PROCEEDINGS OF THIRD MULTIDISCIPLINARY WORKSHOP ON BEAN RESEARCH IN EASTERN AFRICA

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Workshop organizers R A Kirkby CIAT
S T Kanyagia, KARI

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PREFACE

This volume is the proceedings of the third workshop to report review and plan research on beans in eastern Africa carried out by national programmes that are members of the Eastern Africa Bean Research Network (EABRN) established in association with the CIAT Regional Programme on Beans in Eastern Africa The evolution of the EABRN is reflected in the changes that have occurred in the nature and size of the workshops The first (held in Mukono in Uganda in June 1986) reviewed the principal constraints to bean production in eastern Africa and the research accomplished to solve these problems and attempted to identify the main future research needs of the region Thirty five participants (more than half of them from Uganda which supports probably the oldest established bean research programme in Africa) from four countries in the region presented 24 papers In the second workshop in the series (in Nairobi in March 1990) emphasis was on presentation of the research that had been carried out during the intervening four years and notably on reviewing work on the sub projects receiving funds from the regional programme A total of 53 participants from seven countries in the region presented 47 papers eight of which concerned regional collaborative sub projects

In the current workshop three years on 62 participants (see Participants List on pages 365 367) presented 44 research papers They again include progress reports on the much increased number of regional sub projects supported by the EABRN during the past three years Other papers were selected competitively on the basis of abstracts otherwise the contributions would have been too many to discuss in the time available Discussions of papers were held at the end of each session and finally problem focused working groups brought together multi-disciplinary groups of more experienced researchers and development staff to identify priorities for future research

An essential feature of these workshops has been the participation of national staff from the Great Lakes and SADC Regional Projects and personnel of associated international organizations because it is obvious that research in one region will be relevant to ecologically similar environments in all three regions Exchange of information will help to reduce duplication and enable more efficient use of research resources facilitated by participation of EABRN staff also in regional and specialist workshops in the other regions During the past nine years nearly 30 workshops regional and specialist have been organized in the three African regional projects and their proceedings published (see List of Publications pages 368 371 of this volume) In addition there are the Occasional Publications Series which includes internal reports on topics of general interest and the Reprint Series which comprises reprints from scientific journals of papers written by network staff Together these series represent a considerable body of information on the constraints to bean production in Africa and the research conducted to seek practical solutions to them

Funding for the research described here is provided by the United States Agency for International Development the Canadian International Development Agency (CIDA) the Swiss Agency for Development and Cooperation and governments of all concerned national programmes

Information on the networks and copies of all publications may be obtained from

Pan African Coordinator CIAT Kawanda Agricultural Research Institute P O Box 6247 Kampala Uganda

Regional Coordinator SADC/CIAT Regional Programme on Beans for Southern Africa Selian Agricultural Research Centre P O Box 2704 Arusha Tanzania

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SESSION I. OPENING SESSION

WELCOME ADDRESS

Teshome Girma

Chairman, Steering Committee, Regional Programme on Beans in Eastern Africa

Mrs Mary Wabule Assistant Director (Horticulture) representing the Director KARI Dr Cyrus G Ndiritu CIAT Pan African Coordinator Dr Roger A Kirkby Organizers Distinguished Guests Participants Colleagues

It is a great pleasure to welcome you to Thika, Kenya for this Multi-disciplinary Workshop on Bean Research in Eastern Africa The workshop is the third of its kind As you may remember the first regional workshop was held in Mukono Uganda in 1986 concentrating on regional sub project proposals on the diseases and pests considered to be major biotic production constraints to common bean in eastern Africa The second regional workshop was held in Nairobi Kenya in 1990 when emphasis was shifted to agronomic and economic constraints More recently attention has centred on bean dissemination problems

The Eastern Africa Bean Network has also organized tours working group meetings and workshops in respective disciplines The regional steering committee approved the hosting of this workshop as an appropriate forum to exchange experiences and ideas among bean researchers of different disciplines within and outside the region with a view to enhancing the development of this important commodity and to benefit small bean farmers who are confronted with numerous production problems

Ultimately the workshop is expected to produce recommendations which will significantly contribute to the direction of and priorities for future bean research activities in the region

We are grateful to the Government of Kenya and KARI for allowing the Workshop to be held at this venue and to the CIAT regional bean network for financial and technical support

Finally it is my great pleasure to request the Director of KARI Dr Cyrus Ndiritu to address Participants and officially open the Workshop

Thank you very much

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EVOLUTION OF THE EASTERN AFRICA BEAN RESEARCH NETWORK AND OBJECTIVES OF THE WORKSHOP

R A Kirkby

CIAT, Dar es Salaam, Tanzania

THE NETWORK

The principal bean producing countries of this region are Kenya (Africa s largest producer) Uganda and Ethiopia Significant amounts of beans are also produced in Madagascar and Sudan and the crop is important to consumers in Somalia and Mauritius the latter country currently making efforts through research to become self sufficient Mauritius and Tanzania are joining the Network this year Tanzania wishes to take advantage of the agroecological similarities of its northern producing areas with adjacent EABRN countries while continuing its membership of our sister network in the SADC region Mauritius has experiences to offer in cane bean intercropping Although Somalia has ceased to be active in bean research the other countries mentioned here together with CIAT make up the membership of the Eastern Africa Bean Research Network (EABRN)

The base location for much of CIAT s scientific activities continues to be Kawanda in Uganda but support to the region in the fields of entomology pathology and social science is drawn from CIAT s teams located in Arusha in Tanzania and Rubona in Rwanda

The regional coordinator who acts also as CIAT s pan African coordinator is currently based in Dar es Salaam in Tanzania We are grateful to the two donors to EABRN activities for their support the Canadian International Development Agency (CIDA) and the United States Agency for International Development (USAID)

EABRN'S PLANNING FRAMEWORK

Activities are planned by the Network s Steering Committee (SC) Last year the SC developed a planning framework for EABRN which is now being applied in selecting activities for the annual work plan and budget The Network s goal was expressed as to improve food security and availability for small farmers to improve farmers incomes and to increase protein availability for low income groups in member countries by building on previous achievements to improve bean productivity and develop sustainable technology that is adopted by producers

Objectives and strategies (Table 1) are each addressed by intended activities which can be found in the SC s 1992 Minutes available from national coordinators and in research libraries

By the time of our last multidisciplinary workshop in 1990 the number of sub projects had increased to nine six on pest and disease problems and three on agronomic constraints However the focus was still on genetic solutions including drought tolerance and biological nitrogen fixation For EABRN s current financial year (1992/93) the SC approved 26 sub projects selected from among 19 projects that had submitted proposals for continuation as well as 20 new proposals With no increase in funds this has meant not only more competition but also leaner and meaner projects that should give greater value for the funds entrusted to the Network by our donors Funding levels to sub projects active for four or five years were reduced and relatively small sums (about US$1 000 each) were approved for a trial one year period for several new sub projects The average funding level is now US$2,340 per annum

Table 1 EABRN s planning framework objectives and strategies

Objective	Strategy
1 Strengthen and sustain national research programmes	Institutionalise and refine national research planning Assist NARS to sustain or increase resource allocation to bean research Increase effectiveness of national research
2 Improve the sustainability of the Network	Increase the role of NARS in network management Encourage national government and donor financial support to NARS and the Network Increase effective collaboration within the Network Extend collaboration among bean networks
3 Reduce biotic constraints to bean production	Develop high yielding resistant varieties Maintain and enhance germplasm diversity on farms and in NARS Devise other solutions to biotic constraints
4 Improve cropping systems that include beans	Increase productivity of cropping systems in relatively high potential areas Contribute to sustain cropping systems productivity in fragile environments
5 Increase market potential of beans	Address consumer preferences for beans Reduce post harvest losses Improve export opportunities
6 Improve transfer of technology	Increase farmers participation in research Improve national links between extension services and research institutions Accelerate technology transfer through improved seed systems Encourage inter and intra network technology transfer

Topics have diversified in line with regional priorities The Network s portfolio now includes sub projects on varietal tolerance to several soil constraints integrated pest management (IPM) minimum tillage farmer participatory research on soil management and non formal seed dissemination channels (Table 2)

Table 2 EABRN sub project research in 1992/93

Area of research	Number of sub projects	Percentage of budget
Variety development and disease resistance	9	39
Integrated pest and disease management	4	21
Genetic tolerance to soil constraints	6	18
Integrated crop and soil management	4	12
Social science issues	3	10
Total	26	100

A PAN AFRICAN PERSPECTIVE

Our sister network in the Great Lakes Region (GLR) of Central Africa known as RESAPAC from its French acronym continues to be of considerable assistance to EABRN Rwanda has been a useful source of varieties for neighbours that share its environment this enabled Uganda to make quick releases at a time when its own national programme was still in a rebuilding phase More strategically analyses of bean production problems and research opportunities in the GLR characterised by the highest average land pressure and per capita consumption of beans in Africa offer Eastern Africa some pointers to our own future To a considerable extent what they face today we should be ready to confront tomorrow and at least some of the of the potential technologies with which to do this are likely to be similar

The introduction of climbing beans to double yield potential in those highland areas with adequate rainfall is currently the most notable example of this technology borrowing The five new varieties of climbers that proved most successful in Rwanda are currently the subject of farmer testing in Uganda. There is untapped potential for GLR nurseries of bush beans to be evaluated in south west Uganda and north west Tanzania Bean production problems associated with declining soil fertility are likely to become ever more important in our region and the SC s planning framework recognises the need for more attention to crop/soil management research in EABRN

SURVEY OF NETWORK MEMBER SCIENTISTS

Late in 1992 the 95 bean scientists in EABRN member countries who appeared on the Network s mailing list were sent a questionnaire The survey had three purposes The first two were to solicit feedback from members on aspects of the Network that they had found particularly useful and those to which more attention should be given A third purpose was to obtain baseline information on scientists publications records that could be useful in future evaluation of Network performance in stimulating scientific achievements

Participation in the Network

Replies were received from 45 scientists (47%) about half of them being very active in the network through a regional sub project or as a member of the SC Network activities mentioned as having been particularly useful were spread across the current range of activities (Table 3) Those most frequently listed were collaborative research and sub projects training workshops information and publications

Access to gemplasm advice from CIAT scientists and monitoring tours were also important to many scientists

Table 3 Benefits of EABRN participation that have been most valued by national scientists

Nature of collaboration	Number of respondents
Access to bean germplasm	9
Research collaboration	15
Workshops	16
Monitoring tours	7
Information/publications	16
Training	18
Technical advice	7
Research funding	13
Funding for equipment	2
Other	2
None	6

Some of the six respondents who indicated no activity from which they felt they had derived significant benefit no longer work actively on beans However two bean scientists claimed to have little knowledge of the Network in at least one case due to being located at a station isolated from the national coordinating centre

Participants' suggestions for future directions

Many constructive suggestions were made Several respondents wanted to see increased attention being given to research on socio-economic issues (on farm research extension links adoption studies bean utilisation and new research on bean marketing) and to IPM (including diseases) Continuation of post graduate training received wide support and participation of research assistants in regional visits was suggested More advice followup and feedback from CIAT on research and especially sub projects would be appreciated and more use might be made of local resource persons for these purposes Efficiency could be enhanced by increasing the number of sub projects

Rather fewer suggestions were made concerning technical areas that could receive less emphasis but these tended to be too general and widely scattered among essential disciplines to be very useful in priority setting A view was expressed that national coordinating centres should start to receive less network support than outlying stations

Publications by Network members

The total number of bean related publications reported from the start of these scientists careers was 213 (Table 4) However the average of 4 7 publications per scientist masks a wide range in individual performance (0 24 publications) with 66% of respondents reporting from 1 to 6 publications each If we discount reports of an annual or national project nature and unpublished theses (the consistency with which these "required reports were included in respondents returns is open to doubt) the average drops from 4 7 to 2 7 publications per scientist

Table 4 Bean research publications by Network member scientists

Kind of publication	Number of publications
International journals/book chapters	7
Local or regional jornals including BIC	34
CIAT/Network workshop proceedings	49
Other workshop proceedings	32
Postgraduate theses	7
National and other reports	84
Total	213

Almost half (45%) of repondents either had not yet started their research careers or were working on another crop prior to 1986 when the activities of the Regional Bean Programme began As would be expected those working on beans longest have a higher average of 6 0 publications Interestingly however by this measure the rate of output of the group that joined bean research after 1986 is greater than that of the group that was already working on beans at that time (0 84 and 0 71 publications per annum)

Almost one quarter of all publications appeared in proceedings of workshops organised and published by EABRN/CIAT This network activity appears to be meeting a need and to have stimulated publication EABRN also pays subscription charges to the Bean Improvement Cooperative (BIC) for the region s principal research stations which may have contributed to the increasing number of publications reported for this outlet

The shortage of internationally published work is both a concern and a potentially critical baseline statistic for NARS and for the Network A single scientist accounted for four of the 7 publications in this category! Several respondents suggested the Network offer assistance in this area and I am pleased that the SC recently set aside funds to meet scientists page charges for bean papers published by international journals

SUSTAINING THE NETWORK

CIAT aims to complete the *institutionalisation* of this and other regional bean networks by the mid 1990s so as to leave scientific coordination and financial management with institutions of the regions This objective is one of the reasons for the emphasis being given to the establishment of effective management systems and to the encouragement of local leadership

In the early years of the Network CIAT staff organised and facilitated its activities but spent considerably less time in support through research While much of this work is still necessary the more experienced sub project leaders are starting to take on regional roles organising travelling workshops and training and advising weaker national programmes Among those that have received peer recognition as regional scientific leaders special mention might be made of the Ethiopian rust sub project leader s travel to Madagascar where he assisted local scientists in the design of rust research there

This aspect of regional collaboration is of particular interest to NARS directors of research A newly instituted EABRN Directors Committee met last year for the first time and agreed in principle that EABRN should recruit a coordinator from the region to take over network responsibilities from CIAT Exactly how and when this will happen has not been decided yet and the directors will be following the experience of RESAPAC whose directors are currently seeking appropriate institutional arrangements

OBJECTIVES OF THIS WORKSHOP

This workshop is the third multi-disciplinary workshop to be held by this regional Network following those of 1987 and 1990 In line with the current emphasis of the SC upon sub projects as the Network s core the principal objectives are to share information on their technical progress and to obtain comments from a peer group Consequently the SC expects each sub project leader to make a presentation here

SESSION II. GENETIC IMPROVEMENT

BEAN BREEDING STRATEGY IN ETHIOPIA

Teshome Girma and Dereje Negatu

Institute of Agricultural Research, Nazreth, Ethiopia

ABSTRACT

Ethiopia s bean producing areas can be broadly classified into four agroecological zones differing in altitude rainfall and soil The zones also differ in production systems and constraints and purpose of growing beans In the past varietal improvement was centrally coordinated from Nazreth Research Center (NRC) at Melkassa and the specific needs of zonal centers received little attention A decentralized evaluation system of variety trials for germplasm advancement has been established to identify new varieties and requires an efficient zonal programme Continued release of improved lines is dependent on the establishment of strong crossing programmes at NRC and zonal centres

INTRODUCTION

In the past in developing improved bean varieties the National Bean Program tested advanced lines across several environments diverse in altitude rainfall soil and production system with the belief that combined resistance to production limiting factors can increase the adaptive range and general performance of cultivars in different growing conditions (Amare Abebe and Haile Kefene 1989) Several improved varieties were released but the strategy ignored the specific needs of each zone and may have rejected cultivars appropriate to specific production systems

Because of large differences in consumer preference and specificity of adaptation to climatic conditions and cropping systems a single genotype will not be suited to all bean growing environments (Singh 1991) Thus in a National Strategy Planning Workshop held in 1990 it was decided to adopt a decentralized breeding approach for bean improvement to give more rapid genetic progress through increased local selection pressure the use of two seasons per year (in eastern and southern parts of the country) for testing and population advancement and improved professional incentives

This paper describes the classification of bean growing areas of Ethiopia into broad agroecological zones and highlights the strategies followed for varietal improvement

AGROECOLOGICAL ZONATION

Ethiopia s bean producing areas can be broadly classified into four major agroecological zones These are the central eastern southern and western zones grouped according to altitude rainfall soil production system and geographic location (Table 1) Most production constraints are specific though some such as local varieties with low potential yield and susceptibility to pests and diseases and bruchids in stored beans are common to all zones

Table 1 A broad classification of bean producing zones of Ethiopia

Zone	Altitude (masl)	Rainfall	Soil	Production system	Purpose
Central	1500 1900 (medium)	low/ medium	low N P	monocrop single season labour scarce	cash
Eastern	1700 2200 (high)	low/ medium	erosion low N P	intercropping of sorghum/maize two seasons land scarce	food & cash
Southern	1500 1900 (medium)	medium/ high	low N,P	two seasons land scarce	food
Western	1000 1700 (low)	high/ very high	heavy	bush and climbers maize intercropping potential labour and draft power constraints	food

(Source National Strategy Planning Workshop 1990)

Central Zone

The main bean producing area is in the Rift Valley where farmers grow mostly white pea bean types as cash crops Coloured beans are also grown for local consumption Beans are grown as monocrops and have a short growing season so achieve rapid growth compete well with weeds and avoid competition with other crops for labour Production is increasing in the Rift Valley because current rainfall patterns suit beans and the area under the crop considerably increases when the onset of rains is delayed The crop plays an important part in farmers risk aversion strategy (Aleligne Kefyalew 1990)

Eastern Zone

The Eastern Zone comprises a second major bean producing region of Ethiopia Beans are intercropped with sorghum and maize (about 95% of all sorghum in the eastern highlands is intercropped with beans) so shade tolerance and early maturity are important

Beans are grown because of their low moisture requirement and their potential as a catch crop in case of failure of major cereal crops (Shimelis M/Hawariat *et al* 1990) The cultivars and mixtures planted for food and cash differ but white and red beans are preferred Bush types are preferred to climbing types to facilitate leaf stripping in intercropped sorghum and also for their earliness

Southern Zone

The Southern Zone includes Sidamo Gamo Goffa and part of Bale There are two rainy seasons In the first season (March April) farmers grow beans intercropped with maize and in the second season (July/August) beans are grown in monocrop Red and white beans are preferred and mostly used for home consumption (Getahun Degu and Yeshi Chiche 1989) In some areas double cropping with bean has developed in response to land scarcity Bean stem maggots and weeds are the main bean production constraints in the zone

Western Zone

The Western Zone includes the Welega, Illubabor and Gojam administrative regions Small farmers grow beans of various growth habits (climbing or bush) grain sizes (small or large) and grain colours (red white black or mixed) Climbing beans are grown along fences and also intercropped with maize on small plots around homesteads bush types are grown as monocrops In the Bako area, beans are rarely intercropped with maize as this practice creates inconvenience in maize weeding However such problems can be resolved by broadcasting bean seed at the time of ox cultivation (Gemechu Gedeno 1990) In the Illubabor area most farmers practice intercropping of beans with maize rather than sole cropping (Kassahun Seyoum *et al* 1989) Most produce is for home consumption Small quantities of fresh and dry beans are sold in local markets

Gojam especially Pawe settlement area is a lowland environment which has a long unimodal rainy season of about five months Beans are intercropped with maize in a limited area by local farmers in Pawe mostly for home consumption In the Western Zone lack of improved bean cultivars angular leaf spot web blight and bean stem maggots are the major production constraints

STRATEGIES FOR VARIETAL IMPROVEMENT

Beans are grown under varied environmental conditions and production systems varying in growth habit seed size and maturity Seed size growth habit and maturity are intrinsic characteristics and are largely responsible for differences in yield potential of bean cultivars Such yield differences were observed in our variety trials at several research sites in different zones (Tables 2 and 3) Therefore it would be erroneous to think of the same yield potential for all bean types or the same yield target for specific bean types across all growing environments (Singh 1991)

Table 2 Mean seed yields (kg/ha) in National Variety Trials 1990

Type of trial	Alemaya	Awassa	Bako	Jimma	Melkassa
White pea bean	1991	1078	1993	3527	2024
Different color	2466	931	2145	3539	1803
Large seed bean	2299	1187	1224	2779	2294

(Source IAR 1990)

The principle of organizing varietal improvement on a zonal basis was accepted first with food bean types to be followed at a later date with the white pea bean types for considerations of cost effectiveness as well as the need for producing standard white pea beans for export This suggests the need for a temporary national approach to white pea bean improvement which should be maintained until the zonal approach is firmly in place with food bean types

Table 3 Seed yields (kg/ha) of randomly selected varieties from Pre National Variety Trials in 1990

Variety	Alemaya	Awassa	Bako	Jimma	Melkassa
Mexican 142	2156	1057	763	1816	2061
PAC 19	1688	1127	1408	2070	2388
PAN 175	1542	1060	1493	2305	2058
G 11233	1180	1582	1992	3066	1963
TY 3396 1	2652	1060	2008	3633	2316
A 182	1748	1235	1544	2891	1676
ICA Linea 64	2486	1149	1230	3203	2682
Brown Speckled	1794	536	978	2246	1863
Red Wolaita	981	722	1312	2480	1760

(Source IAR 1990)

In consultation with zonal breeders the coordinator/breeder at the coordinating center takes the necessary initiative to introduce new germplasm and identify genotypes appropriate to each zone This helps to avoid duplication in introductions and to follow quarantine regulations which require laboratory and field inspection before distribution

After quarantine inspection and seed multiplication introduced materials are sent simultaneously to each of the four zones in the form of Nursery I and each zone identifies its own entries for subsequent stages of evaluation in zonal trials as shown in Figure 1

Figure 1 Evaluation scheme for varietal improvement on zonal basis

CENTRAL (Melkassa)	EASTERN (Alemaya)	SOUTHERN (Awassa/Areka)	WESTERN (Pawe/Bako/ Jimma)
Nursery I	N I	N I	N I
Zonal Nursery II	ZN II	ZN II	ZN II
Zonal Variety Trial	ZVT	ZVT	ZVT
< ----	National Variety Trials		>
On Farm Trial	OFT	OFT	OFT

(Source National Planning Workshop 1990)

The decentralized approach does not imply that zonal centres cannot request trials/lines from other zones if they feel the need for their zone A National Variety Trial can be formulated by the contribution of elite advanced cultivars from all zones for comparison across environments

Advantage should be taken of the comparative strengths and priorities of several centres The efficiency of each centre in every zone is enhanced by sharing data and trials holding annual meetings and character improvement activities such as pest and disease resistance and tolerance to low soil fertility

Though introduction of established lines from other sources (CIAT and other national programmes) will continue segregating populations from crosses made locally and abroad will assume a greater role in varietal improvement by strengthening the existing crossing programme at NRC and establishing new programmes at zonal centres

Pawe (Western Zone) and Awassa (Southern Zone) Research Centers started to formulate their own zonal variety trials from introduced materials from the NRC several years ago The National Program is trying to strengthen their capability further and the remaining centers are gradually moving towards the same goal It is hoped that this approach will promote the better use of genetic materials and the subsequent release of more cultivars in respective zones

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SCREENING BEANS (*Phaseolus vulgaris* L) FOR ADAPTATION TO THE COOL SEMI ARID HIGHLANDS OF EASTERN AFRICA

W K Rono

Kenya Agricultural Research Institute,
National Dryland Farming Research Centre Katumani,
Machakos, Kenya

ABSTRACT

Two bean nurseries were evaluated for adaptation to cool semi arid highland conditions at Matanya in Nanyuki (1800 masl) during the first (March May) and second (October January) cropping seasons of 1992 The location receives 250 350 mm rainfall per season and has a mean daily temperature of 18 6°C Mean minimum temperatures vary between 9 5 and 14 C The objective is to identify bean lines which are early in maturity high yielding and adapted to cool semi arid conditions In the warm medium climate (WMC) nursery 40 introductions were screened in the first season and 16 in the second season The majority of the introductions flowered and matured later than the local checks Mwezi Moja (Kat mm) GLP 2 and 3334 However AFR 393 AFR 390 AFR 404 AND 737 RWR 159 AFR 398 CAL 103 and DRK 24 were early Maturity periods were generally earlier during the first season Of the 20 introductions in the cool medium climate (CMC) nursery only I AS 245 flowered and matured early and yielded consistently (1201 and 1461 kg/ha during the two seasons respectively) In both nurseries days to flower and days to maturity were negatively correlated with yield while days to maturity was positively correlated with seed weight and pods per plant with yield

INTRODUCTION

Dry beans (*Phaseolus vulgaris* L) are known to have wide adaptation to climate Although they are preferably adapted to high altitudes in the tropics and to temperate zones they are also cultivated in humid and semi arid tropics and in cold climate regions (CIAT 1991) These regions have high rainfall or the crop is cultivated under irrigation The majority of farmers in eastern Africa cultivate their crops under rainfed conditions With the rapid expansion of population in highland medium potential regions there is a tremendous increase in pressure This has led to an influx of young" or starting farmers into both low and high altitude semi arid regions often bringing bean varieties that are unadapted to these conditions Various methods have been used or recommended by bean workers for screening for cold tolerance (Dickson and Boettger 1984 Hollubowicz, 1986) but field screening is probably still an effective method for identifying suitable lines Although some varieties have been developed for hot low altitude semi arid areas (Muigai and Rono 1990) limited attention has been given to the cool semi arid highlands of eastern Africa

The main objective of the study was to identify beans suitable for cultivation in the cool semi arid areas of eastern Africa These cultivars should be early in maturity high yielding and of appropriate seed sizes and colours

MATERIALS AND METHODS

Two types of nursery warm medium climate (WMC) and cool medium climate (CMC) were sown in replicated plots at Matanya, Nanyuki (1800 masl) during the first (March May) and second (October November) cropping seasons of 1992 at a spacing of 45 x 20 cm In the WMC Nursery 40 introductions and three local checks (Mwezi Moja (Kat mm) GLP 2 and 3334) were sown in the first season and 36 lines with two checks in the second season In the CMC Nursery 20 introductions and the same three checks were sown in the first season and 16 lines in the second season

The following agronomic characteristics were estimated from net plots of 3 68m^2 in the first season and 1 28m^2 in the second season

a) days to emergence from planting
b) days to flowering (50%)
c) days to maturity (50%)
d) number of pods per plant
e) number of seeds per pod
f) weight of 100 seeds (g) and
g) seed yield (kg/ha)

Statistical analyses were performed using MSTATC

RESULTS AND DISCUSSION

Warm Medium Climate (WMC) Nursery

The times to emergence were greater (between 12 and 14 days) during the first season (Table 1) than during the second season (7 10 days) (Table 2) probably due to cooler soil temperatures in March

Days to flowering were similar between seasons In the first season eight introductions (AFR 393 AFR 390 AFR 404 AND 737 RWR 159 AFR 398 CAL 104 and DRK 24) were similar in flowering time to the checks but the other introductions were much later During the second season AFR 393 CAL 104 and DRK 24 were later flowering but several of the the remaining introductions were early Maturity periods varied between 74 and 89 days in the first season and 89 and 115 days in the second DRK 24 matured later among the early flowering lines LRK 21 was early in maturity during the first season and RWR 352 during the second season although both flowered late

In both seasons there was considerable variation among entries in pods per plant (2 0 16 3 and 7 3 19 0) seeds per pod (2 0 5 2 and 2 2 5 0) and weight of 100 seeds (28 0 55 0 and 48 0 83 3 g) Pods per plant and seed weight varied between seasons but seeds per pod were unaffected Except for LRK 21 the early to flower and mature lines yielded similar to or better than the checks (897 1992 kg/ha) in the first season RWR 159 was the earliest introduction and best yielder During the second season the earlier maturing lines performed similarly to the later maturing lines AFR 377 was the heaviest yielder (3987 kg/ha) The better average yields during the season were attributed to the prolonged rainy period

Table 1 Phenological and agronomic characteristics of WMC beans Nanyuki long rains 1992

Entries	Days to emerge	Days to flower	Days to mature	Pods/ plant	Seeds/ pod	Wt /100 seeds (g)	Yields (kg/ha)
Mwezi Moja	12	41	76	4 3	3 1	40 0	421
AFR 445	12	50	86	7 5	2 6	43 0	410
AFR 368	12	53	86	4 2	3 3	31 0	481
AFR 393	12	41	74	8 6	3 6	42 0	897
AFR 451	12	50	86	8 7	2 9	36 0	576
AFR 760	12	56	86	6 8	4 2	41 0	688
AFR 761	12	57	81	7 0	3 0	38 0	563
LRK 21	12	54	75	4 3	4 3	35 0	446
AFR 371	12	78	86	9 4	3 7	28 0	655
AND 774	12	50	88	4 9	4 3	31 0	628
AND 182	13	50	86	10 0	3 8	38 0	769
RWR 352	13	47	80	10 7	3 6	40 0	1122
AFR 723	14	47	78	2 0	3 5	30 0	465
AND 765	14	49	84	5 8	3 5	41 0	772
AND 766	12	47	84	8 0	2 8	41 0	777
AFR 461	13	47	81	7 8	4 2	38 0	940
AFR 463	13	49	84	9 7	2 0	40 0	1025
AND 715	13	52	89	8 8	3 4	35 0	1258
AND 733	14	47	86	9 9	3 6	37 5	889
AND 739	14	50	85	8 3	3 7	38 0	919
AND 740	13	47	84	9 2	4 4	31 0	769
AND 749	12	55	83	7 6	3 6	38 0	701
AND 759	13	50	83	9 7	4 3	40 5	989
AND 770	14	47	83	10 1	4 2	42 0	1565
CAL 85	12	50	84	7 6	3 6	35 0	978
AFR 346	12	54	88	10 5	3 4	43 0	1253
AFR 373	14	50	86	10 6	5 2	43 0	1663
AND 735	14	50	81	11 2	3 0	38 0	630
AND 736	14	50	81	15 8	3 0	40 0	1546
AND 763	12	53	85	6 6	3 0	35 0	1158
CAL 103	12	50	76	10 8	3 6	41 0	1090
AFR 377	13	49	83	16 3	3 6	42 0	1764
AFR 390	13	44	81	9 2	3 5	41 0	1380
AFR 404	12	44	80	11 8	3 9	40 0	1650
AND 737	13	44	81	9 5	3 5	45 0	1025
AND 750	13	50	83	9 0	3 6	43 0	1245
CAL 89	13	47	81	14 6	3 2	40 0	1780
RWR 159	12	41	81	14 2	3 4	47 0	1992
AFR 398	12	46	76	10 3	3 1	49 0	1557
CAL 104	12	44	76	12 8	4 2	41 0	1842
DRK 24	12	44	78	14 8	3 1	55 0	1435
3334	12	46	76	10 4	3 5	43 0	1372
GLP 2	12	44	75	10 2	3 0	48 0	1101
Means	12 7	49 2	82 0	9 3	3 5	39 6	1050

