otsyula, (Kenya)

Question: Which pathogens are involved in root rots?

Answer: Three pathogens are involved - *Fusarium* spp., *Scelerotia* spp. and *Pythium* spp. but differ in the stage of plant growth when they attack. *Pythium* occurs early at V2 while *Fusarium* and *Sclerotia* attack later at V3 or V4.

Question: Differences are evident for yield and plant stand but there is also need to reflect whether yield increase is due to added fertilizer or reduced root rot.

Answer: Details of the reactions involved are not yet fully worked out. GLP x 92 seems to have a denser root system and greater tolerance to the pathogens.

Question: It was suggested that sick plots (for the different pathogens) be established at Thika for use in screening to avoid complications of dealing with farmers' plots where inoculum will build up and farmers may wish to rotate to other crops.

Answer: Policy is not in favour of having sick plots on the station, since the research station is free of the root rot problem. Consideration has been given to compensating the farmer, whose land is used for screening, with maize though this may not be favoured by the station. The establishment of a disease plot on the research station at Kakamega may not be completely unacceptable, as such a site on station was inoculated with *Fusarium* spp. and used thereafter for screening.

Comment: Since GLP x 92 shows tolerance it may be worthwhile to screen its parents. Also there are F3 and F4 lines from crosses involving GLP x 92 which are available from University of Nairobi. These too could be screened for tolerance to root rots.

Paper: SNAP BEAN BREEDING - J. K. Kamau, (Kenya)

Question: Which lines have been released?

Answer: None as yet but some exporters were given some seen to test.

Question: Which are the indicators of improvement over Monel?

Answer: There is no reliable data yet for comparison of the lines with Monel. However, characterisation of the pods shows some lines have acceptable quality.

Question: Which are the varieties grown in Western Kenya?

Answer: Farmers from Western Kenya obtain seed from private companies of varieties bred outside the country. According to a survey made there are 15 varieties (lines) documented from the various parts of Kenya.

Question: Emphasis is on rust and ALS but are the new lines screened for resistance?

Answer: The advanced lines are yet to be characterised for resistance to rust and ALS.

Question: Why promote lines without reliable data?

Answer: Presently seed multiplication is underway of advanced breeding lines and then multilocation trials will be conducted.

Suggestions:

- Work in collaboration with a pathologist.
- Use of some of the imported varieties as checks in trials of bred lines.
- Yield and quality characters should be evaluated in the trials.

Paper: SCREENING FOR ADAPTION FOR COOL SEMI-ARID HIGHLANDS OF EASTERN AFRICA - W. RONO, (Kenya)

Work based in Kenya but expected that results applicable for similar regions in E. Africa. For example small pockets in the highlands with very low rainfall in Uganda and Ethiopia and in Kenya mainly mid-rift valley areas with rainfall of 250-300 mm per season, received within 4-6 weeks and temperature ranges between 15-20°C.

Questions:

- Why categorise test lines under different maturity periods? Would it not be better to determine which maturity group is the most favourable and work with that only?

- What connection is there between yield and maturity period?

- What are the reasons justifying more introductions?

Answers:

- Other introductions are required for identification of material acceptable in the region but not for hybridisation/improvement programme.

- There is an overlap of maturity periods, different lines respond differently to moisture stress. Days to flowering and maturity vary depending on moisture stress and timing of the stress. It is better therefore to have a wide range of material to allow the selection of material adapted to the varying "ecoregions" within the semi-arid highlands. There is also variation in response to temperature in relation to maturity period. With moisture stress at planting time many varieties including long maturity period lines may germinate and flower but fail to reach maturity.

- The final results of this sub-project will be disseminated in the region and seed of the adapted lines will be available in limited quantity by October 1994 for trial by programmes in the region with similar problems.

Ousetion: How many seasons crop failure can a farmer who moves into such a dry area expect? Wouldn't it be better to declare some areas risky and non-bean areas?

Answer: In these semi-dry areas crops such as sorghum, millet, cowpeas are traditionally grown but the problem crops up when farmers, usually migrants, insist on growing non-adapted crops such as maize and beans and hence raise the challenge to produce suitable varieties for the region. Inevitably people tend to move with their eating habits.