Table 2 Phenological and agronomic characteristics of warm medium climate beans at Nanyuki during short rains 1992

Entries	Days to emerge	Days to flower	Days to mature	Pods/ plant	Seeds/ pod	Weight/ 100 seeds (g)	Grain yields (kg/ha)
AFR 368	7	49	100	12 5	3 4	48 0	1698
AFR 393	8	51	93	19 0	3 5	51 4	3425
AFR 451	8	48	98	17 4	3 0	57 3	2094
AFR 761	9	41	115	11 1	2 2	56 0	1109
AFR 371	8	41	102	13 3	3 4	57 7	1977
AND 774	8	48	112	14 5	4 6	52 0	3125
AND 192	9	41	92	17 6	3 3	58 7	3301
RWR 352	9	46	94	16 8	3 4	54 8	3156
AND 765	9	50	96	15 2	3 1	54 0	2044
AND 766	9	47	106	14 2	3 1	60 0	2266
AFR 461	10	49	107	13 7	3 8	54 7	2966
AFR 463	8	49	100	10 8	3 3	53 7	2128
AFR 715	8	56	113	10 0	2 6	59 6	1534
AND 733	9	48	106	14 9	3 3	56 3	2885
AND 739	9	44	106	13 7	4 2	58 3	2516
AND 740	9	45	94	14 5	5 0	58 0	2953
AND 749	9	58	113	7 5	4 0	66 3	1482
AND 759	9	49	106	9 4	4 0	59 8	2659
AND 770	9	47	104	14 2	3 8	53 7	2935
CAL 85	9	51	110	9 0	4 0	50 7	2065
AFR 346	10	52	115	11 3	3 9	61 3	2932
AFR 373	8	49	100	13 7	3 6	74 7	3471
AND 735	9	48	113	12 0	5 0	59 7	2185
AND 736	9	48	102	12 9	3 2	54 3	2146
AND 763	9	48	98	13 7	3 9	52 3	1065
CAL 103	9	48	96	7 3	3 2	59 0	1245
AFR 377	10	45	97	15 0	3 5	63 8	3987
AFR 390	8	44	101	15 6	4 1	59 7	2732
AFR 404	8	43	101	15 3	3 5	63 3	2482
AND 737	8	45	92	10 7	3 2	67 5	2232
AND 750	8	57	115	9 6	3 1	66 0	1589
CAL 89	10	45	110	9 2	2 8	59 3	1719
RWR 159	10	44	94	17 3	3 3	59 3	2896
AFR 398	8	44	92	13 1	3 1	65 8	2651
CAL 104	8	49	104	12 6	4 4	59 0	2872
DRK 24	9	47	108	10 6	2 9	83 3	2737
Mwezi Moja	8	39	89	12 3	3 6	61 8	3155
GLP 2	8	42	92	14 6	3 1	66 3	3219
LSD (P<0 05)	1 1	2 1	4 0	4 3	1 2	7 7	1205
CV%	7 4	2 7	2 4	20 2	20 6	8 1	30 2

Cool Medium Climate (CMC) Nursery

Days to emergence varied between 8 and 14 in the first season (Table 3) and 7 and 10 days in the second season (Table 4) similar to the WMC nursery The majority of entries were late in flowering and maturity Although days to flower were similar between seasons most lines matured earlier during the first season Only LAS 245 consistently flowered and matured earlier and yielded better in both seasons Although OBN 67 was the best yielder during the first season it was very susceptible to CBB ALS and anthracnose

Table 3 Phenological and agronomic characteristics of cool medium climate beans at Nanyuki during the long rains 1992

Entries	Days to emerge	Days to flower	Days to mature	Pods/ plant	Seeds/ pod	Weight/ 100 seeds (g)	Grain yields (kg/ha)
GLP 2	12	46	74	7 0	3 2	49 5	497
AND 790	8	46	76	8 3	5 4	22 5	788
OBN 42	10	45	76	10 8	4 3	23 5	832
OBN 48	12	62	95	8 5	3 5	31 0	717
OBN 67	11	58	89	8 2	3 7	19 5	2511
OBN 70	12	59	98	7 0	3 8	23 0	266
AND 814	13	63	99	8 6	3 9	41 5	796
AND 815	14	63	98	5 4	2 6	41 0	462
AND 817	13	63	98	9 5	3 8	32 0	552
AND 822	13	57	74	7 6	3 8	35 0	644
LAS 281	14	57	102				
LAS 319	13	61	100	5 0	2 5	29 0	220
AND 824	13	57	94	7 5	3 8	35 5	919
LAS 294	14	51	94	7 0	3 5	33 0	470
LAS 295	14	61	94	8 2	4 1	36 0	476
LAS 315	12	50	81	8 5	4 3	22 0	1196
LAS 328	13	51	86	8 4	4 2	34 0	1106
LAS 259	13	51	91	6 3	3 2	43 0	734
AFR 410	14	57	88	7 2	3 6	38 0	880
AFR 411	14	60	68	5 1	2 6	43 5	1375
LAS 245	14	41	78	7 2	3 6	34 5	1201
3334	12	46	75	8 5	4 2	46 0	1669
Mwezi Moja	12	41	73	7 5	3 8	43 5	1576
Means	12 6	54 2	86 5	7 6	3 7	34 4	904

Table 4 Phenologıcal and agronomıc characterıstıcs of cool medıum clımate beans at Nanyukı durıng the short raıns 1992

Entrıes	Days to emerge	Days to flower	Days to mature	Pods/ plant	Seeds/ pod	Weıght/ 100 seeds(g)	Graın yıelds (kg/ha)
AND 790	7	50	99	19 3	4 7	31 2	3464
OBN 42	10	49	98	18 0	3 6	27 3	1966
OBN 48	10	62	134	5 0	3 1	34 7	1148
AND 814	9	59	136	4 2	2 4	58 3	1156
AND 815	9	60	132	4 1	2 3	46 0	294
AND 817	9	57	138	9 7	3 6	48 7	1787
AND 822	7	57	133	7 8	3 1	60 7	1581
LAS 319	9	66	141	10 5	3 4	45 3	1167
AND 824	10	58	141	6 0	2 9	56 5	763
LAS 295	8	58	145	9 8	3 7	57 3	1474
LAS 315	8	51	102	205 0	3 9	27 7	2396
LAS 328	8	51	103	9 0	3 8	41 3	872
LAS 259	8	55	136	6 0	3 6	52 0	948
AFR 410	8	59	120	12 2	3 4	59 7	2242
AFR 411	7	59	145	8 4	3 6	62 0	888
LAS 245	7	42	88	13 9	3 6	43 0	1466
Mwezı Moja	8	39	79	14 1	3 6	59 8	2216
GLP 2	8	41	83	13 8	3 2	61 6	2349
LSD (P<0 05)	0 9	0 9	3 3	5 5	1 4	4 7	408
CV%	6 0	1 0	1 6	32 3	24 4	5 8	36 3

Days to flower and days to maturıty were negatıvely correlated wıth yıeld ın both WMC and CMC nurserıes This ıs expected ın areas where the growıng perıod ıs short ındıcatıng that earlıness ın flowerıng and maturıty are ımportant for adaptatıon Days to maturıty were better correlated wıth yıeld than days to flower Sımılar results have been reported by Whıte and Sıngh (1991)

Table 5 Correlatıons among days to flower days to maturıty pods/plant seed weıght and graın yıeld ın 36 warm medıum clımate (WMC) and 16 cool medıum clımate (CMC) beans Nanyukı short raıns 1992

Character combınatıon	WMC	CMC
Days to flower vs graın yıeld	0 16	0 32*
Days to maturıty vs graın yıeld	0 25*	0 43**
Days to maturıty vs seed weıght	0 07	0 68**
Pods/plant vs graın yıeld	0 55**	0 76**
Seed weıght vs graın yıeld	0 20*	0 33*

* ** denotes sıgnıficantly dıfferent from zero at P<0 05 and 0 01 respectıvely

Pods per plant was positively (P<0 01) correlated with yield in both WMC (0 55) and CMC (0 76) nurseries indicating the importance of pod number in determining yield In the CMC Nursery seed size was positively (P<0 01) correlated with days to maturity (0 68) and negatively (P<0 01) correlated with yield indicating selection for medium seed size In contrast the same agronomic characteristics were positively and significantly (P<0 05) correlated in the WMC Nursery

These results indicate the need for further study of promising lines which have potential for cultivation in the semi arid highlands of eastern Africa

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SNAP BEAN BREEDING IN KENYA

J K Kamau S G S Muigai and S M Wachiuri

**Kenya Agricultural Research Institute,
National Horticultural Research Institute Thika Kenya**

ABSTRACT

Nine crosses were made in 1988 between Monel and food beans adapted to Kenyan conditions and resistant to rust angular leaf spot and anthracnose The donor parents were also more vigorous and yielded better than Monel A pedigree selection procedure was applied to the segregating progenies Selection was mainly focused on resistance to rust and angular leaf spot while at the same time retaining the favourable agronomic characters of Monel Most lines in the crosses coded 10 SN 1 6 10 SN 1 4 and 10 SN 1 5 showed high degrees of resistance to rust angular leaf spot and anthracnose (ratings<3) and retained most of the favourable characters of Monel Most of these lines were also of acceptable pod shape cross section colour and taste (ratings<4) and are expected to retain these good traits in more advanced generations At F_8 some of the lines in the above crosses were still segregating for growth habit necessitating single plant selection for another two generations to stabilize the character

INTRODUCTION

Snap beans are cultivated in different climatic zones at varying altitudes and under a variety of management practices in the developing world Their pods differ in size shape taste and colour (ranging from white to black) among and within countries The common denominator is that snap beans are invariably produced by small farmers as a high input high-output market oriented crop close to urban centres (Henry and Janssen 1992)

A cup serving of green snap beans contributes very significantly (11%) to Vitamin A requirements and can be a moderate contributor of riboflavin (7 55%) thiamin (9%) calcium (6 9%) and iron (6 7%) It also contributes exceptionally well to ascorbic acid requirements (60%) Levels of niacin protein and phosphorous contributed are less than 5% of requirements and the calorie contribution is less than 2% (Kelley and Scott 1992)

Snap bean production in developing countries is estimated at 4-4 5 million metric tonnes Latin America produces 250 300 thousand tonnes Africa produces 40 thousand tonnes the Middle East and northern Africa produce 60 thousand tonnes while total Asian snap bean production is 3 6 -4 million tons highly biased towards the China share of 3 3 5 million tonnes

Production of snap beans in Kenya has expanded rapidly in recent years In 1986 four thousand hectares of snap beans were grown but by 1989 the area had increased to ten thousand ha It is grown in areas receiving 500 1500 mm of rainfall per annum at an altitude of 2000 masl (Anon 1989) Irrigation is however required in the drier areas and for off season production Snap beans are grown on 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 control are major financial and labour constraints The most important production reducing diseases are rust anthracnose root rots and various blights The major snap bean insect pests are bean stem maggots whitefly leaf miner pod borer aphids and mites (Henry and Janssen 1992) To generate the potentially high returns on investments the crop requires large amounts of fertilizers and pesticides In addition irrigation has been shown to have a significantly positive effect on production in several countries (Erkal *et al* 1989 Francisco and Domingo 1988) Fertilizers and pesticides constitute 13 53% of total production costs in developing countries

The objectives of this study were to

1 identify genes for resistance to rust *Uromyces phaseoli*

2 hybridize the donor parents with Monel so as to transfer the genes for resistance and

3 evaluate segregating progenies for resistance to rust *Uromyces phaseoli*

MATERIALS AND METHODS

Some 90 snap bean lines were grown at Thika (Samuru site) in the long rains of 1991 The lines were derived by crossing Monel with cooking beans showing a high degree of resistance to rust angular leaf spot and bean common mosaic virus The pedigree breeding method was applied to the segregating progenies

The lines were sown in three rows of 10 m length The spacing between the rows was 50 cm and that between plants within a row was 10 cm DAP was added at planting at the rate of 200 kg/ha Paths of 1 5 m were left between crosses The lines were evaluated for resistance to rust angular leaf spot days to 50% flowering vigour of growth and growth habit At 20 and 35 days from planting bean leaves infected with rust were spread among the bean lines to increase the pathogen inoculum level Single plants showing a high degree of resistance to bean rust and angular leaf spot and vigorous growth were selected During selection the snap bean cultivar Monel which is the most commonly cultivated snap bean cultivar in Kenya, was used as a control

A total of 374 single plants were selected from nine of the 90 lines and sown in single rows at Thika (Mahuti site) in July 1991 using the same planting procedures and selection criteria 493 single plants were selected for further evaluation the following season In addition to the above parameters pod shape taste colour and length were recorded The lines were sown at Thika (Mahuti site) in February 1992 using the planting and rust inoculation procedures described above 142 single plants were selected and sown at Thika (Mahuti site) in the short rains of 1992 93 The lines were evaluated for resistance to rust angular leaf spot vigour growth habit and pod taste cross section colour length and number Planting and rust inoculation procedures were as described earlier

Disease ratings

The nine category disease severity scale described by Schoonhoven *et al* (1981) was used as a measure of the degree of infection by both rust and angular leaf spot 1 = no visible disease symptoms 3 = approximately 5 10% of leaf area infected 5 = approximately 20 30% of leaf area infected 7 = approximately 40 60% of leaf area infected and 9 = more than 80% of leaf area infected

Agronomic character ratings

Pod cross section 1 3 = roundish 4 6 = oval 7 9 flattish

Pod taste 1 3 = sweeter than Monel 4 6 = like Monel 7 9 = bitter taste

Vigour 1 3 = less vigorous than Monel 4 6 = as vigorous as Monel 7 9 more vigorous than Monel

RESULTS AND DISCUSSION

The 374 single plants selected from the 90 bean lines sown in April 1991 combined a high degree of resistance to rust and angular leaf spot (disease rating <3) with vigourous growth Most single plants selected had determinate growth habit which favours ease of handling during weeding controlling diseases and pests and harvesting Most selected lines reached 50% flowering at the same time as Monel The selected single plants also yielded better than Monel which together with their better vigour could have been due to heterosis between the hybridized parents arising from their divergent genetic backgrounds Some of the selected lines had an indistinct climbing habit indicating that the genes controlling this character had intermediate effects and were therefore quantitative

The 493 selected single plants sown at Thika (Mahuti site) in February 1992 for further evaluation showed a high degree of resistance to rust and angular leaf spot (disease rating<3) This was yet an indication that genes for resistance were being passed on to the progenies with progressive selection The vigour of the selected lines was similar to Monel which was an indication of decreasing hybrid vigour with increasing homozygosity Most selected lines were of determinate growth habit with some lines showing undeveloped climbing habits

The pods of most selected were roundish in cross section which is a character associated with the snapping habit of fresh snap beans A few plants had oval pod cross sections and none had a flattish pod cross section This was an indication that the roundish snapping habit of Monel was maintained through selection Most selected lines had straight pods (ratings 1 3) of acceptable length similar to Monel Most of them had a sweet sugarish taste like that of Monel (ratings 1 5) Plants with bitter pods were not selected

Most of the 142 single plants evaluated at Thika (Mahuti site) in the short rains of 1992 93 showed a high degree of resistance to rust and angular leaf spot (ratings <3) (Table 1) This was a further indication that genes for resistance were being passed down the progenies The vigour of the selected lines was like that of Monel further confirmation that the favourable growth characters of Monel were being maintained Some selected lines did not have a uniform determinate growth habit indicating that they were still segregating for growth habit and required further single plant selection so as to stabilize this growth habit The pod cross section taste colour and length of the selected lines were quite similar to those of Monel This was again an indication that the genes determining these favourable characters were being fixed over generations

Table 1 Agronomic characters and disease ratings of 142 snap bean lines evaluated at Thika (Mahuti site) in the short rains of 1992 93

		Disease ratings		Agronomic characters		Pod characteristics				
Family	Line	Rust	ALS	GH	VIG	XSEC	TAST	COL	LNGTH	NO
Monel		4	2	D	3	3	6	3	3	18
10ST1 4	T1	2	3	D	3	3	4	3	4	19
	T3	2	3	D	3	3	4	4	7	17
	T19	2	3	D	3	3	4	3	4	13
	T25	2	3	D	3	4	8	4	4	15
	T26	3	3	D	3	4	3	4	7	14
	T31	3	3	D	3	3	8	3	7	12
	T27	3	3	D	3	4	8	4	7	18
	T28	3	3	D	3	3	3	3	7	14
10SN1 5	A5	1	2	ID	3	7	8	3	7	14
	A11	2	2	ID	3	3	7	7	4	17
	A20	2	2	ID	3	3	4	3	3	15
	A29	2	2	ID	3	3	8	4	4	19
	A30	1	2	ID	3	3	6	3	8	17
	A31	1	2	ID	3	3	6	4	8	20
	A35	1	2	ID	3	3	4	4	4	15
	A45	2	2	ID	3	3	8	4	4	22
	A57	1	2	ID	3	3	6	7	8	26
	A59	1	2	ID	3	3	6	4	4	25
	A60	1	2	ID	3	3	6	4	8	16
	A61	1	2	ID	3	3	4	3	8	27
	A62	2	2	ID	3	3	4	4	9	15
	A71	2	2	ID	3	3	8	7	9	19
	A18	1	3	ID	3	3	4	3	5	17
	A42	1	3	ID	3	3	8	4	9	19
B	B2	4	2	D	4	3	6	3	3	13
	B15	3	3	D	3	3	4	3	5	21
	B18	3	3	D	3	3	4	3	3	15
	B20	2	2	D	3	7	4	3	3	12
	B23	2	3	D	3	3	4	3	3	19
	B24	3	2	D	3	4	7	3	3	19
	B30	2	2	D	3	3	7	3	3	14
	B31	2	3	D	3	3	4	3	7	22
	B34	2	3	D	3	3	7	3	3	15
	B35	2	4	D	3	3	3	3	3	15
	B36	3	4	D	3	3	8	3	3	16
	B37	3	3	D	3	3	8	3	3	14
	B50	3	3	D	3	3	7	3	3	19
	B57	3	3	D	3	3	8	3	3	16
	B59	3	3	D	3	3	4	3	3	14
	B64	3	3	D	3	4	7	3	3	13
	B68	3	3	D	3	3	4	3	3	16

Table 1 (continued)

Family	Line	Disease ratings Rust	ALS	Agronomic characters GH	VIG	Pod characteristics XSEC	TAST	COL	LNGTH	NO
	B75	3	3	D	3	3	4	4	6	17
	B77	3	3	D	3	3	7	3	4	20
	B79	3	3	D	3	3	4	3	3	15
	B81	3	3	D	3	3	4	3	3	14
	B82	2	3	D	4	3	4	3	2	15
	B84	3	3	D	4	3	4	3	3	17
	B89	2	3	D	4	3	4	4	2	18
	B90	2	3	D	3	3	7	3	2	17
	B96	3	3	D	4	3	7	3	3	22
	B103	3	3	D	4	3	4	3	3	13
	B104	2	3	D	4	5	4	3	2	21
	B107	2	2	D	4	4	7	4	2	11
	B108	3	2	D	4	3	4	4	3	14
	B110	3	3	D	4	3	3	7	3	22
	B117	3	3	D	4	3	3	3	3	16
	B118	3	3	D	3	7	4	3	3	18
	B127	2	3	D	3	3	4	3	3	17
	B128	2	2	D	3	3	6	3	2	15
	B135	2	2	D	4	3	4	3	2	19
	B137	2	2	D	4	3	4	3	2	14
	B143	2	2	D	4	3	7	3	2	17
10SN1 4	C2	3	2	D	4	5	6	8	3	12
	C3	2	2	D	4	3	8	8	2	18
	C4	2	2	D	4	3	4	8	2	14
	C8	2	2	D	4	3	4	8	2	22
	C9	2	2	D	4	3	4	8	2	18
	C13	2	2	D	3	5	4	4	2	22
	C17	2	2	D	3	3	4	8	2	20
	C21	1	2	D	3	3	4	8	1	12
	C25	1	2	D	3	3	4	8	1	14
	C28	1	2	D	3	3	4	8	1	14
	C33	1	2	D	3	3	4	8	1	14
10SN1 6	D2	1	2	D	4	3	4	3	1	15
	D5	2	2	D	3	4	6	3	2	32
	D8	1	2	D	3	3	4	3	1	16
	D11	2	2	D	3	3	3	4	2	20
	D12	1	2	D	3	4	4	3	1	32
	D21	1	2	D	3	3	3	3	1	28
	D25	2	2	D	3	3	3	3	2	14
	D26	1	2	D	3	4	4	3	1	15
	D29	1	1	D	3	4	4	3	1	12
	D33	1	2	D	3	4	3	3	1	13
	D37	1	2	D	3	3	4	3	1	17

Table 1 (continued)

		Disease ratings		Agronomic characters		Pod characteristics				
Family	Line	Rust	ALS	GH	VIG	XSEC	TAST	COL	LNGTH	NO
	D45	3	2	D	3	3	3	3	3	17
	D46	2	2	D	3	4	4	3	2	15
	D48	1	3	D	3	4	3	3	1	20
	D54	2	2	D	3	4	3	3	2	47
3X14	E3	1	2	D	3	5	4	3	1	18
	E8	2	2	D	3	3	4	3	2	24
	E14	2	2	D	3	3	6	4	2	14
	E18	1	2	D	3	3	4	4	1	20
	E20	2	3	D	3	5	4	3	2	15
	E29	2	3	D	3	3	4	4	2	20
	E30	3	2	D	3	3	4	3	3	18
	E34	2	3	D	3	7	4	4	2	17
	E36	1	3	D	3	3	4	3	1	22
26SN3 1	F9	2	3	D	3	3	4	3	2	18
	F22	1	2	D	3	3	4	3	1	22
	F23	2	2	D	3	3	4	3	2	20
	F26	1	3	D	3	3	4	3	1	18
	F27	1	3	D	3	3	4	4	1	22
	F28	1	3	D	3	3	4	3	1	28
	F29	3	3	D	3	3	4	3	3	24
	F30	1	3	D	3	3	4	3	1	32
	F31	1	2	D	3	3	4	4	1	28
	F33	1	2	D	3	3	4	4	1	24
9X20	G2	3	2	D	3	3	4	3	3	16
	G16	2	2	D	3	3	4	3	2	20
	G17	3	2	D	3	3	4	3	3	22
	G21	3	2	D	3	5	4	3	3	18
	G23	1	2	D	3	3	4	3	1	20
	G28	2	2	D	3	3	4	3	2	17
	G29	3	1	D	3	3	4	3	3	18
	G30	3	3	D	3	3	4	3	3	15
G	G31	2	3	D	3	3	4	3	2	14
	G32	2	2	D	3	3	4	3	2	14
	G34	3	2	D	3	3	4	3	3	16
26SN3 3	H3	2	2	ID	3	3	6	3	2	18
	H7	2	2	D	3	3	6	3	2	16
	H17	2	2	D	3	3	6	3	2	21
	H27	4	3	D	3	3	4	6	4	14
	H32	4	2	ID	3	3	6	3	4	12
20X10	J2	2	1	D	3	3	4	3	2	14
	J1	2	1	D	3	3	4	3	2	19
K	K3	3	2	D	3	3	4	3	3	25
C	C1	3	3	D	3	3	6	3	2	14

Table 1 (continued)

Family	Line	Disease ratings Rust	ALS	Agronomic characters GH	VIG	Pod characteristics XSEC	TAST	COL	LNGTH	NO
	C2	3	3	D	3	3	6	3	3	15
	C3	3	3	D	3	5	6	3	3	17
	C4	3	2	D	3	3	4	3	3	24
	C5	2	2	D	4	3	6	4	2	17
	C7	2	2	D	5	3	4	4	2	25
	C8	2	2	D	4	3	4	3	2	22
	C9	2	3	D	4	3	6	3	2	14
	C10	2	2	D	4	3	6	9	2	15
	C11	2	2	D	4	3	6	3	2	20
	C12	2	2	D	4	3	6	3	2	30
	C13	2	2	D	3	3	6	4	2	15
	C14	2	2	D	3	3	6	3	2	20

Disease ratings ALS = angular leaf spot agronomic characters GH = growth habit D = determinate ID = indeterminate VIG = vigour pod characteristics XSEC = cross section TAST = taste COL = colour LNGTH = length NO = number

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HETEROSIS AND COMBINING ABILITY FOR YIELD AND OTHER QUANTITATIVE CHARACTERS IN HARICOT BEAN *Phaseolus vulgaris* L

Melaku Ayele

Institute of Agricultural Research Nazreth Ethiopia

ABSTRACT

Eight haricot bean varieties were crossed in all possible combinations excluding reciprocals and the 28 F_1 hybrids and their parents sown in a RCBD at Nazreth Research Center in February 1992 General combining ability (GCA) variances were significant for all characters except seed yield per plant while specific combining ability (SCA) variances were significant for days to flowering days to maturity and number of seeds per pod indicating the importance of both additive and non additive gene action GCA variances were larger than SCA variances for all characters suggesting that additive type gene action was preponderant and that selection should result in the improvement of yield and other traits of economic importance BAT 1198 and I x Rico 23 were good combiners for the yield components pods per plant seeds per plant and seeds per pod while BAT 338 IC A 176 and Carioca exhibited significantly negative GCA effects for cooking time suggesting that they are good combiners for rapid cooking

INTRODUCTION

Research on haricot bean improvement in Ethiopia was scant and uncoordinated until 1972 when a pulse research programme on varietal improvement and crop management was initiated at Nazreth Research Station with main emphasis on haricot bean during the early years The programme has so far depended on evaluation of introductions and local collections and several white and coloured seeded varieties have been released (Imru Assefa 1985 Amare Abebe and Haile Kefene 1989) However attempts to identify varieties with good yield potential stable resistance to major diseases and pests and acceptable seed type and quality were not successful

The selection of promising genotypes from a diverse genetic base and subsequent utilization for hybridization is one of the strategies for improving the productivity of common bean Combining ability analysis is a powerful tool to identify the best combiners which may be hybridized to exploit heterosis and select desirable crosses for further exploitation It is also useful to elucidate the nature of gene action

Combining ability studies conducted with common bean indicate that both additive and non additive gene action are important in the inheritance of seed yield yield components and architectural traits (CIAT 1987 Foolad and Bassiri 1983 Singh and Saini 1982 1983 Vaid *et al* 1985) and that additive gene action is more important than non additive gene action for most traits (CIAT 1984 Nienhuis and Singh 1983 1986 1988 Singh and Saini 1982 1983 Vaid *et al* 1985 Wassimi 1985 Wassimi *et al* 1986) On the contrary non additive gene action (Foolad and Bassiri 1983 Navale and Patil 1982 Singh and Saini 1983) and dominance effects (Chung and Stevenson 1973 Coyne 1968) are important for some traits including seed yield

In this study an attempt has been made to gather information on the ability of eight potentially high yielding cultivars of haricot beans to transmit genetic material to hybrid combinations and to determine the type of gene action involved in the inheritance of yield and its components

MATERIALS AND METHODS

The experiment was carried out at Nazreth Research Center Institute of Agricultural Research Eight cultivars of haricot bean (*P vulgaris* L) (Ex Rico 23 BAT 338 1C Mexican 142 BAT 1198 Black Dessie Negro Mecentral A 176 and Carioca) were crossed in a complete diallel excluding reciprocals in February and July 1991 The 28 F_1 hybrids and their parents were sown on 11 February 1992 under irrigation The trial was laid out in a randomized complete block design with four replications Each plot was a single row 2 m long and the distance between rows was 0 6 m The spacing between plants within the row was 20 cm

The numbers of days to flowering and maturity and cooking times were recorded on whole plots while plant height numbers of pods and seeds per plant number of seeds per pod 100 seed weight and seed yield per plant were determined as averages of the middle six plants per plot Combining ability analysis was performed according to Griffing s Model I method 2 (Griffing 1956)

RESULTS AND DISCUSSION

There were significant differences among entries for all characters except seed yield (Table 1) The heaviest seed yield (26 9 g/plant) was produced by BAT 1198 x Carioca and the least (15 2 g) from A 176 The best parental yield was recorded for BAT 1198 which ranked seventeenth among entries

Table 1 Genotype and general (GCA) and specific combining ability (SCA) mean squares GCA SCA ratios standard errors means LSDs and coefficients of variation (CV) for different characters in eight parent diallel cross of haricot bean at Melkassa in 1992

Character	Mean squares Genotypes	GCA	SCA	GCA/SCA	Error	Mean	LSD P<0 01	CV %
DF	11 66	36 29	5 50	6 6	1 22	40 7	2 05	2 7
DM	17 24	34 87	12 83	2 7	6 10	72 9	4 58	3 4
PH	24 39	45 01	19 24	2 3	10 73	35 6	6 08	9 2
PPP	83 48	279 89	34 38	8 1	30 32	25 4	10 18	1 7
SPP	1450 25	3916 99	833 56	4 7	788 31	107 8	52 08	26 1
SPO	0 88	2 08	0 59	3 5	0 27	4 3	0 97	12 3
SW	20 04	81 08	4 78	17 0	3 03	18 6	3 23	9 4
YP	35 72	47 87	2 68	1 5	31 29	19 8		28 2
CT	27 54	98 67	9 75	10 1	6 17	23 0	4 6	10 7