Question: Is it wise to allocate limited resources/research money to alleviate a created problem or should the problem be addressed by recommending against the move? In other words declare an area unfit for a particular crop.

Answer: It seems such an approach/response involves political decisions.

Paper: BEAN LINES SELECTED FOR MULTIPLE RESISTANCE IN KENYA - P. Kimani et al., (Kenya)

Question: On-farm trials are mentioned but yields are bound to differ since unlike your trials, farmers don't use fertilizers?

Answer: It is expected that yields from on-farm trials will differ from station trials but in areas with good soils high yields are expected.

Questions:

- The varieties being tested have very similar seed characters, how are the farmers going to differentiate between them?
- Emphasis in breeding has been on multiple disease resistance, but in Kakamega differences in yield were small compared to differences in disease reaction. How will this be approached?

Answer: The varieties do differ for seed characters and can also be differentiated on basis of some morphological characters. In case of confounded effects of yield and disease reaction, the most advantageous variety will be recommended for each region.

Question: The paper covered less on disease resistance than yield yet emphasis in programme was on the former - why?

Answer: Multilocation assessment considered disease reaction as well as yield. The title of the paper will be adjusted.

Question: Were there no correlations between disease and yield.

Answer: No correlations were done because initially most concern in selection was on resistance, therefore the comparisons mainly looked at means and ranges.

Question: Aren't the early maturing groups too late ?

Answer: The classification seems to be consistent and the new early maturing lines have more attractive seed characters than Mwezi Moja, yet they mature in a similar period. The new Rosecoco types are close to Mwezi Moja in maturity period.

Questions:

- Should geographical zones, ecological zones or market zones be considered in variety release?

- There was a suggestion that cooking tests should be done in the laboratory before multilocation trials commence and this information can then be included in selection.

Answers:

- Marketing zones are important but as a crop has to be grown ecological zones probably bear more weight.

- During the breeding process the lines have been given out to individuals for cooking and tasting though no concrete data is available.

DISCUSSION AND RECOMMENDATIONS ON SELECTED TOPICS

1. QUARANTINE

Dr Kimani, Mr Rono and Mr Otsyula (from Kenya) reported that the quarantine regulations in Kenya hinder the importation of a large amount of new bean germplasm required by the national breeding programme to increase genetic diversity for improvement of yield and tolerance to biotic and abiotic constraints. It was suggested that these should be revised in relation to the known distribution of races of different pathogens and that large quantities are marketed across the borders.

2. DURATION OF REGIONAL SUB-PROJECTS (RSP)

Owing to limited funding the Steering Committee normally requires all RSPs set an expected termination date and had requested the working group to set such a date for the RSP on snap bean breeding conducted by Mr Kamau at Thika.

Mr Kamau stated he had received homozygous breeding lines of which five have been tested by the agronomist at Thika at one site and season; the line J12 showed a superior yield to the check, Monel. The working group suggested:

(i) multiplication of the lines during the long rains (LR) of 1994 and conduct trials at 4-5 sites with two replicates in short rains of 1994/95.

(ii) selection of around 60 of seventy F2 derived F5 lines currently being screened for multisite, replicated yield testing in the SR of 94/95 with up to 20 superior lines promoted for further testing in the LR of 95.

(iii) that a regional snap bean nursery be distributed in the SR of 95/96.

(iv) that a termination report is expected in July 1995 together with a new proposal if the project is to be continued.

3. PAN-AFRICAN AND REGIONAL TRIALS

The working group acknowledged that the pan-African trial, the AFBYAN, has served its designated purpose well, but would now recommend its termination after dissemination of the third such trial as it provides only a limited number of lines for selection.

The first zonal trial, the EAZBYT 1 (Eastern African zonal bean yield trial), comprising 24 test entries has been distributed to Rwanda, Sudan, Uganda, Tanzania and Madagascar. Ethiopia does not participate to guard against any possibility of introducing the necrotic strains of BCMV, which are currently absent from the country. Most of the entries are CIAT derived lines and although maybe of limited value to programmes that have regularly introduced and screened the VEF nursery from CIAT, is considered to be useful where bean programmes have limited resources.