DF = days to flowering DM = days to maturity PH = plant height (cm) PPP = pods/plant SPP = seeds/plant SPO = seeds/pod SW = weight/100 seeds (g) YP = yield per plant (g) CT = cooking time (minutes)

Mean squares for general combinıng abılıty (GCA) were sıgnıficant at P≤0 01 for all traıts measured except seed yıeld per plant (Table 1) Specıfic combınıng abılıty (SCA) was sıgnıficant at P≤0 01 for days to flowerıng and at P≤0 05 for days to maturıty and number of seeds per pod Thıs ımplıes that for characters such as days to flowerıng and maturıty and number of seeds per pod both addıtıve and non addıtıve types of gene actıon are ımportant though addıtıve gene actıon predomınated The lack of sıgnıficant SCA varıances ın most characters suggested that non addıtıve gene actıon was unımportant Thıs result ıs ın contrast to earlıer fındıngs ın whıch both GCA and SCA mean squares were sıgnıficant for yıeld and yıeld components (CIAT 1984 1987 Ramalho *et al* 1988 Sıngh and Saını 1982 1983 Vaıd *et al* 1985) In the present study both GCA and SCA varıances were sıgnıficant for number of seeds per pod However Foolad and Bassırı (1983) found GCA and SCA both non sıgnıficant for thıs traıt The sıgnıficant addıtıve gene actıon for cookıng tıme agrees wıth Wassımı (1985) who found hıghly sıgnıficant GCA and SCA mean squares ın the F_2 and F_3 generatıons of crosses of eıght common bean genotypes Generally GCA was larger than SCA for all characters studıed In contrast to Wassımı s results the SCA varıance for cookıng tıme was not sıgnıficant ın the present study

The ratıo of GCA to SCA mean squares was greater than unıty for all characters (Table 1) ındıcatıng that theır ınherıtance was governed by addıtıve type of gene actıon Thıs result ıs ın agreement wıth the fındıng of Nıenhuıs and Sıngh (1983 1986) for yıeld yıeld components and archıtectural traıts Ramalho *et al* (1988) for seed yıeld Sıngh and Saını (1982) for seed yıeld and yıeld components and Wassımı (1985) for cookıng tıme Studıes ınvolvıng the ınherıtance of quantıtatıve characters ın bean have generally revealed a predomınance of addıtıve gene actıon For characters of economıc ımportance thıs has breedıng ımplıcatıons sınce addıtıve genetıc varıatıon can be effectıvely exploıted by conventıonal pedıgree methods Moreover the performance of parents can be used to predıct the performance of crosses (Nıenhuıs and Sıngh 1983 1986) Thus parents that express large GCA effects can be crossed to ısolate hıgh yıeldıng segregants usıng approprıate selectıon procedures

Table 2 Estımates of general combınıng abılıty effects for yıeld and other traıts ın eıght varıetıes of harıcot bean grown at Nazreth 1992

	DF		DM		PH		PPP		SPP		SPO		SW		CT	
Genotypes	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
Ex Rıco 23	41 5	1 34**	73 8	0 64	37 0	0 55	28 9	1 02	122 1	8 26*	4 1	0 11	15 5	1 35	24 8	1 11
BAT 338 1C	41 8	0 24	75 0	0 31	35 9	0 81	22 7	2 47	115 0	1 07	5 0	0 39	16 5	0 85	18 9	1 87
Mexıcan 142	41 5	0 19	75 3	0 16	38 1	0 20	31 4	3 54	121 2	4 20	3 8	0 40	15 5	1 18	24 0	1 14**
BAT 1198	42 8	0 66**	74 5	0 56	34 7	1 18	27 1	2 94	120 8	14 2	4 4	0 06	16 5	0 72	25 2	0 13
Black Dessıe	38 0	1 54**	70 3	1 59**	32 5	1 77**	23 0	0 94	89 0	1 29	3 8	0 15	19 3	0 28	26 9	1 37**
Negro Mecentral	43 0	0 79**	77 0	0 81	35 9	1 36**	25 8	0 21	98 5	1 28	4 0	0 04	17 7	0 13	26 0	1 62
A 176	42 0	0 46**	73 8	0 39	36 6	0 11	17 9	3 68**	74 9	13 57	4 2	0 06	20 3	1 02	16 5	2 30**
Carıoca	42 5	0 91	75 8	1 39**	33 4	0 68	18 8	2 49	85 3	14 52**	4 6	0 11	22 2	2 93	19 1	1 20
S E (g_i)†	0 163		0 365		0 485		0 814		4 153		0 078		0 258		0 367	
S E (g_i g_j)	0 247		0 552		0 733		1 231		6 278		0 118		0 390		0 556	

* ** = Estımates of GCA effects sıgnıficantly dıfferent from zero at P≤0 05 and 0 01 levels of sıgnıficance respectıvely DF = days to flowerıng DM = days to maturıty PH = plant heıght (cm) PPP = number of pods/plant SPP = number of seeds/plant SPO = number of seeds per pod SW = weıght/100 seeds (g) YP= seed yıeld per plant (g) CT = cookıng tıme (mınutes)

BAT 1198 was a good combiner for increased numbers of pods and seeds per plant (Table 2) so is a good parent for hybridization programmes aimed at improving yield since these are some of the principal traits determining seed yield BAT 1198 is a white seeded variety showing good yield potential in National Variety Trials across several locations and years

Significant positive GCA effects were exhibited by Mexican 142 for number of pods per plant and by Ex Rico 23 for number of seeds per plant BAT 338 1C showed negative GCA effects for both traits but only that for number of pods per plant was significant In the present study none of the parents were good combiners for all yield components Similar results were reported by Singh and Saini (1983) However CIAT (1984) Nienhuis and Singh (1983 1986) and Vaid *et al* (1985) found cultivars with positive GCA effects for yield and all its components All white seeded parents showed negative significant GCA effects for 100 seed weight Parents A 176 and Carioca were good combiners for 100 seed weight but had negative and significant GCA effects for number of pods and seeds per plant suggesting that the use of these varieties might lead to a reduction in pods and seeds per plant

Ex Rico 23 Mexican 142 Black Dessie and Negro Mecentral were found to transmit longer cooking time to their progenies while BAT 388 1C A 176 and Carioca had significant negative GCAs and decreased cooking time in their progenies A 176 showed the least cooking time and the highest negative GCA for the trait In the evaluation of Senayit Yetneberk (1991) A 176 showed the shortest mean cooking time across locations among the eleven varieties tested including Mexican 142 and Ex Rico 23 Since cooking time is controlled by additive gene action it is possible to cross fast cooking lines with otherwise desirable cultivars and subsequently select for rapid cooking segregants

Carioca was the highest contributor to lateness in flowering and maturity whereas earliness was contributed by Black Dessie Ex Rico 23 showed a negative GCA effect for days to flowering but its GCA effect for maturity was not significant Negro Mecentral also showed positive and significant GCA effects for days to flowering and maturity suggesting that it had the ability to impart lateness to its progeny Significant positive GCA effects for days to flowering were exhibited by BAT 1198 and A 176 Such late maturing varieties will be suitable for areas with long growing seasons Hybrids involving parents with negative GCA effects for maturity can be considered for moisture stress areas

It was hypothesized that if SCA mean squares were not significant as was the case for most traits in the present study the best performing progenies may be produced by combining parents having the highest GCA (Baker 1978) Estimates of SCA effects for the hybrids are presented in Table 3 Ex Rico 23 combined well with Black Dessie while M142xCar and BDxCar combined poorly for number of seeds per pod The hybrid ER23xBD involved moderate and poor combiners whereas M142xCar and BDxCar involved both parents with poor GCA effects (Table 2)

Of all the hybrids only six showed significant negative SCA effects for number of days to flower (Table 3) Among those hybrids with positive SCA effects only three were significant All except one cross involving Ex Rico 23 (ER23xNM) had negative SCA values so flowered earlier than expected based on the mean performance of their parents The SCA effect for days to maturity was significant and positive in only BDxCar whereas 338xM142 BDxMN and NMxCar exhibited negative and significant SCA values

Table 3 Estimates of specific combining ability effects for yield and other traits in 8 x 8 diallel cross of haricot bean at Nazreth in 1992

Genotypes	DF Mean	DF SCA	DM Mean	DM SCA	SPO Mean	SPO SCA
ER23 x 338	38 3	1 386	70 0	1 925	4 7	0 041
ER23 x M142	39 0	0 211	72 0	0 400	4 3	0 302
ER23 x 1198	39 5	0 561	71 5	1 300	4 1	0 295
ER23 x BD	35 5	2 361	69 5	1 150	4 7	0 482
ER23 x NM	40 3	0 064	74 5	1 450	4 9	0 467
ER23 x A176	38 5	1 361	70 5	1 350	4 3	0 132
ER23 x Car	39 3	1 061	74 0	0 375	4 2	0 080
338 x M142	39 3	1 536	70 3	2 475	4 1	0 157
338 x 1198	41 8	0 114	72 5	0 625	4 3	0 407
338 x BD	38 5	0 936	69 0	1 975	4 8	0 303
338 x NM	42 3	0 489	73 5	0 125	4 8	0 088
338 x A176	42 0	0 5	74 3	2 075	4 8	0 099
338 x Car	43 5	1 614	73 3	0 700	4 8	0 287
M142 x 1198	41 3	0 039	74 0	0 400	3 8	0 149
M142 x BD	40 3	1 239	73 0	1 550	4 0	0 253
M142 x NM	40 3	1 086	73 3	0 600	3 8	0 090
M142 x A176	40 8	0 261	71 3	1 400	4 2	0 252
M142 x Car	41 0	0 461	73 3	1 175	2 6	1 131
1198 x BD	39 5	0 361	71 5	0 350	4 4	0 204
1198 x NM	42 3	0 064	74 5	0 250	4 6	0 277
1198 x A176	41 3	0 611	71 5	1 550	4 4	0 048
1198 x Car	42 3	0 061	77 0	2 175	4 5	0 267
BD x NM	39 5	0 486	69 8	2 350	3 7	0 422
BD x A176	41 0	1 339	71 3	0 350	4 2	0 065
BD x Car	41 0	0 889	75 5	2 825	3 4	0 631
NM x A176	42 0	0 014	72 5	0 800	4 5	0 124
NM x Car	42 0	0 436	72 0	3 075	4 6	0 384
A176 x Car	41 8	0 361	73 3	0 625	4 1	0 095
$CD(S_{ij})$ 5%	0 992		2 217		0 470	
$CD(S_{ij}\ S_{ik})$	1 453		3 247		0 680	
$CD(S_{ij}\ S_{kl})$	1 369		3 061		0 649	

DF = days to flowering DM = days to maturity SPO = Seeds/pod * estimates of SCA significantly different from zero at P≤0 05 ER23 = Ex Rico 23 338 = BAT 338 1C M142 = Mexican 142 1198 = BAT 1198 BD = Black Dessie NM = Negro Mecentral A176 = A 176 Car = Carioca

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HARD TO COOK DEFECTS IN BEANS (*Phaseolus vulgaris*) INFLUENCE OF LOCATIONS AND VARIETIES

Senayit Yetneberk

Institute of Agricultural Research, Nazreth, Ethiopia

ABSTRACT

A set of 12 varieties of beans (*Phaseolus vulgaris* L) was evaluated for cooking time at four locations (Awassa Bako Jimma and Nazreth) The set included four varieties of each of three groups white pea beans (WPB) different coloured beans (DCB) and large seeded beans (LSB) The study was conducted to investigate the effects of locations and varieties on cooking characteristics Parameters measured were seed dimensions (length breadth and thickness) seed weight percent non soakers cooking time and some chemical characteristics Cooking was done using the Mattson experimental bean cooker Seed dimensions varied across locations Among the WPBs PAN 134 showed the highest percent non soakers at Bako (21%) and Jimma (25%) Cooking time varied among locations being shortest at Nazreth Red Wolaita (DCB) grown at Awassa Bako Jimma and Nazreth cooked in 25 7 23 7 23 7 and 18 4 minutes respectively The wide range of cooking times within each bean group allows wider choice of varieties for selection to complement their agronomic merits

INTRODUCTION

Grain legumes are important sources of vegetable protein providing a significant proportion of protein needs in many parts of the World (Siegel and Fawcett 1976) The main problem for the utilization of dry beans is their long cooking time which increases further on storage especially in high temperatures and humidities (Burr *et al* 1968) Gloyer (1921) described two types of hardness sclerema, a condition where the cotyledonary portion of the seed does not imbibe water and hard shell or impermeable seed coat The hard shell character is partly genetic (Lebedeff 1943) Removing the seed coat or even scarifying alleviates seed coat impermeability but no remedy has been reported for cotyledon impermeability (Jackson and Varriano Marston 1981)

Hard bean is a textural problem and is defined as a *failure of beans* to soften sufficiently during the normal cooking process (Jones and Boulter 1983) and has been attributed to an increase in the adhesive properties of components in the middle lamella (Bourne 1976) Jones and Boulter (1983) reported that such behaviour was due to reduced imbibition value and pectin solubility both of which can cause a reduction in cell separation Aguilera and Steinsapir (1985) in their studies of scanning electron micrographs demonstrated that hard beans had a tougher middle lamella showed no separation between cells when cooked and contained ungelatinized starch granules

Studies of varietal and agronomic influences on hard to-cook defects are limited Grullon and Jimenez (1982) indicated that cooking time of some common bean varieties was significantly affected by varietal characteristics Strain differences of dry beans in their genetic potential to respond to varying environments and variability over seasons was reported by Hosfield *et al* (1984) Durigan *et al* (1978) found varietal differences in hydration properties and cooking time of beans Soil conditions have been implicated *in hard* to-cook defects Paredes Lapez *et al* (1989) found that beans from a high Ca++ site had longer cooking times which increased rapidly on accelerated storage

In the past bean breeders have selected varieties primarily for high yield pest and disease resistance and acceptable seed colour and flavour The current worldwide decline of fuel supply indicates a need for attention to selection for quicker cooking beans with uniform softness

OBJECTIVES

1 To investigate the effects of locations and varieties on development of hard to-cook defects

2 To identify short cooking varieties as one of the selection criteria

MATERIALS AND METHODS

Two kilogrammes of mature seeds of each of 12 varieties of bean (*Phaseolus vulgaris*) were obtained from the National Bean Program of Ethiopia which is supported by Centro International de Agriculture Tropical (CIAT) bean improvement program The seeds were grown in four locations (Awassa, Bako Jimma and Nazreth) in Ethiopia and harvested in October 1990 The varieties covered a wide spectrum of seed types sizes and colour i e large seeded beans (LSB) different coloured beans (DCB) and white pea beans (WPB)

Seed dimensions

The length and breadth were measured of 10 randomly selected beans placed end to-end (length) or side by side (width) Thickness was measured with a Mitutoyo micrometer screw gauge Average values were reported

Seed weight

The weights of duplicate samples of 100 randomly selected seeds were recorded in grammes Averages of the two readings are reported

Non soakers

One hundred randomly selected beans were soaked in a 250 ml beaker in three times their volume of distilled water at 27°C for 16 hours The beans were drained and blotted to remove surface water The sample was spread on blotting paper and non soakers were selected by hand counted and expressed as percentages Mean values of duplicate readings are reported

Cooking time

Cooking time was determined with the modified Mattson cooking device (Mattson 1946) The beans were soaked in distilled water for 16 hours at 27°C Soaked beans were positioned in each of the 25 cylindrical holes of the cooker so that the piercing tip of a 90 g stainless steel rod was in contact with the surface of each of the beans The cooker was placed in a 2 l stainless steel pan containing 1 l of boiling water Cooking was considered complete when the tip of the rod passed through the bean Cooking time was recorded from immersion of the cooker in the pan to the time 50% of the beans in the sample were pierced The means of duplicate observations are reported

RESULTS AND DISCUSSION

Seed physical characteristics

The physical characteristics of bean grains (thickness breadth length and weight) varied significantly among varieties and locations (P<0 001 except for seed breadth which was P<0 005) and there were significant location x variety interactions (Tables 1-4) These variations may be attributed to genetic and environmental effects

In general differences among varieties were much larger than differences among locations Differences in seed thickness ranged from 4 64 to 5 42 mm for varieties and from 4 84 to 5 16 mm for locations (Table 1) For seed breadth variety means ranged between 5 38 and 7 21 mm and location means between 6 23 and 6 40 mm (Table 2) For seed length variety means were 7 35 13 86 mm and location means 9 89 10 28 mm (Table 3) Seed sizes were 25 22-42 89 g/100 seeds among varieties and 22 23 25 65 g/100 seeds among locations (Table 4)

Table 1 Seed thicknesses (mm) of 12 bean varieties grown at four locations in Ethiopia in 1990

	Locations				
Varieties	Awassa	Bako	Jimma	Nazreth	Means
A 262	4 98	5 18	5 20	5 50	5 22
A 410	4 91	5 37	5 57	5 30	5 29
Brown Speckled	5 11	5 27	5 07	5 22	5 17
ICA 15541	5 00	5 52	5 09	5 52	5 28
A 265	4 64	5 20	5 23	5 23	5 08
A 445	4 86	5 02	5 49	4 84	5 05
Roba 1	4 45	4 65	4 96	4 51	4 64
Red Wolaita	4 46	5 00	4 73	4 86	4 76
EMP 175	4 64	4 93	4 67	4 81	4 76
PAN 134	4 83	4 94	5 15	5 08	5 00
Awash 1	5 15	5 43	5 52	5 58	5 42
Mexican 142	4 99	5 27	5 21	5 05	5 13
Means	4 84	5 15	5 16	5 12	
S E (+)		0 24			

Table 2 Seed breadths (mm) of 12 bean varieties grown at four locations in Ethiopia in 1990

	Locations				
Varieties	Awassa	Bako	Jimma	Nazreth	Means
A 262	6 85	6 85	7 00	6 65	6 84
A 410	6 70	7 25	7 65	7 25	7 21
Brown Speckled	6 85	6 75	7 30	7 10	7 00
ICA 15541	7 00	7 00	7 10	6 95	7 01
A 265	6 35	6 50	6 70	6 65	6 55
A 445	6 30	6 55	7 00	6 55	6 60
Roba 1	5 80	5 75	5 65	5 50	5 68
Red Wolaita	6 60	6 25	5 70	5 75	6 08
EMP 175	5 55	5 25	5 55	5 55	5 48
PAN 134	5 55	5 80	5 90	5 95	5 80
Awash 1	5 55	5 55	5 75	5 60	5 61
Mexican 142	5 25	5 45	5 55	5 25	5 38
Means	6 23	6 25	6 40	6 23	
SE (+)		0 07			

Table 3 Seed lengths (mm) of 12 bean varieties grown at four locations in Ethiopia in 1990

	Locations				
Varieties	Awassa	Bako	Jimma	Nazreth	Means
A 262	10 10	10 30	10 00	10 75	10 29
A 410	10 50	10 30	11 15	11 60	10 88
Brown Speckled	13 50	13 40	13 40	13 80	13 53
ICA 15541	13 65	13 60	14 30	13 90	13 86
A 265	10 40	10 15	10 15	10 65	10 38
A 445	10 00	10 30	10 70	10 70	10 43
Roba 1	8 95	8 80	8 90	9 30	8 99
Red Wolaita	9 95	10 00	9 60	9 85	9 85
EMP 175	9 25	8 10	9 05	9 30	8 93
PAN 134	8 70	8 45	8 45	8 80	8 60
Awash 1	7 55	7 80	7 60	7 55	7 63
Mexican 142	7 35	7 55	7 30	7 20	7 35
Means	9 99	9 89	10 05	10 28	
SE (+)		0 1			

Table 4 Weight of 100 seeds (g) of 12 bean varieties grown at four locations in Ethiopia in 1990

	Locations				
Varieties	Awassa	Bako	Jimma	Nazreth	Means
A 262	25 70	26 73	28 55	28 93	27 48
A 410	24 90	32 60	32 84	31 55	30 47
Brown Speckled	33 40	38 90	34 23	38 80	36 33
ICA 15541	39 94	43 90	44 72	43 00	42 89
A 265	19 95	28 25	28 25	28 44	26 22
A 445	21 87	27 40	28 62	27 07	26 24
Roba 1	16 15	18 75	19 99	17 77	18 17
Red Wolaita	19 70	24 96	22 18	20 06	21 73
EMP 175	16 39	15 05	17 92	18 15	16 88
PAN 134	18 57	16 97	16 95	18 05	17 64
Awash 1	15 93	18 05	17 23	17 80	17 25
Mexican 142	14 20	16 21	15 30	15 17	15 22
Means	22 23	25 65	25 57	25 40	
SE (+)		0 07			

There were no consistent correlations (not reported) between seed dimension characteristics and cooking time Previous studies have demonstrated an association between cooking time and seed thickness in beans but that seed length breadth weight and density are unrelated to water absorption and cooking time (Phirke *et al* 1982 Deshpande 1985)

Non soakers

Among varieties PAN 134 showed the largest percentage of non soakers most conspicuously at Bako (21%) and Jimma (25%) (Table 5) This observation agrees with previous work which suggests that hard shell is partly hereditary (Morris *et al* 1950) Gloyer (1932) indicated that adverse conditions following planting such as cold rainy weather cause progenies to contain large percentages of hard shelled beans At the time of planting Jimma and Bako had rainfalls of 215 7 and 287 4 mm and soil temperatures of 23 1 and 23°C at the same soil depth respectively (Table 6) so these two locations had similar soil temperatures but different amounts of rainfall

Table 5 Percentages of non soaking seeds in 12 bean varieties grown at four locations in Ethiopia in 1990

	Locations				
Varieties	Awassa	Bako	Jimma	Nazreth	Means
A 262	7 0	2 5	3 5	5 0	4 5
Brown Speckled	8 0	4 5	3 5	3 5	4 9
ICA 15541	0 0	4 5	2 5	5 0	3 0
A 445	9 0	0 0	8 5	3 0	5 1
Roba 1	14 0	3 0	5 5	1 0	5 9
Red Wolaita	8 5	0 0	3 0	1 5	3 3
EMP 175	5 0	13 0	5 0	2 0	6 3
PAN 134	15 0	21 0	25 0	4 0	16 3
Awash 1	1 0	0 0	8 0	0 0	2 3
Mexican 142	7 0	2 5	2 5	0 0	3 0
Means	7 5	5 1	6 7	2 5	
SE (+)		0 8			

Cooking times

There were highly significant differences (P<0 001) in cooking times among locations and varieties Among locations the shortest cooking times were observed at Nazreth (Table 7) Varietal differences in cooking time were reported by Durigan *et al* (1978) and Morris *et al* (1950) Sefa Dedeh *et al* (1979) studying the storage of dry beans concluded that the inherent susceptibility of the starch granules and protein matrix to soften may play an important role in degree of softening during cooking Paredes Lapez *et al* (1989) noted long cooking times in common beans grown at a high Ca++ site In the absence of data, it is not possible to relate cooking times in the present study to soil factors The pHs of the soils at Awassa, Bako Jimma and Nazreth were 6 0 5 7 5 2 and 7 6 with sandy clay sandy clay and sandy clay soil textures respectively (Table 6) Nazreth the location which showed the least cooking time had a relatively high soil pH

PCMP number

PCMP number indicates the interplay of phytin pectin calcium and magnesium content of the grain at cellular level (Muller 1967) It can be calculated from

$$\frac{\text{Free pectin x (Ca+1/2 Mg)}}{\text{Phytin}}$$

PCMP numbers and cooking times for variety PAN 134 at the four locations are shown in Table 8 Its PCMP number was greatest at Jimma and Bako and smallest at Nazreth (Table 8) There was a positive relationship between PCMP number and cooking time

Table 6 Rainfall and soil textures pHs and temperatures for the four locations where the 12 bean varieties were grown in 1990

Locations	Rainfall[1] (mm)	Soil textures %[2] Sand	Silt	Clay	Soil pH	Soil temperatures (°C)[3]
Awassa	146	50 00	35 00	15 00	6 0	23 1
Bako	287	27 25	26 75	46 00	5 7	21 7
Jimma	216	35 00	33 75	31 25	5 2	21 0
Nazreth	127	37 50	33 75	28 75	7 6	23 0

[1] rainfall (July 1990) from IAR Agrometereological Service Division Nazreth [2] soil data from IAR Soil and Plant Analysis Section Holeta [3] at 10 cm depth

Table 7 Cooking times (minutes) of 12 bean varieties grown at four locations in Ethiopia in 1990

Varieties	Locations Awassa	Bako	Jimma	Nazreth	Means
A 262	24 75	26 80	16 78	14 48	20 70
Brown Speckled	28 68	29 62	20 62	18 10	24 17
ICA 15541	24 76	21 75	17 38	15 22	19 78
A 265	22 22	26 10	24 75	15 22	22 07
A 445	23 15	25 68	30 10	15 08	23 50
Roba 1	17 88	20 65	13 10	12 38	16 00
Red Wolaita	25 69	23 68	23 68	18 42	22 87
EMP 175	24 18	25 80	30 08	12 12	23 05
PAN 134	17 00	29 65	31 52	14 18	23 09
Awash 1	26 88	21 30	20 88	13 80	20 72
Mexican 142	27 28	18 42	20 22	15 88	20 45
Means	23 86	24 50	22 65	14 99	
SE (+)		0 27			

Table 8 Cookıng tımes and PCMP numbers of bean varıety PAN 134 grown at four locatıons ın Ethıopıa ın 1990

Locatıons	Cookıng tımes (mınutes)	PCMP numbers
Awassa	17 00	24 4
Bako	29 65	29 7
Jımma	31 52	29 4
Nazreth	14 18	16 1

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REGIONAL SUPPORT FOR VARIETY DEVELOPMENT BREEDING FOR RESISTANCE TO NECROSIS INDUCING STRAINS OF BEAN COMMON MOSAIC VIRUS

H E Gridley

CIAT Kawanda Agricultural Research Institute Kampala, Uganda

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 the necrotic *strains* that predominate on the African Continent Selection and multisite yield testing of selections derived from introduced populations and lines 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

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 on the presence of the aphid vector it can cause severe crop loss ranging from 35 to 98% (Galvez 1980)

Ten pathogenicity strains have been identified with resistance conditioned by a dominant necrosis I gene a non specific recessive gene (bc u) and three strain specific recessive genes (bc1 bc2 and bc3) (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 eastern central and southern Africa thus limiting the usefulness in Africa of the many breeding lines from CIAT carrying the I gene

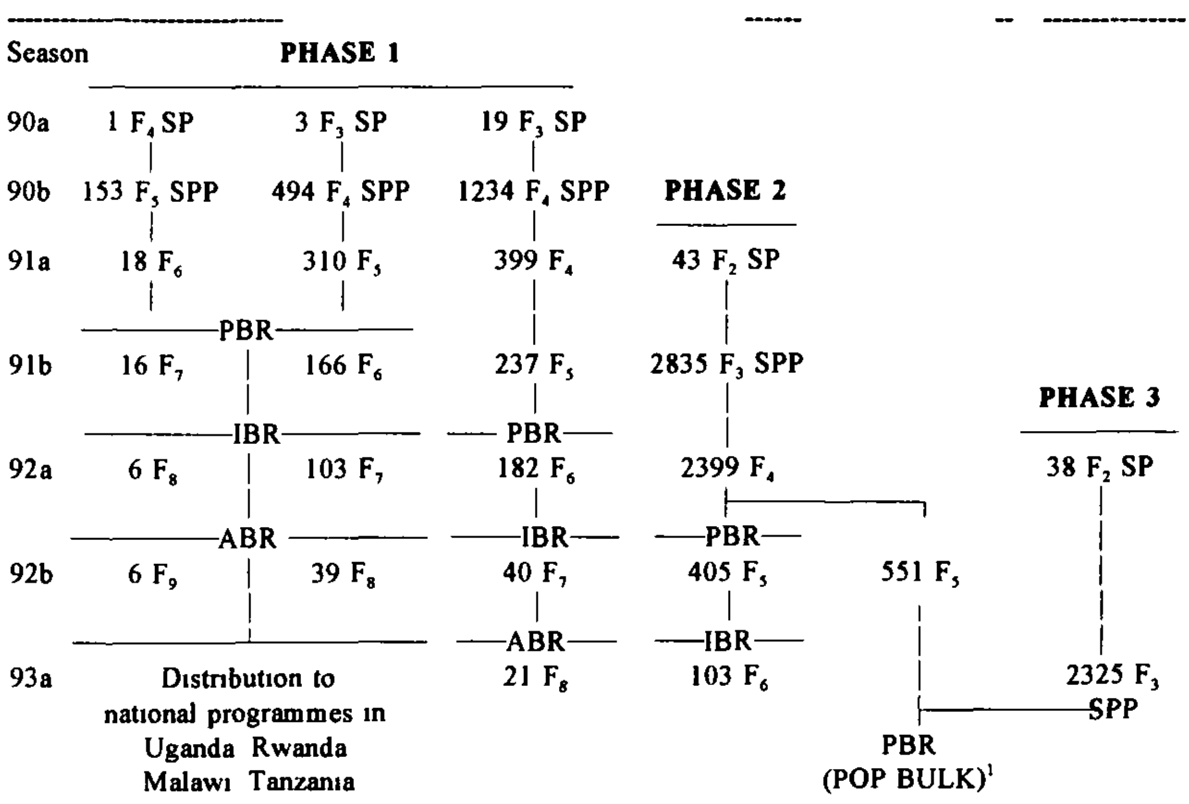
Of the recessive genes bc3 alone confers immunity to all strains of BCMV and has been incorporated at CIAT into a range of breeding lines mainly targeted for consumers in Latin America In 1990 a breeding programme was initiated in Uganda to develop a range of lines carrying this gene with seed characteristics acceptable to consumers in Africa utilizing homozygous breeding lines and segregating populations from CIAT

MATERIALS AND METHODS

After screening and yield evaluation of 122 introductions from CIAT in second season 1990 (90a) superior lines were passed to the national breeding programme for national testing and three of these lines were selected for pre release in 1993 Seventy four small seeded indeterminate lines from a second introduction in the first season 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

Figure 1 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 F_2 with the populations grown with infector rows at a hot spot for NL3 After similar screening symptomless F_3 (single plant) progenies are bulked with the resulting lines undergoing a further generation of screening before potentially resistant lines are tested in multisite yield trials Artificial screening is used to help eliminate susceptible single plants/progenies and lines

Figure 1 Selection for BCMV black root resistance in segregating populations in Uganda from 1990a to 1993a



SP = segregating population SPP = single plant progeny genotypes in succeeding generations referred to as lines PBR IBR ABR = preliminary intermediate and advanced BCMV resistance trials [1] PBR of F5 lines and F3 SPPs bulked within populations

Three phases have been initiated In the first phase following selection and testing 45 F_8 and F_9 large seeded (LS) and 40 F_7 small seeded (SS) bush lines were tested in 92b in advanced (ABR) and intermediate (IBR) yield trials respectively at five sites in 92b 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 phase 405 F_5 lines were yield tested with a further 551 F_5 lines still being screened whilst in the third 2325 F_3 progenies have undergone only a first screening A sample of seed from each of the latter F_5 lines and F_3 progenies have been bulked within populations for yield testing to identify superior populations in which to concentrate future selection and testing

All trials were simple lattices with plot sizes of three rows of 3 m or four rows of 4 m and between and within row spacings of 0 5 m and 0 1 m respectively of test lines plus the following controls

K20 a widely grown large seeded (LS) bush cultivar released in 1968

CAL 96 a large seeded (LS) bush cultivar released in 1991 with a yield potential around 30% greater than K20

MCM 5001 a small seeded (SS) bush cultivar released in 1991 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, according to Johnson Robinson and Comstock (1955) 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

RESULTS AND DISCUSSION

Yield improvement

Genotypes differed significantly for seed yield in all trials at all sites except two for the ABR where coefficients of variation were in excess of 40% data from these sites were excluded from the mean yield over sites

The yields of 75 51 and 11% of the 159 lines in the PIBR 1 and 2 IBR and ABR of 92b respectively exceeded the mean yield over sites of the control cultivars K20 CAL 96 and MCM 5001 (Table 1) The SS lines in the PIBRs and the IBR had the larger increases over the LS controls K20 and CAL 96 with 43 and 26 lines respectively outyielding these by 50% or more six lines recorded double the yield of K20 In contrast no yield increase of the 39 and 9 LS lines over these controls exceeded 50% although such lines are normally considered the more readily adopted However due to its yield potential the SS cultivar MCM 5001 has proved acceptable to farmers and expansion of the area sown to SS types could significantly increase bean production

Table 1 Mean yields (% of control cultivars) over sites of BCMV black root resistant lines in preliminary (PIBR) intermediate (IBR) and advanced (ABR) trials conducted in Uganda in the second season of 1992

	Number of lines											
	PIBR 1/2[1]			ABR			IBR			All trials		
Yield[2]	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 and ABR three IBR five [2] yield of control cultivar 100%

The potential for releasing heavier yielding BCMV resistant SS cultivars is evident with 15 lines in the PIBRs and the IBR outyielding MCM 5001 by up to 25% and the best two recording increases of 27 and 31% Moreover with the F_5 SS lines in the IBR derived from F_2 single plants (Figure 1) exploitation of genetic variation through selection in superior yielding lines may achieve further yield increases

The yield advances were achieved in spite of a severe reduction in genetic variation in the source populations due to only resistant progenies and lines being promoted To counter this a diverse range of populations was 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 1) Crosses have been initiated between heavy yielding lines of diverse origin to generate arrays of well adapted populations to seek further yield advances

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 between line yields were significant except in one case there was no similar concordance in rankings suggesting that cross-over or qualitative 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 suggesting possible redundancy in testing lines at both sites for these two combinations

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

	All sites (2 3)				Two way site combinations (2 3 4 5)						
	Numbers of		LSI				Correlation		No of lines common to 10 heaviest yielding over sites at		
Trial	Sites	Lines	Actual	Trsf	Sites	LSI Actual	rp	rs	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)*

LSI = significance level of line x site interaction Trsf = transformed data KA = Kawanda, BK = Bukalasa, NG = Nakabango IK = Ikulwe rp/rs = simple and rank correlations for seed yield ns * ** *** non significant and significant at P<0 05 P<0 01 and P<0 001 respectively

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 emphasising 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 the fewer significant two way interactions in other trials was reflected in the sites identifying more of the 10 superior lines

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

	All sites (2 3)				Two way site combinations (2,3 4 5)						
	Numbers of		LSI				Correlation		No of lines common to 10 heaviest yielding over sites at		
Trial	Sites	Lines	Actual	Trsf	Sites	LSI Actual	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

Note legend as for Table 3

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 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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PROCEDURES FOR HANDLING BEAN GERMPLASM WITH EMPHASIS ON SILICA GEL SEED DRYING

M Fischler

CIAT Kawanda Agricultural Research Institute Kampala Uganda

ABSTRACT

Preservation of germplasm collections through low temperature storage is problematic because of power failures and equipment breakdown Seed drying using silica gel and long term storage of bean seed were investigated In a desiccator experiment seeds of two bean cultivars were dried for 50 days with silica gel using a gel to seed ratio of 1 2 The final moisture content was 6 1 and 6 6% for the two cultivars Dry seeds were stored in recycled glass soda bottles sealed with wax at 25 C for seven months The seed moisture content remained constant suggesting that recycled glass soda bottles can be used as cheap seed storage containers A germination test after storage showed a high germination rate of 86 and 98% for the two cultivars In order to handle larger amounts of seed a drying facility using silica gel in an air tight PVC drum was developed Forms for collecting passport and characterization data as well as a list of codes are presented Standardization of data collection and management procedures is recommended to ease exchange of information

INTRODUCTION

The Uganda bean germplasm collection is currently preserved at room conditions (13 14% seed moisture content 25°C) due to inadequate low temperature facilities Regeneration of all accessions is required every two to three seasons in order to maintain seed viability Apart form the heavy workload involved frequent regeneration carries the risk of genetic drift

During the reorganization of the bean germplasm collection the need was felt to develop an efficient and simple storage technology Cool storage commonly used in gene banks was not considered as power supply is unreliable and equipment failure frequent On the other hand seed longevity is greatly influenced by moisture content (MC) Harrington (1973) reports that each 1% reduction in seed MC doubles seed longevity Thus when seed MC decreases from 14 to 7% seed storage life is increased 127 times

The use of silica gel for seed drying has been recommended especially for gene banks which have small germplasm collections (Cromarty *et al* 1985 Hanson 1985) Heat drying can cause deterioration of seeds For most species the International Board for Plant Genetic Resources (IBPGR) has recommended drying to 3 7% MC (Tao 1985) The viability of desiccated seeds is preserved at the recommended seed MC provided the seeds are rehydrated prior to germination (Zhang *et al* 1989 Ellis *et al* 1990)

This study investigates the feasibility and technicalities of bean seed drying using silica gel as well as seed storage aspects The objectives were to develop

i) a low cost seed drying technology using silica gel and

ii) a low cost and power independent mid term storage facility using recycled glass soda bottles

Appendices 1 5 of this paper present guidelines for collection characterization and maintenance of bean germplasm a form for collecting passport data and descriptor lists for passport and characterization data

MATERIALS AND METHODS

Seed MCs of two bean cultivars before and after drying over silica gel were measured using the modified high constant temperature oven method ISTA (1976) The bean cultivars were White Haricot (22 g/100 seed) and Rubona 5 (38 g/100 seed) Two 125 g seed samples of each cultivar were weighed and dried to 6 6 5% MC in a desiccator at 25°C with a silica gel seed ratio of 1 2 Silica gel with a colour-changing ability was replaced by the same amount of dry silica gel when 50 75% of the gel had changed colour Seed MC was determined by weighing after 10 25 and 50 days Dry seeds were placed in recycled glass soda bottles (250 ml) with plastic screw caps sealed with candle wax and stored at 25°C Seed MC was monitored by weighing every month over a period of seven months A germination test was carried out seven months after bottling Forty seeds were exposed to room conditions (25°C 60 90% relative humidity) for 48 hours for rehydration prior to the germination test

In order to handle larger amounts of seeds an air tight PVC drum (diameter 45 cm height 75 cm) was fitted with a metal cylindrical grill in the center (diameter 20 cm) The silica gel and the seeds were contained in cloth bags with the gel in the cylinder and the seeds in the drum The silica gel to seed ratio was 1 2 This arrangement allows for drying of 16 18 kg of seed The silica gel was replaced after 3 8 and 14 days and then weekly Seed MCs of 5 samples were determined weekly using a DOLE 400 moisture meter A cost estimate for the drying facility is given in Table 1

Table 1 Cost estimate for seed drying and storage facility using silica gel in an air tight PVC drum

Item	US $
PVC drum (120 l)	50
Fitting of metal cylinder	20
Silica gel (20 kg x US $20)	400
Bottles (per 1 000 accessions)	80
Total	550

RESULTS AND DISCUSSION

Desiccator experiment

Seed MCs of White Haricot and Rubona 5 fell to 6 1 and 6 6% respectively after 50 days of drying over silica gel which was replaced four times during this period The long drying period may be due to the relatively large seed size the thick seed coat and the high protein content of bean seed More frequent replacement of the silica gel would decrease the drying period Zhang (*et al* 1989) indicate that 30 34 days are required to dry bean seeds from 14 to 5% MC using a silica gel seed ratio of 1 2 However seed germination dropped to 76% after bean seeds were dried in 16 days from 9 to 6 1% using a silica gel to seed ratio of 1 2

Dry seeds of Rubona 5 and White Haricot stored for seven months had germination rates of 98 and 86% respectively (Table 2) These results confirm findings of Zhang (*et al* 1989) who observed no significant decrease in germination and vigour after bean seeds had been stored at 6 3% MC at 10 20 and 40°C for six months The germination of seeds kept at seed equilibrium moisture content at 25°C germinated better than dry seed The germination of undried seed is expected to decrease more rapidly than that of dry seed since deterioration of undried seed is faster

The MC of dry seed stored in sealed glass soda bottles remained constant over a period of seven months indicating that recycled soda bottles are a cheap alternative to more expensive storage containers

Table 2 Germination (%) of two bean cultivars undried and dried with silica gel and stored for seven months

Cultivar	Germination rate (%)	
	dried	undried
White Haricot	86	98
Rubona 5	98	100
Mean	92	99

Seed drying in a PVC drum

The 200 accessions of bean seeds were dried to 6 7% MC during a period of nine weeks It is suggested that the silica gel is replaced more frequently in order to reduce drying time Alternatively a gel to seed ratio of 1 1 could be used However the cost will be increased as silica gel while reusable is the costly component of this technology (Appendix 1)

CONCLUSIONS

Silica gel seed drying is an alternative to other drying techniques for germplasm conservation The seed drying facility using an air tight PVC drum is relatively cheap easy to manage and power independent apart from the regeneration of the silica gel A disadvantage is the need for frequent replacement of the silica gel Recycled glass soda bottles proved to be air tight if sealed with candle wax They are an inexpensive alternative to imported seed storage containers

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APPENDIX 1

Guidelines for collection characterization and maintenance of bean germplasm

Number of seeds collected Sample size should be at least 100 seeds for pure lines and 200 500 seeds for mixtures according to the number of components

Passport data Passport data is entered on dBase using descriptors given in Appendix 5

Preliminary evaluation/characterization Forty clean seeds of each newly collected accession are sown for characterization (2 rows x 4 m spacing 0 5 x 0 2 m) Characterization is according to the descriptors given in Appendix 6 The descriptors have been selected from "Phaseolus vulgaris descriptors" IBPGR 1982 and from the descriptors currently used by CIAT

Determination of the seed MC Prior to seed drying with silica gel the seed MC of 5 samples is determined using the high constant oven method recommended by the International Seed Testing Association (ISTA) About 4 g of seed is crushed into pieces not larger than 4 mm weighed to 4 decimal places using an analytical balance and then dried in an oven for 1 hour at 133°C MC is calculated on % wet weight basis and expressed to one decimal place This method is more accurate than using a moisture meter

Seed drying Cleaned seeds are predried in the shade to 13 14% MC weighed and then dried to 7% MC with silica gel in an air tight PVC drum as outlined in this paper

Determination of drying time The correct drying time can be predicted by weight loss using the following formula

Final seed weight = Initial seed weight x (100 Initial % MC)
(100 Final % MC)

The final MC should be 7%

Storage Dry seeds are stored in sealed containers (e g soda bottles as described in this paper) and kept in a cool place preferably below 20°C

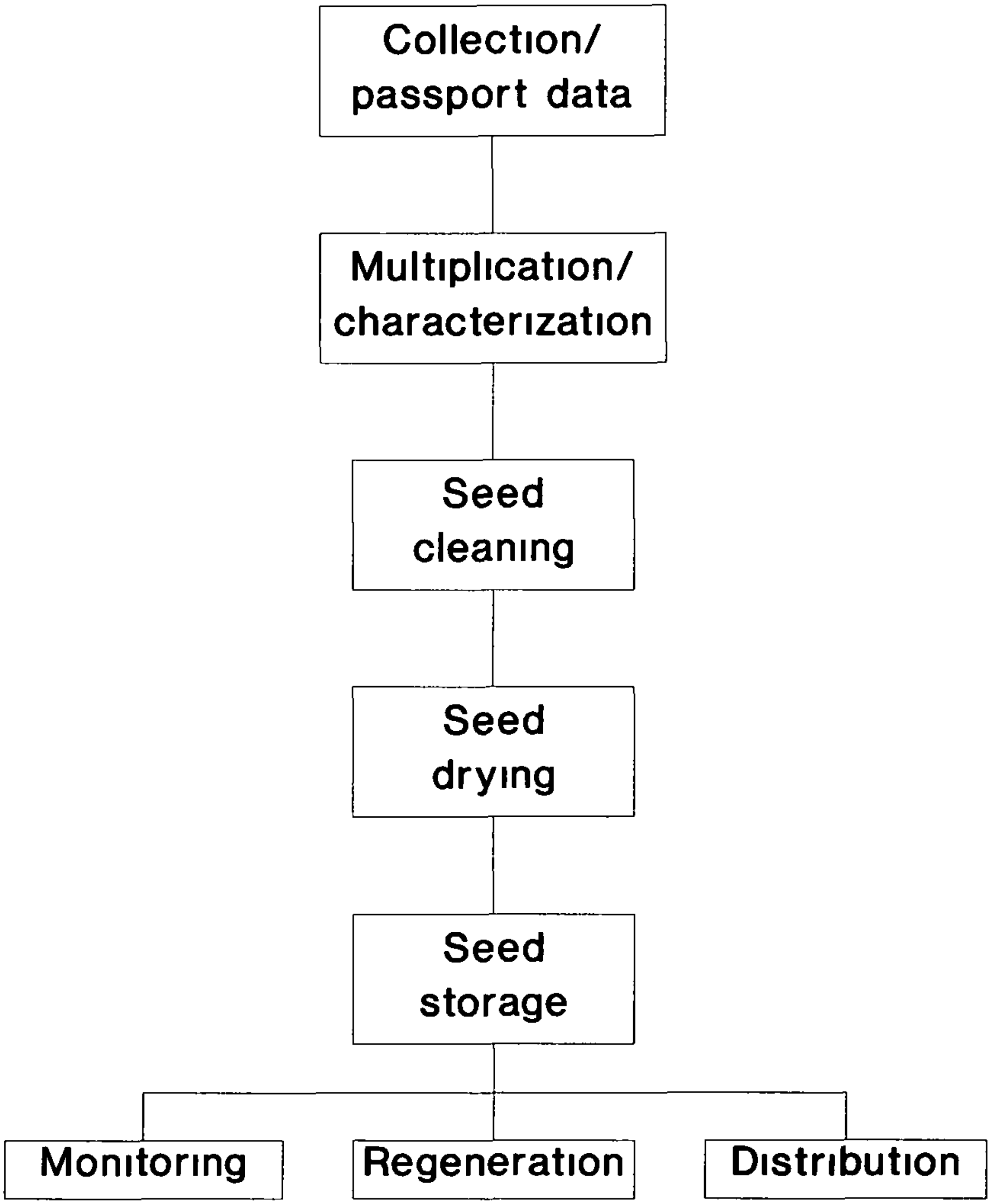
Number of seeds stored IBPGR recommends a minimum sample size of 3 000 seeds for genetically uniform accessions and 4 000 seeds for mixtures of genotypes For large seeded species the sample size can be reduced The sample size of the Ugandan bean germplasm is currently 250 500 ml (350 1200 seeds)

Monitoring stored accessions A germination test using 40 seeds should be carried out every year Regeneration is recommended if the germination rate falls below 85%

Regeneration cycle Regeneration should be carried out when the seed viability falls below 85% Stored at 7% MC regeneration should only be necessary every 3 5 years

APPENDIX 2

Steps in handling germplasm



(after Hanson 1985)

APPENDIX 3
Collectıon data sheet for bean germplasm

1 Collector's name ____________________

2 Collector s sample no ____________________

3 Date of collectıon (month/year) ____________________

4 Country of collectıon ____________________

5 Dıstnct/county ____________________

6 Geographıcal locatıon of sıte ____________________
(vıllage/town or km and dırectıon from nearest vıllage/town e g Hoıma7N)

7 Latıtude of collectıon sıte ____________________
(Degrees and mınutes followed by N or S e g 1030 S)

8 Longıtude of collectıon sıte ____________________
(Degrees and mınutes followed by E or W e g 0545 E)

9 Altıtude of collectıon sıte ____________________
(Elevatıon above sea level ın meters)

10 Collectıon source ____________________
(1=wıld 2=farm land 3=farm store 4=local market 5=commercıal m 6=ınstıtute 7=oth)

11 Local vernacular name(s) ____________________
(ındıcate synonyms ıf exıstıng)

12 Ethnıc group and language ____________________

13 No of plants sampled (at least 5 plants) ____________________
(At least 100 seeds for pure lınes and 200 500 seeds for mıxtures should be collected)

14 Type of sample ____________________
(1=landrace pure 2=landrace mıxture 3=bred cultıvar pure 4=bred cult mıxture 5=other)

16 Seed colour ____________________
(1=whıte 2=cream beıge 3=yellow 4=coffee 5=pınk 6=red 7=purple 8=black 9=grey 10=other)

17 Susceptıbılıty to (3=low susceptıbılıty 5=medıum s 7=hıgh s)

a) pests (specıfy ıf known) ____________________

b) dıseases (specıfy ıf known) ____________________

c) drought ____________________

d) low soıl fertılıty ____________________

18 Cultıvatıon ____________________
(1=monoculture 2=mıxed wıth maıze 3=mıxed wıth cassava 4=mıxed wıth other crops)

19 Other notes ____________________

APPENDIX 4

Descriptors used for passport and collection data

Abbreviation	Description and legend
ACCNO	Accession number u followed by a number assigned to each accession entering into the collection e g u125 Mixtures are separated into components and the number of the component is indicated with a dash (e g u23 1 u23 2 for the two components of mixture No 23)
CONA	Collector's name of original sample
DATE	Date of collection of original sample(month/year e g 0293 = February 1993)
CTRY	Country of collected sample Use the three-digit abbreviations defined by UN and IBPGR (see FAO/IBPGR Plant Genetic Resources Newsl No 49 p 45 48)
DRCT	Name of district/province (first geopolitical subdivision at the national level)
CNTY	Name of county (second geopolit subdivision)
LOCN	Geographical location of collection site (Village/town or kms and direction from nearest town/village)
LATI	Latitude of collection site (Degrees and minutes followed by North or South e g 1030S)
LONG	Longitude of collection site (Degrees and minutes followed by West or East e g 0545E)
ALTI	Altitude Elevation above sea level in meters
SRCE	Collection source (1=wild 2=farm land 3=farm store 4=local market 5=commercialmarket 6=institute 7=other)
NAME	Local vernacular name of accession
SYNO	Synonym(s) of local vernacular name
ETHN	Ethnic group of donor person (or ethnic group living in the area where sample was collected)
LANG	Language spoken by ethnic group indicated
PLNO	Number of plants sampled
TYPE	Type of sample (1=landrace pure 2=landrace mixture 3=bred cultivar pure 4=bred cultivar mixture 5=other)
COLO	Primary seed colour (1=white 2=cream beige 3=yellow 4=coffee 5=pink 6=red 7=purple 8=black 9=grey 10=other)
PEST	Susceptibility to pests in general Scale 1 9 where 3=low 5=medium 7=high susceptibility
DSEA	Susceptibility to diseases in general (specify if known!) Scale as for pests
DGHT	Susceptibility to drought Scale as for pests
LSFY	Susceptibility to low soil fertility Scale as for pests
CULT	If under cultivation cropped as 1=monoculture 2=mixed with maize 3=mixed with cassava 4=mixed with others
ASIZ	Accession size In g or number of seeds for smaller accessions (e g 250g or 45s)
LREG	Date of last regeneration (year and season e g 1992B = second season in 1992)
NREG	No of times accession was regenerated since collection

APPENDIX 5

Descriptors used for characterization and preliminary evaluation of bean germplasm collection

Abbreviation	Description and legend
ACCNO	As in passport data file
NAME	Local vernacular name of accession
CTRY	Country of collected sample Use the three digit abbreviations defined by UN and IBPGR
DRCT	Name of district/province (first geopolitical subdivision at the national level)
PGH	Plant growth habit 1=bush determinate type I 2=bush indeterminate type II 3=semi-climber/prostrate indeterminate type III 4=climber indeterminate type IV
FCW	Flower colour of wings (1=purple 2=red 3=pink 4=yellow 5=white 6=green)
FCS	Flower colour of standard (colour codes as FCW)
DFF	Number of days from emergence to stage where 50% of plants started flowering
DEF	Number of days from emergence to stage where 50% of plants ended flowering
DPM	Days from emergence to physiological maturity
PLH	Plant height (average in cm at maturity from 5 plants measured from cotyledon scar to tip of plant)
NFR	Nodes on stem to first raceme measured at physiological maturity
POP	Position of pods (1=high 2=low 3=evenly distributed uniform)
PFC	Pod fibre content in fully expanded immature pods (0=stringless 3=few strings 5=mod stringy 7=very stringy)
PCO	Pod colour at physiological maturity (1=dark purple 2=red 3=pink 4=yellow 5=cream 6=brown 7=green)
DHA	*Days to harvest (Number of days from emergence until 90% of pods are dry)*
PPP	Number of pods per plant (Average of 10 plants at harvest)
SPP	Number of seeds per pod (Average number of seeds from one pod taken from 10 plants)
PSC	Primary seed colour (1=white 2=cream beige 3=yellow 4=coffee 5=pink 6=red 7=purple 8=black 9=grey 10=other)
SCP	Seed coat pattern (1=plain 2=mottled 3=striped 4=spotted 5=speckled 6=ringed)
SSC	Secondary seed colour (colour of pattern (colours as for PSC)
SSH	Seed shape (1=round 2=ovoid 3=cuboid 4=kidney shaped 5=truncate fastigate)
SCL	Seed coat lustre (brilliance 1=dull (matt) 2=medium 3=shiny)
HSW	100 seed weight (in g to first decimal place at 12 14% seed moisture content)
YIE	Seed yield (g/plot)
BCM	Bean common mosaic virus BCMV (scores 1 9 where 0=absent 3=low 5=medium 7=high susceptibility)
CBB	Common bacterial blight (scores as for BCMV)
ALS	Angular leaf spot (scores as for BCMV)
RST	Rust (scores as for BCMV)
ASC	Ascochyta (scores as for BCMV)
BSM	Bean stem maggots (scores as for BCMV)

DISCUSSION SESSION II GENETIC IMPROVEMENT

Chair P M Kimani Rapporteur C S Mushi

Paper by Teshome Girma and Dereje Negatu

Question Do you have enough breeders to handle the new system?

Teshome Girma This is planned and hopefully in five years time it will be in place

Musaana For how many years did you evaluate the trials shown in Figure 2?

Teshome Girma Normally a trial is carried on for three years

Wortmann Could you indicate how many entries go into each trial/nursery?

Teshome Girma Nursery 1 contains 500 1000 lines depending on what was introduced The numbers are reduced as materials progress through the different evaluation stages

Sengooba How do you consider the costs of the new system?

Teshome Girma Costs have increased but with time we hope to reduce them

Paper by Melaku Ayele

Youngquist Combining ability effects for some lines are specific to this particular trial and may not be the same in another trial of the same materials

Kimani Did you partition the mean square to determine the effects?

Melaku Ayele Yes that is how I arrived at the effects shown in the table

Paper by Senayit Yetneberk

Opio Did you find any correlation between colour and cooking time?

Senayit Yetneberk No

Mitiku Haile Knowing that our farmers can store beans for some time did you observe any variability in cooking time with storability ?

Senayit Yetneberk Yes! The longer you store beans the longer is their cooking time

Nahdy Did you consider cooking time?

Senayit Yetneberk Yes! But the results indicated no relationship

Musaana Are seed size and cooking time affected by location?

Senayit Yetneberk Seed size may differ with location

Paper by Howard Gridley

Kirkby Since this is the first presentation by CIAT staff I would like Howard to explain why we are doing this

Gridley To provide materials with resistance genes to national programmes

Buruchara What is the possibility of national programmes sending advanced breeding materials with the I gene to you for protection?

Gridley In principle yes but this will reduce the work that I am currently handling

Paper by Martin Fischler

Mitiku Haile Your experiment has been conducted for seven months do you consider this short term or medium term storage?

Fischler Short term

Nahdy Are you losing moisture content as you continue with the same samples?

Fischler I dont think so

Teshome Girma Do you determine the seed silica ratio?

Fischler I used 2 1 but will try 1 1

Wortmann What are you proposing for data management?

Fischler I am using DBase because it is easier to handle

Senayit Yetneberk Have you studied the relationship between moisture content and seed viability?