The working group recommend that a second EAZBYT and the first EAZBEN (East African Zonal bean evaluation nursery) be constituted and distributed with CIAT funding. It was agreed that:

- the EAZBYT should contain only type I and II lines with the number of lines contributed by countries as follows: Uganda-7, Kenya-7, Ethiopia-7, Madagascar-2 and Sudan-2; and that the trial would be grown at two to three sites in each country. Trial design and data collection would be as before.

- the EAZBEN should have up to 200 lines of types I, II or III with 60 seeds per entry and that each country could submit up to 50 lines.

One kg of each EAZBYT entry and 200g of each EAZBEN should be sent to Malawi by early November for multiplication; Dr Gridley to circulate the address for seed dispatch.

4. SELECTION CRITERIA AND SEED RELEASE

It was noted that in the Great Lakes Region lines recommended for release are disseminated by NGOs. In other countries in the region testing requirements for release submission are as follows:

- Uganda: 3 seasons in 5 sites/season,

- Ethiopia: 3 seasons in 5 sites/ season,

- Kenya: at least 6 sites,

- Madagascar: no official release committee,

- Sudan: 2 or 3 seasons in 3 to 5 sites.

After lengthy discussion the following release guidelines were suggested:

- for regional release: 2 seasons with a minimum of 3 sites/season,

- for national release: 2 seasons with a minimum of 5 sites/season.

Aside from yield, cooking quality, disease and pest reaction, consumer/producer preferences should considered when considering a line for release.

National programmes are encouraged to increase genetic diversity at the farm level by frequent release of superior genotypes.

5. IMPACT ASSESSMENT

The importance of such assessments to follow up on the adoption of new technology was noted. In Uganda the potential impact of a new release is assessed in terms of the amount of seed disseminated. It was suggested that the sales of new lines by seed stockists would also provide information on potential impact and popularity.

It was recognized that the availability of seed of new releases to the farmers is a problem and national research programmes are encouraged to liaise with NGOs, extension networks and Research-Farmer contact groups to accelerate dissemination.

The working group was very concerned with the limited resources for the maintenance of improved seed and recommended the allocation of funds specifically for this purpose. The Steering Committee of the network is recommended to pass this information to the Directors' Group Meeting.

6. GERMPLASM

6.1. Gene Banks:

National genebanks should be responsible for the collection of beans. Areas currently not represented in the collection need to be identified and collections initiated. Samples of all accessions in national collections should be duplicated in another depository.

6.2. Status on National Germplasm Collections:

Kenya: - around 4000 accessions are held at Thika of mainly dry and snap bean introductions.

Ethiopia: - the genebank has a few CIAT introductions but with only around 150 local accessions more collecting should be undertaken. Available accessions need to be regenerated, characterized and evaluated by the gene bank in collaboration with the national bean programme.

Uganda: - 350 local lines; a collection of climbers was made this year and has yet to be characterized; more collecting needs to be done in the eastern and northern parts of the country.

Madagascar: - around 200 local and 200 introductions; systematic collection of local landraces is needed.

Sudan: 200 accessions mainly CIAT introductions.

Several countries, including Ethiopia, Kenya and Uganda have released new cultivars derived from local landraces indicating the potential of local material and the need to have a collection representing all the genetic variation in a country.

7. USE OF RELATED SPECIES

Lima beans are extensively cultivated in the southern parts of Ethiopia and the highlands of Kenya and increased attention be given to this species as it is often cultivated in areas where food beans cannot be grown. Increased attention should also be paid to *P. coccineus* and *P. acutifolius*.

8. TRAINING

Few funds are now available for postgraduate training but the committee recommended more funds be sought as there is a continued need in this area. More in-country training on on-farm research was suggested and CIAT requested to fund a six day course on this topic.

9. ANY OTHER BUSINESS

(i) The committee fully endorsed the proposal of the Steering Committee to hold a Pan-African Bean Breeders Workshop in 1995.

(ii) This was the first breeders working group meeting and a further meeting was suggested in 1996, following the same format, but there be an invited paper giving an in-depth study on a relevant breeding topic.