Fischler I havent done this

SESSION III. BREEDING FOR DISEASE AND INSECT RESISTANCE

INVESTIGATIONS OF COMMON MOSAIC VIRUS IN EASTERN AFRICA

T Sengooba D G Walkey D J Allen and A Femi Lana

NARO Kawanda Agricultural Research Institute Kampala Uganda,
Horticultural Research International Wellesbourne U K,
CIAT, Selian Agricultural Research Institute Arusha, Tanzania, and
Sokoine University of Agriculture Morogoro, Tanzania

ABSTRACT

Over 500 samples of leguminous plants have been collected and processed Based on symptom expression ELISA results and reactions on the differential set BCMV like isolates have been obtained from *Cassia hirsuta Centrosema pubescens Vigna vexillata Crotalaria incarna Senna bicapsularis S sophera and Phaseolus lunatus* All isolates so far identified have conformed to the NI 3 strain though with slight differences in their reaction on the differential set In a host range study isolates infected their parent host and several other weeds but symptom expression varied from vivid mosaic with leaf curling to symptomless Spread from a wild legume on to a bean crop was indicated Studies of the effect of BCMV on growth and yield components was initiated by inoculating several bean genotypes with a local field isolate of BCMV The plant height number of pods per plant and seeds per pod and seed weight per plant decreased in infected plants The yield reduction and percentage seed transmission varied with genotype from less than 10% to over 40% and from 30% to over 80% respectively Using a range of Drijfhout s isolates on Kanyebwa a local land race NL3 followed by NL6 caused significant reduction in plant height and yield per plant In a field crop loss experiment yield loss varied with genotype ranging from 23 to 59% The number of pods per plant and seeds per pod and seed yield was negatively related to disease scores of individual plants Over 400 genotypes from 10 countries were screened Under field conditions most genotypes showed high to moderate levels of infection About 5% of the genotypes tested carried the I gene

INTRODUCTION

Of the biotic factors that limit bean (*Phaseolus vulgaris* L) production Bean Common Mosaic Virus (BCMV) is considered the most ubiquitous (Morales 1991) BCMV is seed borne and seed transmission is the most important epidemiological factor determining the global distribution of the disease BCMV has ten standard strains (Drijfhout 1978) and resistance to these strains is conferred by the dominant I gene Bean genotypes with the I gene are susceptible to black root a disastrous lethal hypersensitive reaction when challenged with necrotic strains of BCMV

Necrotic strains of BCMV have been reported in the USA Chile and Europe but appear to be more important in Africa (Davis *et al* 1987) Studies of BCMV strain distribution in Africa has revealed that the necrotic strains dominate in eastern and southern Africa with the exception of Ethiopia where only non-necrotic strains have been identified (Spence and Walkey 1992)

Previous work of the BCMV sub-project focused on identification of BCMV strains on beans in the region (Owera, 1989) The present study investigates the occurrence of BCMV in the leguminous flora in Uganda, the nature of such BCMV weed isolates and the possible implications to the ecology of the disease Crop loss studies are also being conducted

BCMV LIKE ISOLATES FROM WILD LEGUMINOUS SPECIES

The objective of this study was to investigate the presence of BCMV necrotic strains in wild legumes in Uganda to provide evidence whether or not BCMV necrotic strains have an African origin

Materials and methods

Samples of wild legume species showing virus like symptoms were collected from various parts of Uganda Young leaves were placed between moist filter papers in polythene bags and kept cool The samples were inoculated on Dubbele Witte immediately or within a few days of collection In some cases dry samples were also collected over calcium chloride following the procedure described by Spence and Walkey (1992) Plants were inoculated manually using standard procedures (Morales 1991) Inoculated plants were kept in an aphid proof screenhouse Isolates which caused mosaic symptoms in Dubble Witte were tested using monoclonal antisera Antiserum 197 detects all BCMV strains and other related potyviruses while I 2 detects only the necrotic strains of BCMV The isolates were further characterised using Drijfhout s (1978) differential hosts

Results and discussion

Over 500 samples were processed Isolates that induced mosaic symptoms when inoculated on Dubbele Witte and which yielded positive reactions in ELISA with I 2 antiserum are listed in Table 1 These isolates are identified as BCMV A serotypes The A serotype isolates so far tested on Drijfhout s differentials have largely conformed with the pathogenicity pattern of the NL 3 strain Some isolates which gave mosaic symptoms with Dubbele Witte and a positive reaction with 197 but not with I 2 antisera have been further studied using electron microscopy differential bean hosts and in ELISA using bc5 a B serotype specific antiserum

Table 1 BCMV necrotic strains identified from wild legumes in Uganda

Isolate	Location	Host	197	I 2	Strain
741	Nakabango	*Centrosema pubescens* Benth	+	+	NL 3
197	Bukalasa	*Senna hirsuta* L	+	+	NL 3
218	Nabingo	*Crotalaria* spp	+	+	NL 3
308	Namalere	*Vigna vexillata* (L) A Rich	+	+	NL 3
463	Namulonge	*Crotalaria incana* L	+	+	NL 3
464	Namulonge	*Crotalaria incana* L	+	+	NT
496	Bajja	*Senna bicapsularis* L	+	+	NT
533	Kigali	*Senna sophera* L	+	+	NT
473	Bukalasa	*Senna hirsuta* L	+	+	NT
574	Bigo	*Phaseolus lunatus* L	NT	+	NT

NT = not tested * Strain determined using Drijfhout s differential

Although these isolates have potyvirus like rod shaped particles most of them were not identified as BCMV and require further characterisation So far in this study only BCMV necrotic isolates (A serotypes) have been identified infecting alternative legume species This conforms with earlier observations that necrotic strains are the predominant types in eastern Africa

HOST RANGE OF BCMV WEED ISOLATES

The purpose of this study was to determine if weed isolates would infect other leguminous weeds when introduced manually

Materials and methods

Seeds of weed species were obtained from ILCA and CIAT Seedlings were raised in pots of 25 cm top diameter at a rate of four seedlings per pot Elisa tests at the early seedling stage using 197 and I 2 monoclonal antisera showed no evidence of BCMV infection Some seedlings were inoculated with isolates 197 308 or 458 a local NL 3 isolate from bean Others were not inoculated to serve as controls The experiment was carried out in an aphid free (Clovis Landes) screenhouse The plants were assessed for BCMV symptoms and with an ELISA to ascertain presence of the virus

Results and discussion

The weed species that gave positive results with BCMV weed isolates are listed in Table 2

Table 2 Weed species showing positive ELISA reactions to BCMV isolates 197 308 and 458

	197		308		458	
Species	Symp	ELISA	Symp	ELISA	Symp	ELISA
Crotalaria spinosa		+	SS	+		+
Desmodium intortum		+		+		+
D incinatum		+		+		+
Canavalia ensiformis	S+Mo	+	S+Mo	+	mm	+
Centrosema pubescens		+	Lc	+		+
Vigna vexillata		+	Mo	+		+
Rhynchosia minima		+		+		+
Crotalaria incarna		+	Mo	+	mm	+
Macroptilium lathyroides	Mo	+	nt	nt	Mo	+
Vigna radiata		+		+		+
Senna hirsuta	mm	+	nt	nt	nt	nt

= no visible symptoms SS = slight stunting S = stunting mm = mild mosaic Mo = clear mosaic Lc = leaf curling + = positive ELISA test nt = not tested

In general the weed isolate 308 gave clearer symptoms than 197 and the bean isolate gave the least symptom expression

Of the species listed in Table 2 *R minima* and *V radiata* have been identified as possible natural hosts of BCMV while *C ensiformis* and *M lathyroides* have been listed among the experimental host range (CM 1988) Among the other species listed *C pubscens V vexillata C incarna* and *S hirsuta* have been identified as natural hosts of BCMV (Spence and Walkey 1992) and should test positive when inoculated artifically *C spinosa* and the two *Desmodium* species are being reported as experimental hosts for the first time

SPATIAL SPREAD OF BCMV FROM WILD LEGUMES TO BEAN CROPS

A number of cultivated legumes have been experimentally demonstrated to be susceptible to BCMV (Galvez, 1980) The virus has also been found to occur naturally in some wild legumes (Meiners 1978 Sarkar and Kulshreshtha 1978 Spence and Walkey 1992)

Materials and methods

A randomised complete block factorial experiment with six treatments in three replicates was sown at Kawanda Research Station during the second season of 1992 The treatments were two bean genotypes (Kanyebwa a local land race susceptible to BCMV and White Haricot a local I gene material) and two sources of inoculum (Kanyebwa beans and *Senna hirsuta* L a weed species from which BCMV like isolates have been isolated on several occasions) (Spence in press Sengooba *et al* in press)

The Kanyebwa seeds were obtained from a BCMV free seed crop from which any plant showing the disease symptoms had been rogued The plots were 10 x 10 m in size and separated by a buffer zone 5 m wide Four weeks before sowing the experimental plots the buffer zones were densely sown with alternate rows of maize and soyabean They were sprayed with the systemic insecticide Rogor to minimize aphid movements from them on to the experimental plots

A line source inoculum pattern was used in the plot layout (Thresh 1976 Fontem 1991) *Senna hirsuta* seedlings were transferred to the field at three months of age after inoculation with an NL3 like weed isolate at four weeks The same isolate was used to inoculate the beans which were sown in the field and inoculated when the primary leaves were fully expanded

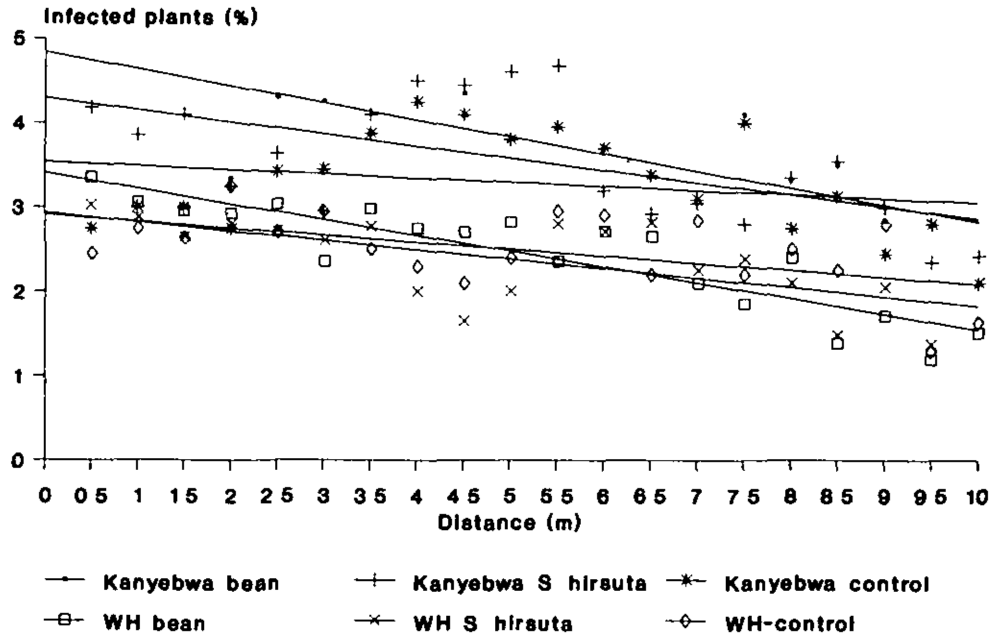
The experimental plots were sown when the sources of inoculum were well established When the primary leaves of the experimental bean plants were fully expanded (10 days after sowing) aphids (*Aphis fabae)* obtained from a pure colony reared in a cage were placed on the inoculum source plants to transmit the infection from infector rows to the plots Disease assessment was based on incidence

Results and discussion

Two weeks after aphid infestation of the infected source plants BCMV incidence was too light and at four weeks it was widespread giving no trend At three weeks after infestation it was apparent that BCMV decreased with increasing distance from inoculum source (Figure 1) Regression or regression related analyses are often used in disease progress studies (Fontem 1991 Headrick and Patacky 1988) Infection with plant pathogens tends to decrease with increasing distance from foci of infection (Thresh 1976 Maddem and Campbell 1986) Here the gradient of BCMV from *S hirsuta* as the infection source indicate that this wild legume was an effective source of the virus

There was a substantial level of infection in the control plots which in the case of White Haricot was not significantly different from that in the plots with inoculum sources This indicates the presence of abundant inoculum outside the infection sources but at least with Kanyebwa the outside inoculum did not overshadow the effect of the experimental inoculum sources The high level of infection in the centres of plots which was relatively uniform in all treatments was probably due to viruliferous aphids from outside sources overflying the maize buffer and alighting on the experimental plots The study did not detect disease progress with time possibly because the one week time interval between record taking was too long

Figure 1 The relationships between % plants infected with BCMV and distance from wild legume and bean sources



Note WH White Haricot

The experiment will need repeating before concrete conclusions can be made During the repeat the following changes will be made

1 the buffer zone will be planted with maize alone

2 *Crotalaria incarna* will be used as the inoculum source instead of *S hirsuta* as the former grows faster and is more easily raised in large quantities in the screenhouse and

3 diseases will be recorded every four days from 14 days after introducing the aphids on to the infector rows

The other investigations conducted under this work were

D screening African bean germplasm for resistance to BCMV

E study of the effects of BCMV on the growth and yield components of several bean genotypes

F study of the effects of different strains of BCMV on the yield and yield components of beans and

G estimation of crop loss due to BCMV in the field

CONCLUSIONS

This study of BCMV is revealing that BCMV occurs in wild legume species in Uganda but the nature of the strain in the wild is not fully understood The bean types in farmers fields are susceptible to BCMV which can cause heavy losses in yield if not checked

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PROGRESS OF STUDIES OF PHOMA BLIGHT OF BEANS IN EASTERN AFRICA

B S Male-Kayiwa

National Agricultural Research Organization,
Kawanda Agricultural Research Institute Kampala, Uganda

ABSTRACT

Assessment of different genotypes for yield loss due to *Phoma (Ascochyta)* blight were done In addition to *Phoma* blight the genotypic yield response was affected by angular leaf spot anthracnose and variability of weather conditions in the different seasons Yield losses of 0 60% were recorded The highest yield loss occurred when disease was severe at pod filling Selections made among crosses in F_2 F_3 F_4 and later generations were advanced to preliminary yield trials In the inheritance study the reactions of the genotypes showed significant differences ($P<0\ 05$) but analysis for combining ability showed significant differences only for specific combining ability implying a significant role of non additive components in the inheritance of resistance in the genotypes assessed More data is being generated for reassessment in order to detect the additive component

INTRODUCTION

The severity of phoma blight in any cropping season is much dependent on environmental influences (CIAT 1987 Schwartz and Galvez 1980 Kannaiyan *et al* 1986 Anon 1987) and sporadic moderate to severe incidents were experienced in 1991 92 in cool high altitude zones of Uganda Rwanda and Zaire In Uganda isolated incidents were observed also at low altitude sites after unusually high rainfall

Crop yield losses of 41 75 percent have been reported on varieties infected with ascochyta (phoma) blight in trials at Popayan (Schwartz *et al* 1981) Though diseases are noted as one of the principal factors limiting yield in Africa (van Schoonhoven 1980) the yield losses incurred due to disease are not always quantified Estimation of the crop loss associated with a particular disease requires data from field experiments over several seasons (James 1974) Lack of specific fungicides and interactions with many fungal bacterial and viral diseases make estimation of yield loss due to phoma blight a very difficult exercise Use of isogenic lines is recommended for crop loss studies associated with some diseases but such an approach is invalid for phoma blight where resistance is assumed to be of a polygenic nature

Breeding for resistance is considered a cheap alternative to chemical control especially for bean crops grown at a subsistence level Resistance sources are extremely rare in *Phaseolus vulgaris* of bush growth habit but some resistance has been identified among climbing beans Since the resistance was suspected to be of a polygenic nature a recurrent selection programme was suggested (CIAT 1987) Use of recurrent selection necessitates the creation of large and genetically variable panmictic populations through a series of crosses which are then subjected to selection pressure over several generations For faster progress varieties with high general combining ability (GCA) should be inter crossed to accumulate desirable alleles within high yielding genotypes adapted to the region

The experiments carried out within the period 1991 92 included crop loss studies aimed at quantifying yield loss associated with phoma blight The effects of severe attacks of phoma blight at different growth stages was also investigated to identify the growth stage at which severe attacks would inflict the heaviest yield loss A wide range of hybridization to generate variation in resistance was undertaken and several filial generations evaluated in inoculated field trials

MATERIALS AND METHODS

a) Nine genotypes were evaluated in a split plot design with genotypes in sub plots and three disease levels treatments in main plots Disease levels were natural epidemic protected plot sprayed with Dithane M45 at 3 kg/ha at weekly intervals from growth stage V_4 to physiological maturity (R_8) and inoculated with phoma blight spores at weekly intervals from growth stage V_4 to R_8 Data recorded included diseases scored on a 1 9 scale and plot yield The trial was conducted at Kachwekano during Seasons 90B 91A and 91B

b) Three varieties of known reaction to phoma blight namely G 4603 (resistant) K 20 (intermediate) and EMP 117 (susceptible) were selected for study of effects of phoma blight infection at different growth stages on yield Seven treatments were simulated natural epidemic fungicidal protection from V_4 to R_8 fungicidal protection from R_6 to R_8 fungicidal protection from R_7 to R_8 inoculated with phoma blight spores (pbs) at R_6 inoculated with pbs at R_6 and R_7 and inoculated with pbs at R_5 R_6 and R_7 The trial was a split plot design with treatments in main plots and genotypes in sub plots The fungicidal control measures were similar to the first experiment

c) Varieties selected from previous AFBYAN entries representing different origins were hybridized with selected varieties with resistant or intermediate reactions to phoma blight The donors mainly utilized were G 4603 BAT 1416 BAT 1569 G 17098 and G 10747 all from previous International Ascochyta Blight Nurseries F_1 plants were raised in the field under fungicidal protection to obtain reasonable numbers of seeds F_2 F_3 F_4 and F_5 generations were grown in an infested field at Kachwekano inoculated with pbs at R6 and single plant selections were made in F_2 and F_3 on the basis of reaction to phoma blight Family sections were made among F_3 and F_4 progeny rows for yield evaluation in subsequent generations Some F_3 populations were evaluated at Rwerere in Season 91B

d) In the inheritance studies six parents (G 4603 BAT 1416 BAT 1569 K 20 Rushare and Carioca) were crossed in a complete diallel and the F_1s inoculated with a spore suspension of 1×10^4 spores/ml The plants were maintained under polythene humidity chambers in a screenhouse at Kachwekano where temperatures ranged between 15 and 18°C while humidity was on average 75% during the period of experimentation (January December 1992) The progress of disease severity on individual plants was monitored on a percentage basis for 14 days The Area Under the Disease Progress Curve (AUDPC) was calculated and used as a measure of the relative delay in disease expression due to genotypic resistance to the disease

RESULTS AND DISCUSSION

The mean squares from the analyses of variance of the yield data from the first yield loss trial are shown in Table 1 Significant yield reductions due to treatments were detected only in Season 91B In Seasons 90B and 91A disease expression did not differ among treatments and yield losses were not significant There were significant differences among variety yields in each season and overall and there was a significant S x V interaction The heaviest yields and largest phoma blight scores were observed in the season with the highest rainfall

The yields of the individual varieties when protected and the percent reductions in natural and severe infection by phoma blight are shown in Table 2 The yield reduction is also affected by other diseases such as anthracnose and angular leaf spot whose severity changed under the different treatments

Table 1 Mean squares from analysis of variance of seed yields from disease loss trial in Seasons 90B 91A and 91B

Source of variation	df	90B	91A	91B	Combined
Treatments (T)	2	ns	ns	626853**	4612361**
Varieties (V)	8	888120**	194522**	2333673**	826368**
T x V	16	ns	ns	ns	ns
Seasons (S)	2				4746325**
S x T	4				ns
S x V	16				512561**
S x T x V	32				ns

** significant at P<0 05 ns = not significant

Table 2 Percentage yield reductions in nine varieties under natural and severe phoma blight infection

Entries	Protected plot yield (g)[1]	% reduction Natural	Severe
Carioca	1205	24 8	31 0
EMP 117	1348	21 1	35 2
BAT 1416	1230	22 4	32 7
G 2316	1498	35 6	31 1
BAN 6	1040	30 5	31 0
G 4603	1610	34 4	49 2
G 17098	1436	34 7	32 8
BAT 1569	1156	52 0	61 3
K 20	1584	15 5	41 2

[1] mean of three seasons

The advantage of resistant variety G 4603 could not be demonstrated as its high susceptibility to anthracnose drastically reduced its yield In the second yield loss trial extreme yield reduction occurred when disease severity was high at R_7 Though yields were reduced in all three varieties when inoculated at anthesis and pod filling G 4603 yielded more than K 20 which yields heavier under fungicidal protection

In the inheritance study analysis of variance of the parents and F_1 data showed significant differences (P<0 05) among genotypes However combining ability analysis indicated that only specific combing ability is significant (P<0 05) in the expression of phoma blight resistance This was interpreted to indicate non additive genetic effects having a large influence on the expression of phoma blight

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SCREENING DRY BEAN (*Phaseolus vulgaris*) GENOTYPES FOR RESISTANCE TO *Macrophomina phaseolina*, THE CHARCOAL ROT PATHOGEN

W.A Songa

**Kenya Agricultural Research Institute,
National Dryland Farming Research Centre Katumani Machakos, Kenya**

ABSTRACT

Macrophomina phaseolina colonized whole grain rice and sclerotia were compared for their effectiveness as inoculants Colonized rice was found to be a simple and effective inoculant The tooth pick method was adopted for adult plant inoculation for its severity and uniformity Fifty three dry bean accessions from introduced improved and local germplasm were evaluated for their reactions to *M phaseolina* in field and greenhouse The greenhouse evaluation comprised two trials The first evaluated 27 accessions in a randomized complete block with four replications and five seeds per replicate The second trial consisted of 53 accessions with 3 replicates and four seeds per replicate Each accession was accompanied by a control Of the 27 accessions evaluated twice none were classified resistant (disease severity rating (DSR) = 1 3) but 13 were intermediate (DSR = 3 1 6 0) according to the CIAT evaluation scale of 1 = no visible symptoms to 9 = plant dead Field evaluations are still in progress at the time of writing Field nurseries have been established at the KARI experimental farms at Kiboko and Kibwezi Each accession is being evaluated in paired rows (with and without inoculation) in a randomized block design with three replicates

INTRODUCTION

Charcoal rot is an important disease of beans in areas where drought stress and high temperatures are common The disease is prevalent in many parts of the semi arid eastern Kenya and northern Sudan where dry beans are grown The disease has been reported to be severe in many locations of the Eastern Province of Kenya (Mukunya *et al* 1983) and in Sudan high mortality has been reported in early sown crops (Ali *et al* 1988) With the exception of seed treatment with benomyl (Benlate) or carboxin (Vitavax) which helps to control the disease in the early stages of growth existing control measures do not significantly reduce disease levels Host plant resistance with good cultural practices can be effective in controlling this disease Screening for disease resistant genotypes and the development of resistant varieties would provide seed based technology suitable for the subsistence farming systems where most dry beans are grown

The objectives of the study are to

(1) identify reliable field screening methods for resistance to *M phaseolina* in semi arid areas of eastern Africa

(2) identify bean germplasm with resistance or tolerance to *M phaseolina* and

(3) develop a regional *M phaseolina* nursery

GREENHOUSE AND FIELD INOCULATION METHODS FOR *M PHASEOLINA*

In the field severe symptoms of charcoal rot are observed in beans in the seedling stage and frequently in adult plants towards the end of the reproductive phase Screening dry bean genotypes for resistance to charcoal rot requires an efficient inoculation method in which disease escapes are avoided Soil inoculation techniques using sclerotia, mycelium and colonized whole grain rice have been reported (Abawi and Pastor Corrales 1986 Dhingra and Sinclair 1985) This study has the objective of identifying an inoculation method that is suitable for screening dry bean genotypes for resistance to *M phaseolina* in greenhouse and field

Materials and methods

Isolates of *M phaseolina* were obtained from infected sorghum maize and dry bean from charcoal rot hot spots of Kiboko in Machakos District Ishiara in Embu and Marimanti in Tharaka Nithi Small pieces of fibrovascular bundles from field infected sorghum and maize plants were surface sterilized with 1% sodium hypochlorite rinsed in distilled water plated on potato dextrose agar (PDA) and incubated at 30 C Slices of dry bean tissues infected with sclerotia and pycnidia were surface sterilized plated on PDA and incubated in similar fashion Pure cultures of *M phaseolina* were easily obtained from the initial cultures

An isolate (Isolate 10) from the dry bean from Kiboko was used for greenhouse and field inoculation of dry beans Colonized whole grain rice and sclerotia were used as inocula

Colonized whole grain rice was prepared by first autoclaving rice (1 1 w v rice seed water) before inoculation with *M phaseolina* and then incubating at 33 C Within 15 days the rice was colonized by *M phaseolina* and was used for inoculation in the greenhouse at the rate of three colonized rice seeds per bean seed

Sclerotia were produced by inoculating PDA in 9 cm petri dishes and incubating at 30 C for three days long enough for sclerotia production in most isolates (Chidambaram and Mathur 1975) The fungus on PDA was finely chopped shaken in 1% sodium hypochlorite for 5 8 minutes and washed thoroughly in 125 and 38 mm sieves in tandem Sclerotia were collected from the 38 mm sieve and the rest discarded Sclerotia numbers/ml of suspension were calculated using a gridded nematode counting dish and the appropriate dilution made up in distilled water The viabilities of the sclerotia were determined by plating 100 sclerotia of Isolate 10 on ten petri dishes with PDA medium The dishes were incubated at 33°C and germination of the sclerotia was found to be 98% after 48 hours Approximately 200 300 sclerotia in 3 ml distilled water were pipetted into each seed hole at planting

The numbers of plants that did not emerge and the number that rotted post-emergence were recorded The pre-emergence loss was assumed to result from seed rot due to *M phaseolina* A susceptible line (A 464 from CIAT) was used to test the effectiveness of inoculation The design in both methods was a randomized block with four replications (4 pots with 4 plants/pot for each replicate) The experiment was repeated three times

Results

Inoculation with whole grain rice colonised by *M phaseolina* was more effective in causing disease than inoculation with sclerotia (Table 1) Colonized whole grain rice is produced more rapidly and more easily than sclerotia making this method more appropriate for inoculation in both greenhouse and field

Table 1 Numbers of plants of dry bean susceptible line A 464 killed in three trials by *M phaseolina* inoculated as sclerotia and colonized whole grain rice

Inoculum	Pre-emergence loss 1	2	3	Post-emergence rot 1	2	3	Means
Sclerotia	0	0	2	4	7	5	6 0
Rice	1	3	2	5	6	5	7 3
Control	0	0	0	0	0	0	0
LSD (P<0 05)			2 389				

REACTION OF DRY BEAN GENOTYPES TO *M phaseolina* IN GREENHOUSE AND FIELD

Whole grain rice colonized by *M phaseolina* is efficient in causing charcoal rot in seedling and adult dry beans (Abawi and Pastor Corrales 1986) Screening dry beans at the adult stage however requires introduction of the inoculum at a later stage The toothpick inoculation method allows this and is also a severe and uniform method enabling evaluation for both disease incidence and severity (Echavez Badel and Beaver 1987)

In this study *M phaseolina*-colonized whole grain rice was used for testing seedling reactions to *M phaseolina* in greenhouse and field and toothpick inoculation for adult plant reaction in the field Isolate 10 of *M phaseolina* obtained from an infected bean at Kiboko was used throughout this study

Material and methods

Greenhouse tests Two evaluation trials were carried out in a greenhouse at Katumani The first evaluation trial was conducted in 1992 and consisted of 27 local introduced and improved genotypes The second trial was carried out in 1993 and comprised 53 genotypes including entries from the first trial The inoculation procedure consisted of placing three colonized whole grain rice seeds in contact with each bean seed and covering with 4-5 cm sterilized soil In the first trial each genotype was sown in four replications with five seeds per replicate (12 cm diameter pot) The second trial was sown in three replications with four seeds per replicate (10 cm diameter pot) In both trials there was an uninoculated control for each genotype evaluated

Disease severity ratings (DSR) were recorded 14 days after inoculation using the CIAT evaluation scale of 1 = no visible symptoms to 9 = all stem tissues and tip affected plants dead

Field tests Field tests of dry bean genotypes for resistance to *M phaseolina* are now in progress at the charcoal rot hot spots of Kiboko and Kibwezi The first trials were planted on 15 February 1993 at Kiboko and 16 February 1993 at Kibwezi The trials which involve 53 accessions are arranged in randomized block designs with three replications Each plot consists of two rows 3 m long Thirty seeds were sown in each row One row was inoculated with rice seeds colonized by *M phaseolina* at a rate of 2 3 colonized rice seeds per bean seed The second row was uninoculated Planting furrows were opened manually and 120 kg/ha of NPK 18 46 0 fertilizer was applied mixed with 1 25 kg/ha carbofuran (Furadan) for insect control The trial is maintained according to commercial production recommendations including disease and insect control and weeding and irrigated as necessary The numbers of plants emerged or infected with *M phaseolina* will be recorded 3 weeks after sowing and plants surviving and infected with *M phaseolina* and seed weights will be recorded at harvest

A similar trial was set up at both sites with the 53 genotypes in paired rows of 2 m long These trials are for the purpose of screening the adult bean genotypes using the toothpick inoculation method Each line is sown with 20 seeds per 2 m row One row will be inoculated and the other left as the control The inoculum will be applied on toothpicks soaked with sterile potato dextrose agar The bean plants will be inoculated by inserting the infected toothpick into the stem just below the cotyledonary node Sterile toothpicks will be used on the control rows Inoculation will be practised 30 days after germination Disease severity will be measured by the number of infected nodes and mean lengths of discoloured stems

Table 2 Disease reactions (scale 1 9) of dry bean genotypes to *M phaseolina* in greenhouse tests in 1992 and 1993

Type of material	Bean genotypes	1992	1993		1993
Introduced lines	V 8010	4 6	5 3	Spelekendwa	6 7
	BAT 1477	6 7	7 6	A 286	8 6
	EMP 86	6 6	4 6	G 8025	8 0
	BAT 1297	7 0	5 0	G 5201	4 0
	A 70	6 0	4 0	BAT 798	4 3
	A 120	4 6	3 0	Aguascalientes 13	6 7
	BAT 1651	5 3	6 6	Ex Rico 23	6 7
	G 5059	4 6	6 0	ICA 15506	4 0
	CG/82 24	4 3	7 0	Mexican 142	6 3
	CG/82-69	3 0	4 3	BAT 125	4 0
	BAT 1400	3 3	5 6	BAT 477	4 6
	BAT 1385	4 7	5 7	G 2816	6 0
	CG/82 79	3 3	5 3	G 4830	5 3
	V 8025	6 0	8 0	A 422	5 7
	BAT 1289	5 7	6 0	A 410	8 3
	A 55	6 7	6 6	EMP 105	1 6
	BAT 1581	6 0	8 7	A 4446	5 3
	V 8017	6 0	4 7	ANT 338	6 7
	BAT 1293	4 0	5 7	BAT 338 1C	5 0
	A 300	4 0	7 6	A 54	5 3
	A 247	4 0	7 0	PAN 133	6 0
	A 464	5 3	9 0	KAT X 68	5 0
Improved lines	GLP 1004	3 0	4 6	KAT X 16	6 3
	KAT B2	4 5	7 0	KAT X 68	5 0
	KAT B1	3 5	5 0		
	KAT B9	5 0	2 6		
Local lines				Nyayo	4 5
				Katumbuka	5 3

RESULTS

Greenhouse tests The results of the greenhouse tests are shown in Table 2 BAT 1400 BAT 1293 CG/82/69 and CG/82/79 among the introduced lines and GLP 1004 and KAT B1 improved lines were most resistant in the first trial (disease reactions 4 or less) The most resistant genotypes in the second trial were A 120 A 70 ICA 15506 EMP 105 BAT 125 and G 5201 among introduced lines KAT B9 an improved line and Katumbuka a local landrace BAT 1477 BAT 1297 BAT 1581 and A 55 gave highly susceptible reactions (score 6 or more) in both trials

Field tests Field screening is still in progress

DISCUSSION

Macrophomina phaseolina-colonized rice seeds were effective in causing charcoal rot of dry beans in both pre and post-emergence stages This form of inoculum is produced rapidly and easily and is highly suitable for large scale inoculations The greenhouse evaluation succeeded in separating promising materials from highly susceptible genotypes Susceptible genotypes were evident at emergence The first indication of susceptibility was poor emergence and dark sunken lesions on the cotyledons of emerged seedlings Lesions expanded rapidly reaching stem tissues within 4-6 days and killing seedlings within 14 days These observations agree with those of Pastor Corrales and Abawi (1986) and Gangopadhyay *et al* (1970) who reported that *M phaseolina* causes severe damping off of soybean seedlings with plant losses up to 77% The line A 464 reported susceptible at CIAT (Pastor-Corrales and Abawi 1988) was also susceptible at Katumani Some lines reported resistant at CIAT for example BAT 1297 were found susceptible These findings suggest differences in pathogenicity of the isolates used or differing reactions of bean genotypes in different environments Field reactions have to be determined for comparison with reactions in greenhouse conditions

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MANAGEMENT OF BEAN ANTHRACNOSE IN ETHIOPIA

Tesfaye Bishir

Plant Protection Research Center (PPRC), Ambo, Ethiopia

ABSTRACT

Surveys of major bean growing areas of Ethiopia showed high incidences of diseases including anthracnose in common bean Eight races of anthracnose were distinguished among 12 isolates collected from 8 areas in two seasons by inoculation on to 12 differential bean genotypes Field trials at Ambo in 1992 93 demonstrated yield losses due to anthracnose ranging up to 41 1% and reductions in seed size of up to 23 9%

INTRODUCTION

Common bean (*Phaseolus vulgaris* L) is the most important traditional pulse of lowland areas of Ethiopia particularly the Rift Valley It is a basic component of cropping systems of small farmers and of diets of people of eastern Africa Average yields of peasant farmers are extremely poor ranging between 600 and 800 kg/ha, due to a combination of several constraints among which diseases play a major role (Habtu Assefa and Dereje Gorfu 1985)

Bean anthracnose incited by *Colletotrichum lindemuthianum* (Sacc & Magn) was not practically important in Ethiopia in past years but a recent outbreak of the disease has been confirmed by intensive and extensive surveys in major bean growing areas Anthracnose causes heavy bean yield losses whenever susceptible bean cultivars are grown in locations with cool to moderate temperature and high humidity or free moisture (Schwartz and Galvez 1980) Very little information is available on the epidemiology and management of the disease This paper presents results of surveys race identification screening of resistant varieties and loss assessment trails undertaken in Ethiopia

MATERIALS AND METHODS

Surveys of major bean growing areas were organized and laboratory greenhouse and field experiments were conducted at the Plant Protection Research Center at Ambo in 1990 1992

Bean anthracnose surveys

Anthracnose surveys were conducted in major bean production areas in the Rift Valley and southern Ethiopia Samples were collected at intervals of 15 20 km on farmers and state farm fields 10 15 sample plants were randomly selected along the diagonals and were assessed on a 1 9 scale at growth stages close to R6 R8 (van Schoonhoven and Pastor Corrales 1987)

Race identification

Samples of bean anthracnose were collected from Ambo Nazreth Mojo Meki Ziway Awassa, Arsi Negele and Areka The isolates were purified multiplied and inoculated on 12 standard differentials in both field and greenhouse The reactions of the differentials were recorded using a 1 9 scale and transformed to a binary system to identify races (van Schoonhoven and Pastor Corrales 1987 Barrus 1918) The reactions of differentials were analyzed in greenhouse and field

Greenhouse test Five seeds of each differential were sown in 10 cm diameter pots kept for 10 15 days in the greenhouse at about 21 30°C Ten-day old seedlings were inoculated with a two week old culture of *Colletotrichum lindemuthianum* at a concentration of $2x10^6$ sp/ml (Barrus 1918) Each plant was evaluated seven days after inoculation

Field test The trial was laid out in a RCBD with three replications The plots were two rows 4 m long and 0 30 m apart The susceptible checks Mexican 142 Jalesco 33 and CUV 168 14 were sown every five entries Disease reactions were assessed on a 1 9 scale before flowering and at full podding

Loss assessment

The experiment was conducted in the field in a RCBD with six replications The susceptible cultivar Mexican 142 was used Mancozeb (0 2%) was applied as a foliar spray at 7 14 21 and 28 day intervals The plot size was eight rows 4 m long and 40 cm apart The four central rows were harvested Diseases were recorded on a 1 9 scale on each plot every 2 weeks following the first spray In addition 16 plants were randomly selected and tagged in each plot for intensive disease evaluation The data collected included numbers of infected leaflets and pods (total and healthy) disease severity lesion number yield and weight of 100 seeds Differences in yield were determined according to FAO (1971)

Screening nurseries

Field experiments were carried out in 1990 and 1992 Each nursery was composed of 100 entries with a plot size of two rows 2 m long and 30 cm apart and two replicates A susceptible cultivar (Mexican 142) was sown between and around the replications 25 days before the test entries were sown in order to increase the inoculum pressure Resistant (Red Wolaita) intermediate (Black Dessie) and susceptible (Mexican 142) checks were sown every ten test entries All nurseries were exposed to natural infection and some were also inoculated with mixed anthracnose populations Disease reactions were evaluated on a 1 9 scale before and after flowering and at the podding stage

RESULTS AND DISCUSSION

Surveys

Several diseases were observed throughout the major bean growing regions The most common were anthracnose rust common bacterial blight angular leaf spot floury leaf spot phoma blight ascohyta blight and halo blight Disease incidence was very high probably due to high rainfall and cool weather conditions The incidence of anthracnose was particularly severe at Ambo and slight to moderate at Awassa Areka and Debre Zeit research centres (PPRC 1989 Stewart and Dagnatchew Yirgou 1967)

In 1990 and 1992 the survey included some lowland areas of the Rift Valley and the Southern Zone including lower and mid altitude areas (1600 2150 masl) of the Western Region The severity of anthracnose was 34 3% in the Rift valley 24 2% in the Southern Zone and 32 8% in the Western Zone Rust and CBB were at lower levels The severity of anthracnose was very high in the Rift Valley and moderate in other regions (Table 1)

Table 1 Incidence and severity of anthracnose in major bean growing regions of Ethiopia, 1990 and 1992

Location	Altitude (masl)	Anthracnose	Rust	CBB
Rift Valley				
Mojo	1910	51 0	33 0	31 0
Meki	1690	30 0	34 0	21 0
Ziway	1600	25 0	35 0	20 0
Adamitulu	1690	34 0	29 0	24 0
Alemaya	2020	30 4	29 0	21 0
Mean		34 3	32 0	23 7
Southern zone				
Awassa	1740	22 0	20 0	15 0
Wolaita Sodo	2010	25 0	35 0	15 0
Arsi Negele	1930	25 0	23 0	28 0
Mean		24 2	26 0	19 0
Western zone				
Bako	1600	21 0	34 0	20 0
Didesa	1610	35 0	21 0	20 0
Metu		28 0	19 0	15 0
Jimma	2000	45 0	35 0	23 0
Ambo	2150	35 0	30 0	28 0
Mean		32 8	27 0	21 0

A total of 58 isolates were collected some from experimental fields where many bean genotypes were concentrated Farmers fields were uniformly sown with the susceptible cultivar Mexican 142 The use of seeds from the previous crop for sowing causes the build up of anthracnose inoculum through aggregation of host crops in space and time (Zadoks and Schein 1979) Thus over time the prevalence and severity of anthracnose have progressively increased in farmers fields and experimental sites possibly accompanied by an increase in the variability of the pathogen

Race identification

Races 1 3009 898 and 128 were tentatively identified during the 1990 crop season In 1992 eight isolates were tested repeatedly on the differential varieties and eight other races were identified (Table 2)

Similar reactions were observed on MDRK PI 207 262 To and Tu for Bako isolates and on PI 207 262 for Ziway isolates for two years In contrast Ambo and Awassa isolates showed different reactions in both years These may be true differential reactions because the isolates were collected in different years it is also possible that the isolates were heterogenous Tests will be repeated at CIAT In the field a high incidence of anthracnose occurred at Ambo in 1992 Of the 12 differential cultivars only Michelets Cornell 49 242 Widusa and Tu (race 537) were susceptible in the field

Table 2 Reaction of differential varieties to anthracnose isolates collected from major bean growing regions of Ethiopia in 1990 and 1992

		1990				1992							
		Amb	Awa	Bak	Ziw	Amb	Awa	Bak	Ziw	Are	Ada	Mek	Ale
Michelets	1	S	S	R	R	S*	S	R	R	S	R	S	R
MDRK	2	R	R	S	R	R	R	S	R				
Perry Marrow	4	R	R	R	R	S	R	R	R				
Cornell 49 2528		R	R	R	R	S*	R	R	S				
Widusa	16	R	R	R	R	S*	S	R	S				
Kaboon	32	R	R	R	R	R	S	R	S				
Mexico 222	64	R	S	S	S	R	S	R	R				
PI 207 262	128	R	S	S	S	R	S	S	S				
To	256	R	S	S	R	R	S	S	S				
Tu	512	R	S	S	R	S*	S	S	S				
AB 136	1024	R	R	R	R	R	R	R	R				
G 2333	2048	R	S	R	R	R	R	R	R				
Races		1	3009	898	128	525	1009	898					

Amb = Ambo Awa = Awassa Bak = Bako Ziw = Ziway Are = Areka Ada = Adami Tulu
Ale = Alem Genu

Loss assessment

The least infection on pods and leaflets occurred with the 7 days spray interval With wider spray intervals the progress of the disease was also significant (Table 3)

Table 3 Number of infected pods and leaflets/plant

Spray intervals (days)	Recordings 1	2	3	4	5	6	Infected pods (%)	Infected leaflets/ plot
7	0	3 8	1 3	2 2	3 3	4 0	26 7	3 2
14	0	6 3	5 3	4 7	6 5	6 7	48 2	5 5
21	0	5 2	5 5	5 2	8 0	8 0	56 9	6 3
28	0	4 2	6 2	6 7	9 7	10 3	63 2	8 0
Unsprayed	2 8	6 8	7 6	10 3	14 0	19 0	82 6	14 0

There were sıgnıficant dıfferences ın anthracnose reactıons among treatments The most frequent sprays consıstently produced the least dısease severıty and the largest yıeld Yıeld losses were 41 1 27 6 26 0 and 22 4% for 7 14 21 and 28 days spray ıntervals respectıvely (Table 4) Losses ın 1000 seed weıght were also sıgnıficant among the treatments rangıng between 23 9 and 10 4%

Table 4 Anthracnose scores yıelds and seed sızes ın Dısease Loss Trıal at Ambo ın 1992 93

Spray ıntervals (days)	Dısease scores on sıx dates						Yıeld		Seed weıght	
	1st	2nd	3rd	5th	6th	7th	kg/ha	% loss	g/1000	% loss
7	1 2	2 8	2 0	2 7	2 7	3 3	1845	41 1	145	23 9
14	2 0	3 0	3 3	3 0	4 2	4 2	1502	27 6	131	15 5
21	1 7	3 8	3 5	3 7	4 8	5 0	1469	26 0	126	12 2
28	2 3	3 2	4 2	4 8	5 7	6 0	1401	22 4	123	10 4
Unsprayed	1 3	4 0	4 2	4 7	7 0	8 3	1087		110	

Screenıng nurserıes

The results of screenıng nurserıes revealed that 20 entrıes exhıbıted resıstance (1 3 score) to anthracnose These entrıes were also resıstant to other folıar dıseases (rust and CBB) and theır yıelds were greater than the yıelds of other entrıes (Table 5) The remaınıng test materıals were moderately and hıghly susceptıble to anthracnose

Dısease pressures were very hıgh ın the 1990 and 1992 seasons as weather condıtıons were conducıve to dısease development

Table 5 Dısease reactıons and yıelds of entrıes ın anthracnose nursery at Ambo ın 1990 1992

Entrıes	Anth	Rust	CBB	Yıeld (g/plot)
Cocoala creme	3	7	1	300
Imuna	2	1	4	140
Kaboon	2	6	4	330
Prıncor	3	3	1	125
PVAD 1184	2	1	4	350
PVAD 791	2	4	5	425
ZAA 5	2	2	1	245
PAD 37	2	1	1	240
A 475	2	1	4	135
K2	3	1	5	100
A 585	3	6	1	650
A 613	3	1	4	290
SUG 9	2	1	6	120
A 193	3	1	1	250
Perry Marrow	3	2	3	300
Ancash 66	2	1	4	395
DAT 841	3	1	1	295
ACV 46	2	1	1	215
PVMX 1659	2	1	7	350
Ecuador 1056	3	1	1	485
Negro 150	1	1	3	345
Mexıco 235	1	1	5	250
Contanex	1	1	3	390
Eth 10 27	3	3	3	259
Eth 39	2	2	3	305
Red Wolaıta	3	3	4	390
Black Dessıe	5	6	2	150
Mexıcan 142	8	5	3	101

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PERFORMANCE OF ADVANCED GENERATION BEAN LINES SELECTED FOR MULTIPLE DISEASE RESISTANCE

P M Kimani, A W Mwang'ombe and J W Kimenju

**Department of Crop Science University of Nairobi
Nairobi Kenya**

ABSTRACT

Fifty common bean (*Phaseolus vulgaris* L) lines were selected from populations created from crosses among seven parents including four popular cultivars (GLP 2) GLP 288 (Rosecoco) GLP 24 (Canadian Wonder) and GLP X 92 (Mwitemania/Pinto type) The parents differed in resistance to some of the most important bean diseases of eastern Africa (rust *Uromyces phaseoli* (Rebe) Wint angular leaf spot *Phaeoisariopsis griseola* anthracnose *Colletotrichum lindemuthianum* halo blight *Pseudomonas syringae pv phaseolicola* bean common mosaic virus (BCMV) and common blight *Xanthomonas campestris pv phaseoli* (Smith) Dye) yield maturity and seed and morphological characteristics Selected lines from the nearly homozygous F_7 F_8 and F_9 generations were evaluated at five locations between 1989 and 1992 under both artificial inoculation and natural epiphytotics The lines showed considerable variation in disease reaction maturity yield and seed characteristics Ten early (80 85 days) 20 medium (86 95 days) and 20 late (> 96 days) maturing lines with yields of over 2 t grain ha ^{1} and superior to local commercial cultivars were finally selected These lines combined resistance to three or more diseases with preferred seed characteristics

INTRODUCTION

Most bean cultivars currently grown in eastern Africa are susceptible to one or more diseases (Kimani *et al* 1990) When such cultivars are grown in areas where the diseases are endemic their yields are dramatically reduced (Gridley 1990) Disease incidence and severity tend to vary among locations and seasons Because of the wide range of climatic conditions it is difficult to breed cultivars suited to every region Cultivars with wide adaptability and with resistance to the major diseases can stabilize yields in a wide range of environments Relatively little work has been done in the region to develop bean cultivars with multiple resistance In recent years national programs have started development of bean populations with resistance to specific major diseases such as common bacterial blight (Musaana and Opio 1990) rust (Assefa 1990) phoma blight (Sengooba and Male Kayiwa, 1990) and bean common mosaic virus (Owera, 1990) for utilization in the whole region CIAT has made considerable efforts to identify and incorporate resistance into breeding lines which have been distributed in disease nurseries for evaluation by national programmes for resistance to prevalent pathogens (Gridley 1990) Lines with resistance to common bacteria blight halo blight and rust from such nurseries have been identified in test sites in Uganda Confirmed sources of resistance are intended for utilization in developing multiple resistant cultivars Kimani *et al* (1990) selected several F_4 and F_5 lines combining resistance to three or more diseases acceptable seed characteristics and yield potential from populations created from a seven parent diallel cross The purpose of this paper is to describe the performance of advanced generation lines from these selections with respect to disease reaction yield and related traits

MATERIALS AND METHODS

Over two hundred F_4 and F_5 lines selected from nine populations were grown in nine environments between 1988 and 1992 in Kenya These lines were derived from crosses among four commercial cultivars GLP 2 (Rosecoco) GLP 288 (Rosecoco) GLP 24 (Canadian Wonder) GLP X 92 (Mwitemania) one line developed through mutation breeding (M 535) one recently introduced white seeded breeding line (L 226 10) and a local black seeded landrace (NB 123) In addition 30 advanced lines (M9 and M10) derived from irradiated seeds of Canadian Wonder were included (Kimani 1988) Disease and yield characteristics of the parental lines and their F_1 to F_5 generations have been previously described (Kimani *et al* 1990) Popular local cultivars (GLP 2 GLP 24 and GLP X 92) were used as checks

The lines were grown at Kabete during the 1988 short rain season and the 1989 and 1990 long rain seasons In 1991 they were grown at Kabete (Nairobi district) Thika (Muranga district) Marimanti (Meru district) and Rongai (Nakuru district) during the long rain season and at Kabete and Tigoni (Kiambu district) during the short rain season They were also grown at Kabete during the 1992 long rain season The trials were arranged in a randomized complete block design with four replicates Each plot consisted of four rows 5 m long Spacing was 50 cm between rows and 10 cm within rows 100 kg ha $^{-1}$ diammonium phosphate (18% N and 45% P_2O_5) was applied at planting Plots were kept weed free by hand cultivation Seeds harvested each season were used for sowing in the next season

Plots were rated for reactions to rust BCMV angular leaf spot anthracnose and halo blight pathogens From 1988 to 1990 disease assessment was based on natural epiphytotics In 1991 and 1992 the trials were also artificially inoculated with all the five pathogens To ensure that the materials were subjected to a wide variety of existing pathotypes isolates were gathered from different bean growing areas in Kenya The isolates were multiplied separately and mixed before inoculation Procedures for pathogen isolation multiplication and inoculation were described previously (Kimani *et al* 1990) CBB) was rated only in 1989 1991 and 1992 A 1 9 disease severity scale was used which corresponds to the 1 5 scale described previously (1 2 3 4 and 5 corresponds to 1 3 5 7 and 9 respectively) (Kimani *et al* 1990) Diseases were assessed about 21 days after inoculation (R6) and at mid pod filling (R8) The larger of the two ratings was taken as the final score Ten randomly selected plants in each plot were tagged and assessed for disease severity on leaves (R6 stage) and on pods (R8 stage) Susceptible plants and/or lines and those with other undesirable characters were discarded Grain yields and times to flowering and maturity was recorded on the inner two rows of each plot A random sample of 100 seeds from each plot was used to determine seed size

Data was analyzed on individual site basis to determine if they were any significant genotypic differences A combined analysis was performed according to procedures outlined by Gomez and Gomez (1984) each location in a particular year and season being considered an environment Genotypes were considered fixed and environments random Protected least significant differences (PLSDs) were used for means separation Maturity groups were analysed separately

RESULTS AND DISCUSSION

Analysis of variance showed that there were significant differences in maturity disease rating seed characteristics and yields among lines and environments (Table 1 2 and 3) Of the two hundred lines evaluated for nine seasons 50 were finally selected for combining desirable seed characteristics disease resistance and yield Segregation for various characters decreased consistently as the materials were advanced from F_4 generation and had virtually ceased by the F_9 and F_{10} generations The selected lines originated from 14 of the 36 F_2 populations

Table 1 Days to flowenng and maturity seed types and sizes disease ratings and grain yields of ten early maturing bean lines and cultivars grown in nine environments in 1988 92

Lines/ cultivars	DFF	DM	Seed type	Weight of 100 seeds (g)	Disease ratings (means 4 worst seasons) BCMV	HB	CBB	Anth	Rust	ALS	Grain yields (kg/ha)
K7/6A	42	81	RC	57 8	0	1 5	1 1	3 5	1 6	5 4	2758
K7/9A	40	83	RC	55 6	0	2 0	1 0	1 9	3 3	4 4	2172
K7/12A/2	45	83	RC	60 4	0	1 5	1 1	2 1	3 0	4 5	2484
K7/13A III	43	84	RC	52 7	0	3 0	1 0	2 0	2 7	5 5	2210
K7/26B	43	81	RC	60 8	0	2 0	1 0	3 6	2 6	5 1	2721
K7/27A/1	42	83	RC	57 3	0	1 5	1 0	1 7	1 5	5 7	2260
K15/1A1	42	83	RC	57 5	0	2 5	1 0	3 5	4 0	3 1	2228
K15/2A/1	42	83	RC	51 9	0	2 5	1 1	3 7	4 5	4 8	2370
K15/6C 1	44	83	RC	57 5	0	2 5	1 1	4 5	3 8	4 8	2172
K15/7A	42	83	RC	58 5	0	2 5	1 1	4 1	5 5	5 3	2232
GLP 2	45	87	RC	55 1	4 7	3 6	3 0	2 6	3 7	4 0	1781
GLP 24	49	96	CW	41 0	4 5	3 8	2 2	4 9	2 8	2 4	1806
GLP 92	41	97	MW	42 0	6 9	2 8	1 0	5 5	8 2	4 1	1435
Mwezi Moja	39	85	MM	44 0	3 2	6 0	1 0	3 2	2 0	5 7	1372
LSD (P<0 05)	3 4	3 1		9 9	1 1	1 2	1 0	2 3	1 7	2 3	1079

DFF = number of days to flowenng DM = number of days to maturity HB = halo blight CBB = common bacterial blight Anth = anthracnose ALS = angular leaf spot RC = Rosecoco CW = Canadian Wonder MW = Mwitemania MM = Mwezi Moja RH = Red Haricot = checks

Maturity

The selected lines were classified early medium and late based on flowenng and maturity data The early group matured in 80 85 days and flowered in 40-44 days (Table 1) Medium maturity lines flowered in 49 52 days and matured in 86 95 days (Table 2) while the late group also flowered in 49 52 days but matured in 96 100 days (Table 3) Times to flowenng and maturity varied with locations and seasons Of the 50 selected lines ten were early maturing and there were 20 each in the medium and late maturing groups Van Rheenen *et al* (1984) reported the duration of flowenng and maturity in four bean cultivars (GLP 24 GLP 92 and GLP 1004) released through the grain legume project and currently grown commercially in Kenya Mwezi Moja (GLP 1004) was the earliest flowenng in 39 days and maturing in 85 days The new early maturing lines compare favourably with this cultivar Under the proposed maturity classification of the new bean lines GLP 2 (Rosecoco) GLP 24 (Canadian Wonder) are medium maturing while GLP 92 (Mwitemania) is late maturing Mwezi Moja falls in the early maturing category The early maturing cultivars are recommended for semi arid and medium rainfall areas where the growing season is short However they also can be grown during the short rain season in areas with bimodal rainfall thus ensuring two crops per year The medium maturity cultivars such as GLP 24 are recommended for medium rainfall areas only (Van Rheenen *et al* 1984) The later maturing cultivars such as GLP 92 and some medium duration cultivars especially GLP 2 are recommended in high rainfall areas In practice these cultivars are often grown outside the recommended areas due to local variability in climatic conditions especially the length of the growing season prevalent diseases strong preferences for certain seed types and yield performance The constraints are likely to be overcome with the new lines which showed considerable variability in seed characteristics and disease resistance and wide adaptability

Table 2 Days to flowering and maturity seed types and sizes disease ratings and grain yields of 20 medium maturing bean lines and cultivars grown in nine environments in 1988 92

Lines/ cultivars	DFF	DM	Seed type	Weight of 100 seeds (g)	BCMV	HB	CBB	Anth	Rust	ALS	Grain yields (kg/ha)
					Disease ratings						
K1/2B/1	49	86	CW	43 4	0	3 5	1 1	4 9	2 6	3 1	2555
K6/6B II	49	90	RC	45 7	0	1 0	1 2	2 3	4 1	3 5	2572
K6/10B	51	93	CW	41 6	0	1 5	1 0	1 5	3 0	2 9	2367
K7/6B I	46	86	RC	62 7	0	1 0	1 0	2 5	2 1	6 4	2836
K7/26B/1	51	88	RC	42 8	0	2 0	1 0	2 7	2 4	4 9	2447
K8/24B	51	95	MW	35 9	1 5	2 6	1 0	2 6	3 5	5 5	1947
K13/1A II	50	88	CW	46 2	0	2 7	1 0	3 8	3 6	3 2	2610
K13/9B	51	93	MM	53 4	0	1 5	1 1	2 9	2 7	2 6	2372
K15/1A	51	89	MW	35 9	3 5	2 5	1 0	3 6	3 5	4 7	2039
K19/4A	49	88	CW	41 6	0	1 0	1 0	1 9	3 0	2 5	2626
K19/4C	51	93	MM	53 3	0	1 5	1 0	2 4	1 7	3 9	2921
K19/22A I	51	93	RC	53 3	0	1 0	1 0	1 9	2 9	2 7	2754
K19/38A	49	88	RC	51 1	0	1 1	1 1	2 1	3 7	2 8	2660
K21/46A II	51	93	CW	49 7	0	2 6	1 0	2 3	5 5	2 7	2465
K25/13A	52	88	RC	38 2	1 0	2 5	1 1	2 1	3 8	3 6	1808
K33/38A	51	86	RH	40 7	0	2 5	1 0	2 9	2 2	1 3	1920
K33/38B	51	86	RH	47 1	0	2 5	1 0	3 5	2 5	2 1	2192
M262/16	52	90	CW	34 3	0	1 5	1 0	2 6	2 4	2 3	2874
M355/1	50	88	CW	38 9	0	2 5	1 1	3 9	2 1	3 5	2810
M355/27	49	93	CW	46 2	0	2 6	1 0	3 8	1 5	3 2	2702
GLP 2	45	87	RC	55 1	4 7	3 6	3 0	2 6	3 7	4 0	1781
GLP 24	49	96	CW	41 0	4 5	3 8	2 2	4 9	2 8	2 4	1806
GLP 92	41	97	MW	42 0	6 9	2 8	1 0	5 5	8 2	4 1	1435
Mwezi Moja	39	85	mm	44 0	3 2	6 0	1 0	3 2	2 0	5 7	1372
LSD (P<0 05)	3 3	2 2		7 7	1 1	0 8	0 9	1 2	1 6	1 4	1262 9

Footnotes as for Table 1

Disease reactions

All the lines were rated resistant to BCMV except the late maturing K15/1A which was rated intermediate (Table 3) Most plants susceptible to BCMV did not flower or produce seed and were therefore eliminated through natural or objective selection Consequently susceptible plants or lines which were easily identified decreased considerably in more advanced generations For the purpose of fungal and bacterial disease evaluation grades 1 3 were considered resistant 4-6 intermediate and 7 9 susceptible All lines showed high levels of resistance to halo blight (*Pseudomonas syringae pv phaseolicola*) and common blight (*Xanthomonas campestris pv phaseoli* (Smith) Dye) except the medium maturity K1/2B/1 and the late maturing K3/2B/2 which showed an intermediate reaction Reactions to *Colletotrichum lindemuthianum* (anthracnose) varied among selected lines Among the early maturity group K7/27A/1 K7/13A III K7/9A and K7/12A/2 were rated resistant to anthracnose All other early maturing lines showed intermediate levels of resistance Fourteen medium and 15 late maturing lines were resistant to anthracnose with the rest showing intermediate resistance Six 13 and 11 early medium and late maturity lines respectively were rated resistant to rust (*Uromyces phaseoli*

(Rebe) Wint) The early maturing lines K7/6A K7/27A/1 the medium maturing lines K19/14C and the mutation breeding derived line (M355/27) as well as the late maturing K23/19C M335/21 and M355/2 showed outstanding resistance to rust both under artificial inoculation and natural epiphytotics Most lines showed intermediate levels of resistance to angular leaf spot (*Phaseoisariopsis griseola*) Only one line (K15/1A1) was rated resistant to this disease among the early maturity group (Table 1) There were 12 medium and 6 late maturing lines resistant to angular leaf spot The medium maturity line K33/38B showed outstanding resistance to angular leaf spot In all cases the lines showing high susceptibility to any disease were discarded during the selection process However remnant seeds of lines showing outstanding resistance to particular disease(s) and or other desirable attributes were retained for future breeding work

The results indicated that the selected lines have resistance to the major diseases of beans in Kenya and to a large extent in eastern Africa where the same diseases are prevalent The check cultivars which were also used as parents in crossing blocks showed susceptibility to various diseases (Kimani *et al* 1990 Van Rheenen *et al* 1984) GLP 2 (Rosecoco) perhaps the most popular bean cultivars in Kenya is susceptible to angular leaf spot and moderately susceptible to rust and halo blight (Tables 1 2 and 3) but is resistant to BCMV and anthracnose Van Rheenen *et al* (1984) rated Canadian Wonder (GLP 24) as very susceptible to rust intermediate in resistance to halo blight and moderately susceptible to BCMV On the basis of trials conducted between 1974 and 1978 it was rated resistant to anthracnose and angular leaf spot GLP 92 (Mwitemania) although a good yielding variety with wide adaptation is very susceptible to rust BCMV and anthracnose but resistant to halo blight Mwezi Moja (GLP 1004) a popular bean cultivar in drier and medium rainfall areas is susceptible to halo blight and angular leaf spot GLP 288 is susceptible to rust and angular leaf spot It appears that the resistance to specific diseases in the parental cultivars was successfully transferred to their progenies and effectively selected for in advanced generations For example the resistance to BCMV rust and anthracnose in the early maturing lines which were derived from GLP 2 and GLP 288 can be attributed to GLP 2 However the intermediate ratings of angular leaf spot may be due to the fact that both parents had moderate to low levels of resistance to this pathogen It is also possible that resistance to this disease is governed by more than one gene and combination of different alleles from the two parents leads to improved resistance as is evident for K15/1A1 (Table 1) It is also clear that the selected lines have better levels of resistance to most diseases than the commercial cultivars Disease severity was generally greater in the wetter seasons

Seed characteristics

The physical appearance of bean seeds is of great importance to traders and consumers For example Rosecoco beans with large red flecks on cream are attractive in appearance to many customers and usually fetch the highest prices in wholesale markets in urban areas in Kenya Recent studies (Munene 1992) showed strong preference for Rosecoco beans in many areas in Kenya Seed characteristics were therefore considered important during selection The four main commercial bean cultivars differ in their seed characteristics and can classified broadly into five categories

Rosecoco type (red flecks on cream) such as GLP 2 and GLP 288
Canadian Wonder type (purple) such as GLP 24
Mwitemania or Pinto type (white flecks on black) such as GLP 92
Mwezi Moja types (grayish with white flecks)
Red Haricot types with solid red colour

Table 3 Days to flowenng and maturity seed types and sizes disease ratings and grain yields of 20 late maturing bean lines and cultivars grown in nine environments in 1988 92

Lines/ cultivars	DFF	DM	Seed type	Weight of 100 seeds (g)	BCMV	HB	CBB	Anth	Rust	ALS	Grain yields (kg/ha)
					Disease ratings						
K/2B/2	51	99	CW	40 2	0	3 6	1 4	2 1	2 5	2 6	2783
K13/5B I	51	98	RC	55 9	0	2 1	1 2	3 1	3 0	4 4	2341
K13/26B	51	98	RC	51 8	0	2 1	1 0	2 8	3 5	5 4	2436
K13/26C	50	96	RC	54 9	0	1 6	1 0	2 6	4 0	4 9	2552
K13/27A	51	98	RC	65 1	0	2 1	1 0	1 8	5 0	4 4	2734
K13/27A/1	52	97	CW	50 9	0	2 1	1 1	3 0	5 0	4 9	2560
K21/24A	50	98	RC	47 2	0	2 5	1 0	3 8	4 2	4 4	2465
K21/46A	51	96	CW	45 9	0	2 5	1 0	2 1	5 5	4 1	2725
K23/19C	52	97	RC	46 5	0	2 0	1 0	1 7	1 7	4 9	2418
K23/21	52	98	CW	39 7	0	2 0	1 0	1 6	3 3	4 0	2402
K23/28C/3	52	98	RC	50 3	0	2 5	1 1	2 2	3 2	4 0	2171
K28/29A	51	97	CW	39 9	0	1 0	1 0	3 6	4 5	2 6	2610
K28/33B I	52	99	CW	37 5	0	2 0	1 2	3 0	3 6	2 3	2752
K29/6C I	52	99	MM	38 3	0	2 0	1 1	2 6	2 7	4 7	2140
K29/36D I	51	98	CW	50 6	0	2 0	1 1	3 8	4 2	4 0	2488
K33/28C II	51	98	RH	35 4	0	2 0	1 0	2 1	3 1	3 0	2106
M262/13	52	98	CW	37 3	0	2 0	1 1	3 2	3 1	3 0	3406
M262/35	52	98	CW	39 8	0	1 1	1 1	2 3	3 0	2 8	3496
M355/21	50	97	CW	43 7	0	2 5	1 1	4 2	1 8	4 0	3388
M355/22	49	96	CW	43 1	0	2 6	1 1	3 8	1 4	4 0	2597
GLP 2	45	87	RC	55 1	4 7	3 6	3 0	2 6	3 7	4 0	1781
GLP 24	49	96	CW	41 0	4 5	3 8	2 2	4 9	2 8	2 4	1806
GLP 92	41	97	MW	42 0	6 9	2 8	1 0	5 5	8 2	4 1	1435
Mwezi Moja	39	85	MM	44 0	3 2	6 0	1 0	3 2	2 0	5 7	1372
LSD (P<0 05)	3 3	2 5		8 5	0 9	0 9	0 6	0 9	1 8	1 5	1399 0

Footnotes as for Table 1

Detailed descriptions of these seed types were provided by van Rheenen (1979) All the early maturity lines were Rosecoco type but differ in intensity and pattern of the main seed colours They are also large seeded (50 61g/100 seeds) The medium maturing lines have seed types of five categories Canadian Wonder (8) Rosecoco (6) Mwitemania (2) Mwezi Moja (2) and Red Haricot (2) (Table 2) Fifteen have large seeds (>40g/100 seeds) and five medium sized seeds (30-40g/100 seeds) Among late maturing lines 11 are Canadian Wonder type 7 are Rosecoco and each of Red Haricot and Mwezi Moja Of the twenty lines 14 are large seeded and 6 have medium sized seeds

Grain yields

The fifty lines also were selected on the basis of their average yield over the nine environments All the lines selected except K33/38A and the K25/13A had yields over 2 t ha^{-1} generally heavier than the check cultivars K33/38A a medium maturity line was selected because of its seed characteristics (Red Haricot type) and high levels of disease resistance especially to angular leaf spot and CBB There were significant differences among lines and environments Generally all lines gave heavier yields during the long rain season than the short rains Buruchara and Tyagi (1979) also reported better yields during the long rain season probably due to better moisture supply Although relatively higher disease levels were recorded during the wetter seasons yield reduction was minimized by resistance to various diseases Average yield was greatest among the late maturing group (2628 3 kg ha $^{-1}$) and poorest among early maturing lines (2363 6 kg ha $^{-1}$) Two early maturing lines K7/6A and K7/26B produced yields over 2 600 kg ha $^{-1}$ Three late maturing lines (M262/13 M262/35 and M355/21) derived from irradiated Canadian Wonder (GLP 24) had yields over 3 t ha $^{-1}$

The results of this study indicate that selection for improved disease resistance seed characteristics and grain yield was effective This is important in view of the fact that diseases are a major limiting factor to productivity in farmers fields in this region (Kimani *et al* 1990) However resistance without consideration for consumer preferences for seed characteristics would constrain rapid adoption of the promising lines when they are released This aspect also was considered The lines were screened under a wide array of growing conditions and therefore exposed to the various strains of the major pathogens which are known to exist The next part of this work will include on farm tests and evaluation of consumer preference and cooking quality prior to release of the new varieties The selection of lines of differing maturity will help to develop cultivars suited to differing lengths of growing season

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DISCUSSION SESSION III BREEDING FOR DISEASE AND INSECT RESISTANCE

Chair M Fischler Rapporteur A F Opio

Paper by Theresa Sengooba

Buruchara Is the origin of the strains of BCMV found on wild host plants known?

Sengooba The studies carried out indicate that the strains originated most likely in the region but we are not sure yet Therefore we call them BCMV like isolates Further studies are necessary

Paper by W Songa

Ajanga Originally you used several isolates but in the end you were using only one Where did this isolate originate? Why are you now using only one isolate to test for resistance ?

Songa The isolate used was from dry bean I intended to narrow the volume of germplasm before multilocational testing in the region where a mixture of indigenous isolates will be used

Buruchara The objectives of your sub project are to develop suitable screening methodology screen germplasm for resistance and develop a regional nursery What is the link between these objective and utilization of their results by breeders?

Songa I should have said at the beginning that germplasm screening is conducted in close collaboration with the breeder The regional nursery is for the purpose of either releasing identified resistant cultivars straight to farmers if they have other acceptable agronomic characters or for use as sources of resistance in the breeding programme The next crucial step after establishing the regional nursery is to initiate a breeding programme for the development of resistant varieties and therefore a seed based technology to manage the diseases

Opio Why did you use only one isolate in the evaluation of inoculation methods? Yet it has been reported that there are interactions between isolates and inoculation methods I assume you will be evaluating bean germplasm after your inoculation studies I suggest that instead of using one isolate (isolate 10) use a mixture of isolates otherwise you may get escapes

Songa I used one isolate (isolate 10) which I found very pathogenic and a fast grower on artificial media to reduce the germplasm for subsequent screening Promising genotypes selected for multi locational testing will then be re screened using isolates indigenous to the test location A single isolate is satisfactory for developing an effective inoculation method since I was using a known highly susceptible genotype for the experiment Your suggestion to use a mixture of isolates while evaluating germplasm to avoid escapes is well taken

Sengooba In field screening with *Macrophomina phaseolina* don t you sometimes have complications from other root rot pathogens? How do you handle this problem?

Songa Each genotype is grown in double rows and the control row is used for correction since diseases other than *Macrophomina phaseolina* should infect the control as well Indeed I agree with you that when many other root rots are involved the evaluation is far from easy and can be unreliable

Tesfaye Beshir I suggest use of mixed isolates for screening for resistance to *M phaseolina* because otherwise you may lose the best genotypes

Paper by Tesfaye Beshir

Mitiku Haile In your conclusion you indicated that the disease pressure is expanding from year to year Is this because you are exploring areas hitherto unsurveyed or because susceptible varieties are being introduced in previously surveyed areas?

Tesfaye Beshir Disease pressure is increasing in previously surveyed areas because farmers use their own infected seeds from season to season

Sengooba Is there any breeding effort to combat anthracnose in Ethiopia? This is a disease where sources of resistance are fairly well documented and there is a need to concentrate on breeding for resistance while the pathologist concentrates on collection of isolates and study of their variation so that he can subsequently play a major role in evaluating breeders materials

Tesfaye Beshir So far we do not have any line bred for resistance to anthracnose in Ethiopia We pass resistant varieties to the breeders for future use and make a strong follow up on this

Mitiku Haile We have been informed that a variety which was resistant to a certain isolate in several locations is now breaking-down This I believe is a challenge to breeders and pathologists Would you comment on how this variety which is considered to be resistant in Latin America Africa and many locations in Ethiopia succumbed only in one site at Sodo?

Tesfaye Beshir This can be answered only by collecting races from different locations and improving screening techniques

Paper by F Makini

Rachier Why did you choose to use only 98 genotypes while there are many more genotypes at Thika?

Makini I decided to work with a hundred lines to start with because this number is manageable As some of these are rejected as susceptible other lines will be tested

Buruchara You did not show whether and how your research activities will provide service to other researchers who are interested to know whether their materials are resistant to angular leaf spot?

Makini I will be collaborating with other scientists in the region whereby they can send me their materials for testing Already I am collaborating with the university of Nairobi and we are testing different lines for resistance to ALS as well as other diseases Scientists interested to know whether their materials are resistant to ALS will be welcome to send them to me for testing

Opio Is your sub project only for Kenya or the whole of eastern Africa?

Makini The sub project covers the whole of eastern Africa

Paper by P M Kimani, A W Mwang'ombe and J W Kimenju

Gridley Do you now have sufficient information for release of the superior lines tested in your programme?

Kimani Yes to a large extent but we would still like to evaluate them under a wider range of conditions including on farm trials in the next three seasons in all seven provinces of Kenya

Kanyagia In your presentation you said you have found some varieties which are resistant to particular diseases and some are high yielders Are you going to include farmers in your on farm trials?

Kimani We are going to start soon

Mushi In your presentation you mentioned that in some locations you failed to inoculate the plants How similar are the two seasons in those environments where you couldn't artificially inoculate?

Kimani Locations were clustered according to conditions and to artificially inoculate one that is representative There is more disease in wetter seasons

Tenaw Workayehu More than one disease was observed in the same plants In your study did you study the diseases separately or together?

Kimani In the initial stages (F_2 F_3) we rated diseases separately and then we used multiple inoculations for selected lines

Buruchara Do you think that farmers need to be introduced earlier in your breeding process? Has your evaluation been based on farmer managed or on station conditions ?

Kimani Yes but the issue is how early I think a breeder should develop the materials initially and consult with farmers on issues of interest which he may not be sure about (e g seed types preferences) but actual testing of lines in farmers fields should come much later when the number is reduced Evaluation has been done on station We plan to test the selected lines in farmers fields under monocrop and associated cropping This will help identify which lines are suited to specific cropping systems

Otsyula Are you going to use zonal means or rely on national multi location testing only? Don't you think that if locations are very variable the means might be misleading?

Kimani The final evaluation will be based on specific agro-ecological zones to determine which cultivars are best in those areas i e specific adaptability It will be of interest to see if any of the lines have general adaptability

Opio Which isolate of *Xanthomonas campestris* pv *phaseoli* (causal agent of CBB) did you use in screening your crosses ?

Kimani We used a mixture of isolates from different bean growing areas

General discussion

P M Kimani There is on going debate whether to aim at single gene resistance or polygenic (horizontal) resistance Experience in other crops shows that polygenic resistance is more durable If lines are screened in a range of different environments we can assume that we test for durable resistance

Musaana Pathologists should isolate and culture the particular isolate (race) that has infected the donor parent Thereafter existing sources of resistance have to be screened against this particular race and if any prove resistant to it use gene pyramiding or back crossing to improve that important donor parent which has broken down

Opio From experience with BCMV CBB and now anthracnose Ethiopia seems to be very different as far as isolates of pathogens are concerned (e g necrotic strains of BCMV are present in most countries of Africa but are absent from Ethiopia some very aggressive strains of the CBB pathogen are only found in Ethiopia but not in other African countries one variety which is resistant to all races of the anthracnose pathogen is susceptible in Ethiopia) I suggest that the breeders treat Ethiopia as a special case when breeding varieties for the whole region

Sengooba It seems that much work is going on in parallel at this moment (e g crop loss studies carried out for each disease) Much time and information is lost There is a need for a closer collaboration amongst pathologists and between breeders and pathologists

Comment There are some problems of coordination and exchange of information Valuable lines are lost because they prove to be susceptible to a particular disease but other useful agronomic traits are not considered

Gridley I thought this problem was discussed before Agronomic traits are recorded the same time as diseases are scored

Musaana (Makini paper) ALS comes in very early in Uganda One hundred lines is not enough for initial screening there should be about a thousand lines I suggest you contact other countries in order to obtain more lines for screening

Mushi What is the origin of GLP 2?

Musaana GLP 2 originally came from Uganda, where it is called K20 It was released in Uganda in 1968 at F_8 stage

Buruchara Is there a need for closer interrelationships among the sub projects working on diseases?

Kirkby I suggest that this important point should be discussed in the working group on Thursday

Opio Each scientist working on a particular disease is carrying out crop loss studies Can we develop a standardized procedure/methodology to assess crop loss due to diseases at the farm level

Rono Yes but we should first screen lines at hot spots for each disease separately in order to have a base

Buruchara Diseases must first be prioritized according to importance for each environment so we have to evaluate each disease separately in order to establish the relationship between disease level and yield loss At farm level we face a mixture of diseases and the question is whether we can identify a common methodology to assess yield loss

SESSION IV INTEGRATED MANAGEMENT OF DISEASES AND PESTS

BEAN RUST IN EASTERN AFRICA RESEARCH RESULT HIGHLIGHTS 1990-1992

Habtu Assefa

Institute of Agricultural Research, Nazreth, Ethiopia

ABSTRACT

Bean rust is a widespread and economically important disease of beans in Africa A survey of farmers fields provided information on the relative importance of rust in a multiple pathosystem where other foliar diseases co exist Crop loss studies suggest the damaging potential of rust especially in susceptible entries The effectiveness of varietal mixtures in reducing disease epidemics and the variability of genotypes for components of partial resistance suggest means of future rust control strategies Future studies need to address research areas such as the effects of intercrops biological control physiologic races and performance of rust resistant entries across regions Understanding of rust epidemiology in these and other areas should form a basis for developing an effective integrated rust management strategy

INTRODUCTION

Numerous bean diseases are reported in Africa, among which bean rust caused by *Uromyces appendiculatus* has a wide geographic distribution (Wallace 1939 Leakey 1963 Howland and Macartney 1966 Edje *et al* 1973 Wamoelo 1973 Patel 1975 Allen 1983) Research information on the epidemiology of bean rust and understanding of bean rust status under farmers circumstances is badly needed

Lack of knowledge of the geographic distribution of bean rust its relative importance *vis a vis* other foliar diseases economic importance physiologic races biological control and epidemic development in varietal mixtures and in intercrops has restricted the development of resistant varieties with wide adaptation potential

Because of this a rust sub project was proposed in 1987 to understand the epidemiology and control of bean rust in Eastern Africa The major focuses of the research were foliar disease survey crop loss assessment pathogenicity analysis varietal mixtures and varietal resistance Ethiopia acted as a coordinating center and collaborating countries included Uganda Rwanda Kenya Zambia, Mauritius Zaire and Madagascar Except in Uganda, the main area of collaboration remains the bean rust regional nursery so most of the information contained in this report is from research conducted in Ethiopia Results of the 1988 and 1989 experiments have been reported elsewhere (Habtu Assefa 1990) This report summarizes results obtained from the 1990 1991 and 1992 experiments

BEAN CROP SURVEY

Surveys of bean crops and diseases were conducted in 1990 1991 and 1992 in the major bean growing areas of Ethiopia Central Rift Valley and Southern Western and Eastern Regions

The surveys revealed important differences among regions The Central Rift Valley is characterized by monomodal rainfall (June to September) and beans are cultivated as a monocrop once yearly mainly as a cash crop The dominant variety is Mexican 142 Farmers neither apply fertilizer nor weed There is a large variation in sowing date mainly depending on the timing of the first showers In this area, important diseases of beans are rust anthracnose and CBB Bean rust is found widely scattered and severity is highly concentrated In the wetter zones anthracnose is dominant but where temperatures are warmer and rainfall limiting CBB is most prevalent In areas where farmers use good healthy seed the incidence of anthracnose is greatly reduced

The southern region is characterized by a bimodal rainfall pattern and beans are grown twice each year (July October and February May) either in monocrop or association with enset maize coffee sweet potato or potato They are grown mainly for food the dominant variety being Red Wolaita Because of a good extension program farmers practise row planting weeding and fertilization which offers better yield potential (800 1200 kg/ha) However plant populations are sparse due to lack of seeds and as in the Central Rift Valley sowing dates are extremely variable depending on rainfall and preceeding crops Diseases include rust anthracnose CBB and angular leaf spot Rust is both dominant and widespread The incidences of anthracnose CBB and angular leaf spot are slight and highly scattered Red Wolaita is susceptible to all these diseases but perhaps due to the farmers practice of using healthy clean seed and weed free fields the incidences of anthracnose and CBB are much reduced

In the western areas both bush and pole beans (climbers) are grown Pole beans are traditionally grown as garden crops Bush beans are grown as monocrops or intercropped with maize or sorghum Five diseases are found associated with beans rust anthracnose CBB angular leaf spot and floury leaf spot Due to the humid conditions prevailing in the west angular leaf spot and floury leaf spot are dominant In pole beans the major disease is phoma (ascochyta) blight and is found in most gardens Scattered but slight incidence of rust is found in pole beans

The eastern highlands of Ethiopia grow beans as monocrops or intercropped with maize sorghum or chat Farmers in this region traditionally grow mixtures of beans of different seed colours and sizes Due to security problems only a limited visit was made to this region and the result obtained is only preliminary From this limited survey rust and CBB are the two diseases found widely distributed

The large variation in climate influences the level and type of disease occurring in these regions Of the six diseases mentioned in the survey report rust anthracnose and CBB are most widespread while angular leaf spot floury leaf spot and phoma blight have limited distribution restricted to western areas of Ethiopia There is also wide variation within regions attributable to crop agronomic and climatic factors Further analysis of the survey data should reveal associations among agronomic practice climatic factors and disease severities

ASSESSMENT OF LOSSES

Information on the impact of bean rust on bean crops is very limited in Africa A preliminary result on the importance of bean rust in beans in some parts of Ethiopia is given in a previous report (Habtu Assefa, 1990) This study presented the results of a single factor and critical stage analysis In 1990 1991 and 1992 field experiments were designed to incorporate other crop and disease factors to determine the relative importance of rust in a multiple factor phenomena The study was conducted at Ambo in 1990 and 1992 and at Debre Zeit in 1991 and 1992 Disease levels were manipulated by means of fungicide application at several spray day intervals Crop and disease assessments were made at weekly intervals

The results of the two field expenments ındicate that of the four yıeld components assessed seed yıelds and seed weıghts vaned most due to changes ın spray treatments Spray treatments also ınduced changes ın leaf area ındex ıntensıty of rust and other dıseases and amount of dead tıssue

At Ambo seed yıeld losses of 0 84 3% were recorded ın Mexıcan 142 and 0 29 6% ın 6R 395 The range of loss ın seed weıght was 0 16 9% for Mexıcan 142 and 0 11 5% for 6R 395 The range of seed yıeld loss ın the Debre Zeıt expenment was 0-42% The yıelds attaıned were respectıvely 156 217 and 186 g/m^2 for Mexıcan 142 and 6R 395 at Ambo and for Mexıcan 142 at Debre Zeıt

Of the four other factors studıed (LAI rust other dıseases dead tıssue) treatments had most effect on I AI and rust seventy The treatments had no sıgnıficant effect on the seventy of other dıseases and the amount of dead tıssue Overall the results suggested a possıble relatıonshıp wıth yıeld loss under both envıronments Seeds per pod was an unrelıable parameter to determıne the effects of varıatıon ın rust seventy

VARIETAL MIXTURES

The use of vanetal mıxtures ıs common ın tradıtıonal Afncan bean productıon systems The effectıveness of vanetal mıxtures ın controllıng fungal dıseases ıs well documented (Leonard 1969 Johnson and Allen 1975 Shaık 1985 Mundt and Leonard 1986) The effects of bean genotype mıxtures on the development of rust was examıned under field condıtıons ın Ethıopıa (Ambo and Debre Zeıt) and Uganda (Kawanda) ın 1990 and 1991 Due to hıgh ınterplot ınterference as a result of poor performance of the soybean guard rows data collected ın Kawanda revealed no sıgnıficant varıatıon among treatments At Ambo and Debre Zeıt outsıde ınterference was at an acceptable level and the results suggested that growıng mıxtures of resıstant (Negro Mecentral) and susceptıble (Mexıcan 142) cultıvars resulted ın a low rate of dısease expansıon and ıncrease than growıng a susceptıble genotype alone The effectıveness of vanetal mıxtures ıncreased wıth ıncreasıng levels of resıstant vanetıes ın the mıxture Mıxtures wıth less than 20% susceptıbles were always more effectıve than mıxtures wıth greater proportıons of susceptıbles

PARTIAL RESISTANCE STUDIES

Partıal resıstance (PR) a type of resıstance that causes a reduced epıdemıc buıld up of a pathogen despıte a susceptıble ınfectıon type (Zadoks and Scheın 1979 Parlevlıet 1981) can be expressed at dıfferent phases durıng the lıfe cycle of a pathogen In determınıng the rate of epıdemıc buıld up latency penod ınfectıon efficıency sporulatıon capacıty and sporulatıon penod have been used as estımates of PR ın several pathosystems

The effects of genotypes leaf age and spore densıty on latency penod ınfectıon efficıency sporulatıon capacıty and ınfectıous penod were studıed ın the bean bean rust pathosystem Fıfteen genotypes three plant ages and three spore densıtıes were compared ın a completely randomısed desıgn ın a greenhouse study at Melkassa Research Center

The study revealed wıde varıatıon ın both latency penod (LP) and ınfectıon efficıency (IE) ın response to changes ın genotypes plant age and spore densıtıes LP was ınfluenced by genotypes plant age and to some degree by spore densıty Among the 15 genotypes tested LP was 9 5 16 5 11 5 17 5 and 11 5 15 0 days respectıvely when ınoculatıons were performed 10 20 and 30 days after plantıng BAT 338 1C remaıned resıstant (no pustules were observed) under all treatment combınatıons Ex Rıco 23 (Awash 1) and A 176 recently released varıetıes exhıbıted hıgh degrees of PR by showıng much ıncreased LPs LP also ıncreased wıth ıncreasıng age of plants and decreased slıghtly as spore densıty ıncreased IEs were greatest for genotypes Ky Wonder 765 Jalısco 33 Ky Wonder 760 and Brown Speckled and least for Dıacol Calıma and ICA 15541 No rust was observed on BAT 338 1C and Ex

Rico 23 at 15 days after inoculation IE was also affected by age of plants and spore density

These results suggest the existence of considerable variation in LP and IE Differences in LP and IE among genotypes leaf ages and spore density suggest LP and IE to be important components of PR which can be used in the selection of race non specific resistant genotypes

REGIONAL NURSERY

Improvement and selection of resistant varieties form the basis of rust control strategies Since 1989 sets of bean entries have been composed and dispatched to several countries in Africa (Uganda Mauritius Rwanda, Tanzania and Zambia) for rust evaluation across different environments To date results are available only from Uganda and Ethiopia

The rust regional nursery was composed of 80 entries at Kawanda (Uganda) and 103 entries at Ambo (Ethiopia) In 1990 and 1992 there was a good disease pressure at Ambo but the rust severity was slight at Kawanda In 1991 the regional nursery was not grown in Ethiopia but in Kawanda the trial was conducted with high disease pressure In Kawanda test entries were evaluated at R5 R6 R7 R8 and R9 stages of growth 24 were resistant 43 intermediate and 13 susceptible In Ambo 40 entries were resistant 43 intermediate and 22 susceptible Varieties such as PAN 134 and BAT 448 proved resistant in both locations

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2 ' Oct

STUDY OF BEAN RUST IN MADAGASCAR
DISEASE SURVEY AND VARIETY RESISTANCE TRIAL

A Rabakoarihanta and G Rakotomalala

Centre National de la Recherche Appliquée au Developpement Rural, FOFIFA/DRA, Antananarivo Madagascar

ABSTRACT

A disease survey showed that rust was the most important disease of early and late sown beans in the main growing season of the High Plateaux Ascochyta blight was most important in mid season beans in Antsirabe and during the dry season in Anjiro Moramanga The rust reactions of 25 varieties were evaluated exposed to natural infection at four locations Rust was minor at Antsirabe but severe on susceptible varieties at Nanisana Cala and Ambatobe Several varieties exhibited minor rust in some locations Ikinimba Argentino and Goiania Precoce were rust free in all four nurseries

INTRODUCTION

It is known that several diseases affect the bean crop and constitute important constraints to bean production in Madagascar Among these diseases rust caused by *Uromyces appendiculatus* should receive special attention Substantial yield losses (18 100%) due to rust infestation have been reported in Latin America (Schwartz and Galvez 1980) Rust is widespread throughout Madagascar but its importance is not known as no study has ever carried out to evaluate the economic loss it causes Moreover its incidence and severity are influenced by season cropping system and cultivars This situation renders any study of disease assessment complicated and led us to propose a specific project which was approved by the East African Regional Bean Project Steering Commitee in 1991

The main objectives of the project were to assess and control crop damage due to rust to develop resistant or tolerant bean varieties for each bean growing region and cropping system and to identify the races of rust existing in the country

MATERIALS AND METHODS

To assess the importance of rust a survey of bean diseases was conducted in bean growing regions in the High Plateau of Madagascar and on the experimental fields of research stations Five bean diseases were considered rust anthracnose ascochyta blight angular leaf spot and root rots Diseases were evaluated using a rating scale of 1 to 6 where 1 signified very important and 6 negligible

To achieve the second objective 25 bean varieties (Table 1) were tested for their reaction to rust at four representative locations and at different times of sowing The experimental designs used were a triple lattice or a completely randomized block in three replications depending on the availability of space at each location Each plot comprised five rows 4 m long and 40 cm apart Organic and mineral fertilizers were applied at sowing time We relied on natural infection at all four locations Reaction to rust was evaluated during the developmental stages R6 (flowering) R8 (pod filling) and R9 (physiological maturity) on a scale of 1 to 9 where 1 = highly resistant and 9 = highly susceptible Classification into resistant or susceptible was based on the percent of leaf area covered by rust pustules

We were unable to work on the third objective to identify rust races existing in Madagascar as the differential cultivars and bean rust nursery sent from CIAT were not released from local quarantine

Table 1 Origins of bean varieties used in trials

Varieties	Origins
A 410	AFBYAN II
Blanc de Majunga	Local
Pintado	Brasil
Menakely	Local
Black Turtle Soup	South Africa
Bean Redlands	Collection CALA N° 35
Rosinah G2	Brasil
Gallaroy	Collection CALA N° 21
PH 14	Prospection IBPGR/FOFIFA Hauts Plateaux M/car
Lingot blanc	Local
Rouge de Majunga	Local
Zebra	South Africa
Ikinimba	AFBYAN II
Argentino	CIAT
PH 19 14	Prospection IBPGR Hauts plateaux M/car
Gratiot	Collection CALA N° 23
Goiania Precoce	Brasil
Carioca	AFBYAN II
Bico de Oro	Brasil
Ex Rico 23	AFBYAN II
Ranjonomby	Local
Small Coffee A	South Africa
Octopan	South Africa
Tsaramiananakavy	Local
Royal Red Kidney	South Africa

RESULTS

Disease survey

The relative importance of the five classes of bean diseases in eight locations is shown in Table 2 The locations situated in central (High Plateaux) and eastern areas of Madagascar can be classified into four groups according to growing period

In the first three locations of the High Plateaux (Nanisana Betsizaraina and Arivonimamo) where sowing was during the main growing season rust was the most important disease followed by anthracnose angular leaf spot and ascochyta blight

Table 2 Importance of bean diseases on experimental stations and farmers fields

Location	Disease scores[1] ANT[2]	Rust	ALS	ASC	ROT	Period observed	Varieties observed
Nanisana	5	1	5	5	6	Jan Apr 92	25 entries in variety trial
Betsizaraina	2	1	4	5	6	Dec 91 Mar 92	Menakely Lingot blanc
Arivonimamo	3	1	3	4	2	Jan Apr 92	Lingot blanc Menakely Black Turtle Soup
Antsirabe	3	5	2	1	6	Feb May 92	25 entries of variety trial
Ankazobe	6	1	6	6	6	Mar Jun 92	Lingot blanc
Ambatobe	3	1	2	5	6	Apr Jul 92	25 entries of variety trial
Ambatondrazaka Cala	6	5	6	6	6	Aug Nov 92	25 entries of variety trial
Anjiro Moramanga	3	6	4	1	6	Jun Sep 92	Local varieties

[1] 1 = very important 6 = negligible [2] ANT = anthracnose ALS = angular leaf spot ASC = ascochyta blight ROT = root rots

In Antsirabe where sowing was in the mid season (the main growing season begins in November) the most prevalent disease was ascochyta blight followed by angular leaf spot and anthracnose Rust was not important although it was observed in a few varieties In two other locations of the High Plateaux (Ankazobe and Ambatobe) where sowing was during March April rust was important The other diseases were negligible in Ankazobe but angular leaf spot and anthracnose were noticeable in Ambatobe In the eastern part of the country in CALA and Anjiro Moramanga bean was grown as an off season crop during the dry season Rust was not important but ascochyta blight was severe at Anjiro Moramanga

Variety resistance trial

The reactions of the 25 bean varieties to rust at four locations are shown in Table 3

In Nanisana eight varieties were identified as highly resistant as no disease symptoms were observed on them They were Goiania Precoce Carioca Ikinimba Argentino Royal Red Kidney Octopan Pintado and Ex Rico 23 Gallaroy and Gratiot were susceptible The variety Octopan was highly susceptible to anthracnose

Table 3 Reaction of 25 bean varieties to rust at Namsana (NNS) Antsirabe (ATS) Ambatondrazaka (CALA) and Ambatobe (ABT)

	Disease reactions[1]			
Varieties	NNS	ATS	CALA	ABT
A 410	3	1	1	1
Blanc de Majunga	3	2	1	
Pintado	2	1	3	9
Menakely	3	2	1	9
Black Turtle Soup	3	1	2	6
Bean Redlands	3	1	1	3
Rosinha G2	3	1	1	1
Gallaroy	8	1	3	7
PH 14 1	3	1	1	9
Lingot blanc anj	3	1	1	9
Rouge de Majunga	3	1	1	9
Zebra	4	2	6	9
Ikinimba	1	1	1	1
Argentino	1	1	1	1
PH 19 14	4	2	1	9
Gratiot	8	1	5	
Goiania Precoce	1	1	1	1
Carioca	1	1	1	
Bico de Oro	3	1	1	9
Ex Rico 23	3	1	1	1
Ranjonomby	4	1	1	9
Small Coffee A	4	1	1	9
Octopan	1	1	3	9
Tsaramianankavy	4	1	1	7
Royal Red Kidney	1	1	1	7

[1] 1 = absence of symptoms 3 = resistant 5 = intermediate 7 = susceptible 9 = highly susceptible
NNS = Namsana ATS = Antsirabe ABT = Ambatobe

In Antsirabe rust infestation occurred with minor severity on only four varieties Menakely Blanc de Majunga, PH 19 14 and Zebra Symptoms of ascochyta blight and angular leaf spot were observed on all varieties In CALA slight rust symptoms were observed on the variety Zebra which was thus considered susceptible There was no rust on the remaining varieties Finally in Ambatobe six varieties were found to be highly resistant to rust Goiania Precoce A 410 Rosinah G2 Ex Rico 23 Ikinimba and Argentino Bico de Ouro Lingot blanc Small Coffee A Octopan Zebra Menakely PH 19 14 and Ranjonomby were highly susceptible The variety Gallaroy was susceptible

Thus three varieties were found highly resistant at both Namsana and Ambatobe Ikinimba, Argentino and Goiania Precoce

DISCUSSION AND CONCLUSIONS

Rust appears to be the most important disease during the main growing season in central areas of Madagascar Temperature and humidity during this period favour infection by the pathogen During the dry season which runs from June to November rust was not important in CALA and Anjiro

Rust occurred on some varieties in CALA and Antsirabe but was absent from most varieties Absence of symptoms was not due to specific resistance but to unfavourable environmental conditions which inhibited the development of the rust pathogen Thus the importance of rust was dependent upon environmental conditions Such evaluation was based solely on visual observation to gain an early understanding of the importance of rust in relation to other diseases More precise estimates would be obtained from a study of yield in relation to the severity of the disease

Rust was first observed in the preflowering stage at Ambatobe on a few varieties which were later found highly susceptible but did not appear on most varieties until pod formation and pod filling The severity of symptoms was obviously dependent on the time when rust occurred

Resistant varieties were identified only in Namsana and Ambatobe where all classes of reaction were observed Also reaction of different bean cultivars was variable depending on location reflecting the variability of the pathogen

PERSPECTIVES

understand the distribution and variation of rust pathogen under field conditions in Madagascar

design control methods which may confer stable resistance to desirable bean varieties

WORK PLAN FOR THE FUTURE

identify main bean growing areas infested with rust and evaluate importance of disease

study virulence distribution for each cropping type

identify races using differential varieties provided by CIAT

screen germplasm for resistance in bean growing regions

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COLLABORATIVE RESEARCH PROJECT ON COMMON BACTERIAL BLIGHT OF BEANS

A F Opio and M S Musaana

NARO Kawanda Agricultural Research Institute, Kampala, Uganda

ABSTRACT

Studies of breeding methods and resistance of beans to common blight were conducted The nature and extent of variability of *Xanthomonas campestris* pv *phaseoli* (Xcp) its transmission and survival and yield losses associated with the pathogen were also studied Differences exist in levels of resistance between leaves stems pods and seeds on the same plant Gene action controlling resistance in most of the crosses studied was additive but was influenced by the growth stage at which data were recorded The pathogenic variation of Xcp was quantitative on *Phaseolus vulgaris* and qualitative on *P acutifolius* There were differences in Xcp transmission efficiency among bean genotypes The seed to primary seedling infection ratio ranged between 1 1 and 1 3 Fifteen species of weeds and two non host crops supported epiphytic populations of Xcp Yield losses ranged from 61 7% in susceptible genotypes to insignificant in resistants

JUSTIFICATION

Common bacterial blight (CBB) caused by *Xanthomonas campestris* pv *phaseoli* is a major disease of beans in eastern Africa It is the second most prevalent disease of beans in Uganda after angular leaf spot (Sengooba 1985) It is ranked second in importance in Malawi third in Zaire and Ethiopia fourth in Kenya sixth in Rwanda and seventh in Tanzania and Zambia

A regional sub project was initiated in 1987 to investigate different aspects of the disease in order to devise effective and economic control measures for farmers in the region The results obtained between 1987 and 1989 were reported in an earlier workshop (Musaana and Opio 1990) The present report includes research and results obtained from 1990 to 1992

OBJECTIVES

1 To study the pathogenic variation of *Xanthomonas campestris* pv *phaseoli* (Xcp) in eastern Africa

2 To continue identifying entries for the Eastern African Regional Common Blight Nursery

3 To incorporate resistance to CBB into landraces and establish quantitative differences among resistant sources with respect to susceptibility to CBB

4 To study the interrelationships between resistance to CBB and quality traits in common bean

5 To study the stages where selection in segregating populations is reliable

6 To establish the relationships between seedling and adult plant resistance and compare greenhouse and growth chamber methods for predicting field resistance

7 To determine whether there are differences among genotypes in their ability to transmit CBB with a view to selecting for low seed transmission efficiency

8 To study the survival of Xcp on weeds non hosts and infected debris and in soil

9 To determine crop loss due to CBB

RESULTS

The results will be described for each objective in the order given above

Pathogenic variation of Xcp in Eastern Africa

Ninety three Xcp isolates were collected from five countries in eastern Africa as follows Uganda (68) Ethiopia (13) Tanzania (7) Rwanda (2) and Kenya (3) The variation of the isolates was initially studied using growth characteristics on media The media used were MXP (a semi selection media for Xcp) yeast dextrose carbonate agar (YDCA) King s media B (KMB) and Nutrient Broth Yeast (NBY) KMB and NBY were used to detect the brown pigment produced by the fuscous variant (Ramos *et al* 1991)

The isolates differed in their growth characteristics on media Three quarters of the isolates collected were fuscous variants and one quarter were yellow The fuscous variants were slower growing and smaller in size than the yellow types The isolates were grouped into 15 phage types but there were no correlations among phage type pathogenicity and geographic origin

Thirty isolates were selected for testing on 20 common bean and 8 tepary bean genotypes on the basis of the contrasting environments of collection All the Xcp isolates tested induced some reaction on the 20 common bean genotypes (Table 1) There were differences in aggressiveness of the isolates There were significant (P<0 01) differences among genotypes in reaction to CBB and the isolate x genotype interaction was significant However it was not possible to group the isolates according to bean genotypes The type of reaction induced on the 20 common bean genotypes was different for each of the 30 isolates under similar environmental conditions

Two types of reaction were noted on leaves of tepary bean a compatible reaction where there was water soaking followed by necrosis and an incompatible reaction where there was no visible response to some isolates Based on these results the 30 Xcp isolates were arranged in seven groups (Table 2) The results obtained indicate a quantitative relationship between Xcp and common bean and a qualitative relationship between Xcp and tepary bean

Table 1 *Xanthomonas campestris* pv *phaseoli* isolates grouped according to the leaf reactions of eight genotypes of *Phaseolus acutifolius*

	Phaseolus acutifolius genotypes								
Isolates	T1	T5	T8b	T19	T21	T22	PI 321 638	L242-45	Group
1005	R	R	R	R	R	S	R**	R	1
1010									
1032									
1069									
1024	R	R	R	R	S	R	S	R	2
1048									
1073									
1034	S	R	R	R	R	R	R	S	3
1038	R	I	R	I	S	R	S	R	4
1067									
1065	R	I	R	R	R	S	I	R	5
1068	R	R	R	I	S	R	S	R	6
1083									
Remaining isolates[b]	R	R	R	R	R	R	R	R	7

= leaf reactions R = immune R** = tolerant (<0 5 1 4 mm water soaked area around the cut) I = intermediate (1 5-4 4 mm water soaked area around the cut) S = susceptible (4 5 >7 mm water soaked area around the cut) [b] 17 isolates which induced no reaction on any of the eight genotypes of *Phaseolus acutifolius* were 1046 1040 1042 1030 1029 1096 1090 1011 1112 1099 1033 1074 1066 1002 1007 1026 and 1043

Eastern African Regional Common Bacterial Blight Nursery (EARCBBN)

The EARCBBN is composed of bean lines that are resistant to CBB in the region The present nursery includes 70 entries from Ethiopia, Uganda Kenya Tanzania Rwanda Burundi and Malawi In 1991 the nursery was evaluated in Uganda Rwanda and Ethiopia In 1992 it was evaluated in Rwanda Ethiopia, Tanzania Zaire and Kenya Results have not been received from Tanzania and Zaire

Lines in this nursery can be utilized by breeders in national programems for improving resistance to CBB The breeder has utilized some of the lines in this nursery to improve the resistance of acceptable bean varieties from Uganda, Ethiopia Rwanda and Tanzania The entries will be changed periodically depending on the availability of new genotypes resistant to Xcp

Transmission efficiency

Ten elite bean breeders lines from different countries in eastern Africa and the five most aggressive Xcp isolates (Opio 1991) were used for this study The bean lines included K20 RWR 136 239 B b 1 GLP 585 2439 B b 1 Awash 1 Cal 96 Roba 1 ICA Linea 64 and MCM 585 Kasuka Nywele and Kanyebwa were susceptible controls and XAN 112 was a resistant control The Xcp isolates were 1068 1073 1069 1010 and 1029

There were sigmficant differences (P<0 05) among genotypes in their ability to transmit Xcp from seed to seedling Kasuka Nywele showed the largest number of infected seedlings Among test lines K20 showed the highest number of infected seedlings followed by RWR 136 2395 B b I GLP 585 2439 B b I Awash 1 Cal 96 Roba 1 and ICA Linea 64 in that order All seedlings from MCM 5001 and XAN 112 were healthy

These results indicate that genotypes like MCM 5001 and XAN 112 which have resistance to seed transmission can be utilized by breeders to develop bean lines resistant to both CBB infection and seed transmission

Table 2 The number of genes controlling resistance in beans to Xcp derived by two methods from various crosses

Cross	of analysis	Number of Genes V3	R6	Pods
K20 x Jules	M	2(1 3 1)	2(1 3 1)	2(1 3 1)
	S	2	2	2
K20 x PI207262	M	P*(31 17 1)	P*(20 10 1)	P*(36 71 1)
	S	3	1	1
K20 x IAPAR 16	M	2(1 3 1)	2(1 3 1)	2(1 3 1)
	S	2	2	2
K20 x BAC 6	M	P*(1 7 1)	P*(1 15 1)	P*(8 10 1)
	S	3	2	2
ZPv 292 x Jules	M	P*(9 13 1)	P*(7 6 1)	P*(6 15 1)
	S	4	2	2
ZPv 292 x PI207262	M	P*(38 70 1)	2(1 3 1)	2(1 3 1)
	S	2	1	1
ZPv 292 x IAPAR 16	M	P*(8 14 1)	P*(9 20 1)	P*(6 17 1)
	S	2	2	2
ZPv 292 x BAC 6	M	P*(75 76 1)	P*(10 17 1)	P*(3 20 1)
	S	3	3	2
IAPAR 16 x PI207262	M	P*(1 65)	P**(7 13 2)	P**(6 14 3)
	S	1	1	1
IAPAR 16 x BAC 6	M	2**(1 3 1)	2(1 3 1)	1(3 1)
	S	1	1	1

P* = polygenic inheritance P** = transgressive segregation observed M = Mendelian S = Stanisfield V3 and R6 = vegetative and reproductive growth stages

Survival of Xcp on weeds and non-host plants

Survival of Xcp in infected bean debris soil weeds and non host crops was investigated at Kawanda Research Station and Bukalasa experimental farm from April 1990 to October 1992 It was found that Xcp could survive in infected debris soil and weeds for several months in the absence of a bean crop The population dynamics of Xcp was governed by the movement of the bacterium from infected debris to the soil Crop rotation resulted in reduced Xcp populations in the absence of a bean crop Fifteen species of weeds and two non host crops supported epiphytic populations of Xcp No weed supported epiphytic populations of the bacterium seven months after harvesting beans

Assessment of yield losses caused by common bacterial blight

Field experiments were conducted at Bukalasa experimental farm in Uganda for three growing seasons (March June 1990 August Novemeber 1990 and March June 1991) to determine the yield losses caused by CBB in common bean

Different levels of disease were generated by using three chemical treatments three bean genotypes differing in susceptibility and three seed symptom catergories The chemicals used were cupric carbonate cupric sulphate and water as a control The three genotypes were Kanyebwa (susceptible) K20 (intermediate) and XAN 112 (resistant) The three seed symptom categories were severely diseased slightly diseased and symptomless The experimental design was a split plot with four replications The chemicals were the main plots and varieties and categories of seed were the subplots

The bean yield losses associated with CBB varied with the susceptibility of the genotype and stage of growth Losses in the susceptible genotype Kanyebwa ranged from 26 6 to 61 7% at pod filling Losses in the tolerant genotype K20 ranged from 6 2 to 7 8% at pod formation The resistant genotype XAN 112 suffered no significant yield losses at any stage of growth

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EFFECTS OF CULTURAL AND VARIETAL COMPONENTS IN INTEGRATED MANAGEMENT OF ROOT ROTS OF BEANS IN RWANDA

R Buruchara, U Scheidegger and L Sperling

CIAT ISAR Rubona Butare Rwanda

ABSTRACT

Root rots are among the principal diseases that limit bean production in Rwanda These diseases caused by soilborne pathogens are better controlled using an approach whereby management components which are complementary are applied in an integrated manner since no single component is entirely effective Studies to evaluate the effects of some of the potentially useful cultural and varietal components in the management of root rots were conducted under on farm and on station conditions during seasons A and B of 1991 and 1992 Cultural practices tested were use of raised beds/ridges and different types of organic amend ments The varietal reactions of several entries were determined under field conditions Incorporation of leucaena leaves and twigs as green manure two weeks before planting resulted in reduced plant mortality and severity of root rots and increase in yield However the relative effects were more marked in 1992A when conditions (high rainfall when the crop is at seedling stage) favoured severe root rot infection Besides green manures of leucaena appeared to contribute to the nutrition of the plants possibly enhancing their tolerance to root rots Similarly ridges were effective in reducing plant mortality and increasing yields only in 1992A Raised beds evaluated in 1991A and B and ridges in 1992B showed no significant effects due to lower rainfall early in the seasons A number of breeding lines were identified as resistant to high pressures of pythium and rhizoctonia root rots

INTRODUCTION

In the past few years the importance of root rots has increased in the Great Lakes Region of Central Africa particularly in Rwanda (Trutmann and Graf 1988) The diseases have been associated with five or more fungal pathogens which occur singly or in a complex (Rusuku 1991) Use of a single control measure is not effective so it is advisable to consider a combination of different control methods in an integrated approach

Certain cultural practices influence the severity of root rots Some of the practices create unfavourable conditions for pathogen development and survival leading to reduction in inoculum levels lack of disease development or promotion of plant growth and vigour so that plants become tolerant to infection despite the presence of the pathogen Growing of beans on raised beds or ridges for example has been shown to reduce the severity of root rots caused by *Pythium* spp (Abawi and Pastor Corrales 1990) In some areas of northern Rwanda and in valley bottoms certain crops including beans are grown on raised beds principally to ensure good soil drainage Similarly use of leucaena green manure has been shown in screenhouse trials to reduce severity of root rots and promote plant growth and vigour (Buruchara 1991) The objectives of these studies were to evaluate the effectiveness of certain cultural and varietal components which may be used in the management of root rots

MATERIALS AND METHODS

On station and on farm trials were conducted concurrently to evaluate the effects of raised beds ridges and different types of organic amendments applied as green manures on the severity of root rots On station trials were conducted at the experimental farm of the Universite National du Rwanda (UNR) Butare which has a history of root rot problems while on farm trials were conducted in Runyinya commune (about 9 km west of Butare) where root rots are a problem and soil fertility is poor Farmers perception of root rot problems and choice of management options to be tested on farm were agreed upon in meetings with farmers

Organic amendments

Leaves and twigs of leucaena (*Leucaena leucocephala*) were incorporated in the soil as green manure 10 14 days before planting following the beginning of rains Initially (1991A and B seasons) green manures were applied at a rate of 20 t/ha fresh weight Subsequent evaluations (1992A and B seasons) were based on reduced levels of 5 and 10 t/ha Other sources of organic amendments such as calliandra sesbania wattle bark grass weeds and decomposing coffee pulp were also evaluated in on station trials

Raised beds and ridges

The effects of planting on raised beds 1 m wide and about 30 cm high was evaluated during the 1991A and B seasons Planting was at random as commonly practised by farmers using a plant density of approximately 250 thousand plants/ha Later (1992A and B) planting on ridges about 20 cm high and 50 cm apart was also evaluated In the latter planting was done in rows

Varietal reactions

About 100 entries (bush and semi-climbers) of advanced breeding lines contributed by the national programme of the three countries in the Great Lakes Region to form a nursery called PRELAAC 5 were evaluated at Rubona under high root rot pressure mainly from *Pythium* and *Rhizoctonia* spp

RESULTS AND DISCUSSION

Organic amendments

In both on farm and on station trials organic amendments (20 t/ha) significantly reduced root rot severity and increased yields during both seasons of 1991 without influencing seedling emergence or plant stand In on station trials a yield increase of 43% over the control was obtained in 1991A and 60% in 1991B However overall yields were greater in 1991A than 1991B mainly due to higher pressure from foliar diseases in the latter season

In 1992A root rots were very severe nationwide resulting in significant bean crop losses On farm trials conducted during the season showed that 5 t/ha of leucaena significantly ($P<0\ 05$) reduced plant mortality due to damping-off (V4 and R6 growth stages) and severity of root rots in local mixtures Rates of 10 t/ha of leucaena significantly reduced plant mortality and disease severity and resulted in a yield increase of 128% (Table 1) Application of 5 t/ha leucaena showed a better yield response on variety RWR 221 (364 kg/ha) than on the local mixture (99 kg/ha) On the other hand increasing the rates from 5 to 10 t/ha gave a better yield response on the local varietal mixture (503 kg/ha) than on RWR 221 (189 kg/ha) Since RWR 221 is resistant to root rots the effect of organic amendment appeared to be in improving soil fertility However a relatively better response by RWR 221 than the local varietal mixture at 5 t/ha of organic amendment used were probably due to its tolerance of poor soil fertility The local varietal mixture gave better and significant responses with 10 t/ha of organic amendments

Table 1 Effects of variety and organic amendments (Leucaena) on the severity of root rots and yield in on farm trials at Runyinya 1992A

Varieties	Organic amendment levels (t/ha)[1]	% plant loss[2] V4	% plant loss[2] V6	Disease severity[3]	Yield (kg/ha)	Yield advantage % of LM 0	Yield advantage % of RW 0
Local mixture	0	42 1a	47 5a	38 2a	467a		
	5	34 6ab	37 1b	28 2b	566a	21	
	10	30 6b	31 6b	16 8c	1069b	128	
RWR 221	0	13 4c	14 4c	17 5c	1470c	215	
	5	12 9c	13 3c	11 5cd	1835cd	293	25
	10	9 3c	10 9c	6 6d	2033d	335	38
CV(%)		35 6	37 4	40 4	35 6		
LSD		7 6	8 6	8 1	381		

LM = local mixture RW = RWR 221 (resistant to root rots) [1] = Leucaena applied as green manure 10 days before planting [2] = plant loss at V4 and R6 expressed as % of seed sown [3] = disease severity as % hypocotyl and root tissue covered with lesions means followed by the same letter in a column are not statistically different ($p<0\ 05$) according to Duncan s Multiple Range test

Results obtained in on station trials (over two seasons) also showed that calliandra and sesbania significantly reduced severity of root rots and increased yields compared to the control Decomposing coffee pulp had non significant effects on yield in one season apparently depending on extent of decomposition Grass weeds gave varied response depending on their constituents Wattle bark leaves and decomposing organic matter from banana leaves gave no positive effect over the control

These results demonstrate that leucaena green manure has an effect in reducing severity of root rots and improving yields and confirms previous observations made in greenhouse trials (Buruchara 1991) It is thought that the effects of the leucaena may be due to increased microbial activity and improvement of nutritional status resulting from its decomposition

Leucaena was the organic amendment most appreciated by collaborating farmers during all the seasons tested Desirable attributes cited were 1 reduction of loss of plants due to root rots 2 increase in yield 3 increase in vegetative growth (for leaf consumption) and 4 positive residual effect on sorghum grown after beans The main constraint cited was availability of sufficient quantities but farmers showed interest to produce the green manure as hedgerows or on contours

Raised beds and ridges

Raised beds had no effect on disease severity or yield in 1991A and B in either on station or on farm trials As a result farmers did not consider them useful options in the management of root rots They also regarded their high labour demands as additional disadvantages This was the basis for modification and subsequent testing of ridges In on station trials raised beds significantly improved dry matter production

The effect of ridging was apparent in 1992A when rainfall was heavy during the seedling stage and root rots were severe Plant mortality due to damping-off of the local varietal mixture was reduced by about 40% at both V4 and R6 stages and yield was increased by 139% (Table 2) The advantage of using ridges with the resistant variety RWR 221 was small (7%) In 1992B the rains were relatively poor and there was no effect of ridging on disease severity and yield

Table 2 Effect of variety and ridging on severity of root rots and yield in on farm trials at Runyinya 1992A season

		% plant loss								Yield advantage	
						Disease		Yield		(% LM with	
		V4		V6		severity		(kg/ha)		out RD)	
Varieties	Treatment	92A	92B	92A	92B	92A	92B	92A	92B	92A	92B
Local mixture	RD	46 5	11 4	51 0	34 6	38 9		390	672		
	+RD	28 0	10 4	30 2	28 2	16 0		935	737	139	9
RWR 221	RD	12 8	10 4	13 7	19 6	18 0		1670	1620	328	141
	+RD	7 1	8 3	7 8	19 1	9 7		1786	1562	358	132
CV(%)		33 5	27 9	32 3	37 6	32 9		35 9	35 4		

LM = local mixture RD = flat +RD = ridged [1] = plant loss at V4 and R6 expressed as % of seed sown [2] = disease severity as % hypocotyl and root tissue covered with lesions = paired treatment means significantly different (p<0 05) according to Duncan s Multiple Range test

The effects of planting on ridges were however appreciated by all participating farmers during 1992A The method was similarly considered laborious and its effects were not consistent in the two seasons Due to seasonal variation in rainfall amount farmers considered ridges useful in periods and areas of high rainfall or in plots and areas prone to be waterlogging

Raised beds (1991A and B) and ridges (1992B) had non significant effects on disease severity and yield because conditions were not ideal for the development of damping-off pathogens such as *Pythium* and *Rhizoctonia* spp during the early and critical stages But during season 1992A ridging had a significant effect both on disease severity and yield indicating that ridging is useful in root rot infested soils associated with high moisture or during seasons of heavy rainfall

Varietal components

During the 1992A season 100 entries of PRELAAC 5 were evaluated at Rubona under high root rot pressure mainly from *Pythium* spp and *Rhizoctonia solani* The reactions of entries varied widely ranging from very susceptible to very resistant Among the resistant entries were MLB 10 89B MLB 13 88B MLB 17 88A MLB 36 89A MLB 38 89A MLB 39 89A MLB-40 89A MLB 42 89A MLB-43 89A MLB-47 89A MLB-48 89A MLB-49 89B contributed by the national bean programme of Zaire RWR 432 and RWR 719 contributed by Rwanda and EM 1616 EM 22/20 SCAM 80 CM/15 and MORE 90026 contributed by Burundi Susceptible varieties showed high plant mortality (80 95%) and lesions covering the hypocotyl whereas resistant varieties had very little plant mortality (14%)

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STUDIES OF THE CONTROL OF THE BEAN BRUCHIDS *Acanthoscelides obtectus* (Say) AND *Zabrotes subfasciatus* (Boheman) BRUCHIDAE COLEOPTERA IN EASTERN AFRICA

M Nahdy Silim

National Agricultural Research Organization
Kawanda Agricultural Research Institute Kampala Uganda

ABSTRACT

Bean bruchid research in eastern Africa was initiated with CIAT assistance in 1990 to complement studies being conducted elsewhere in Africa Bruchid distribution was studied and findings presented in the bean research workshop (1990) in Nairobi Farmers perceptions of bruchid damage and control were investigated in representative agro ecological zones of Uganda

A line of *Phaseolus vulgaris* (RAZ 2) bred for resistance to *Z subfasciatus* showed significantly fewer insects emerged and less seed damage and weight loss than local susceptible varieties Two methods of solar disinfestation (direct exposure to sunlight T1 and enhanced heat T2) were compared on beans infested with *Acanthoscelides obtectus* There was a high build up of temperature and greater adult mortality in T2 In T1 there was 100% adult escape There was no significant difference in total adult emergence between the two treatments after an incubation period of five weeks Low adult emergence in T2 was attributed to higher kill due to solar heat and in T1 to the exclusion of adults and eggs

Repeated sieving of stored beans every five days for a period of 50 days gave excellent control of *A obtectus* The seeds of five of the 25 legume species collected within Uganda were capable of being infested by *A obtectus* They were cowpea tepary beans pigeonpea and two species not yet identified The hues and patterns of the pygidium were found to provide an accurate and easy method of separating *A obtectus* males from females

In 1992 a bean bruchid travelling workshop and survey involving scientists from all three regions was conducted in Uganda Tanzania and Zimbabwe in collaboration with the bean research network of CIAT in Africa This was with the aim of investigating distribution patterns damage levels and control methods for the two bruchids to determine farmers perceptions of bruchid damage and to collect germplasm

INTRODUCTION

The bruchids *Acanthoscelides obtectus* and *Zabrotes subfasciatus* are the two most important pests of stored beans in Africa They cause damage weight losses and reductions in quality and seed viability Loss levels in eastern Africa have been estimated at between 30% and 73% (Karel and Khamala 1978) In Uganda levels have been estimated to be 3 and 8% weight loss in storage durations of 3 and 6 months respectively (Silim *et al* 1991)

A obtectus has been found to be the predominant species in cooler regions and *Z subfasciatus* the commonest species in warmer environments (van Schoonhoven and Cardona 1986) Infestations by *A obtectus* begin in the field and intensify in storage *Z subfasciatus* infestations often begin in storage (Silim 1990) *A obtectus* oviposits on pods under field conditions while on grains eggs are laid loosely among the seeds *Z subfasciatus* glues the eggs to the grains

Insecticides are the most publicized method of bruchid control but are mostly unavailable to or unaffordable by subsistence farmers In addition dust formulations have limited shelf life and are prone to user abuse Other control methods include bean resistance coating with oil and bean tumbling (Quentin *et al* 1991) Coating with oil and bean tumbling though successful experimentally may have limited adaptability due to their cost and inconvenience respectively Alternative safe and reliable on farm control methods are needed Research has therefore been focused on control practices found at on farm levels including solar heat treatment bean sieving and the use of locally available protectants

FARMERS' PERCEPTIONS OF AND CONTROL OF BEAN BRUCHIDS IN UGANDA

Materials and methods

A survey was conducted to investigate farmers perceptions of bruchid damage and control methods used and assess damage/loss levels 130 farmers in nine representative districts in the four agro ecological zones of Uganda were selected for the survey A questionnaire was prepared for farmers responses Bean samples (500 g) were collected for analysis of damage weight loss and species identification

Results and discussion

The majority of the respondents were males in the age range of 20 to over 50 years and have been growing beans for 10 to over 30 years depending on age Though two growing seasons were identified in all bean growing areas 34% of the farmers (mostly in Agro-ecological Zone III) grew bean in only one season Bean production per family ranged between 50 and 300 kg per season Harvested beans were sun-dried and threshed Bean seeds were redried and stored for home consumption seed or sale Storage durations were 1-4 months (41%) 5 8 months (50%) and up to one year (90%) Bruchids were identified as the main storage concern Most farmers (56%) thought that some bean varieties are more susceptible to bruchid infestation than others Smaller seeded varieties were considered more resistant

The commonest bruchid control strategy used by farmers was sun drying for redrying and heat disinfestation Reinfestation after solar heat treatment was considered rapid Other bruchid control media used included tobacco leaves wood ash banana juice and red pepper Some 27% of farmers thought nothing could be done to control bruchids The only method considered very effective was chemical control Among the chemicals used were Actellic Malathion DDT and various other non storage insecticides Most traditional methods were considered ineffectual and had other problems associated with their use such as difficulties in cooking eating and cleaning

RESISTANCE TRIALS ON *Z subfasciatus*

Materials and methods

Four bean varieties were tested (RAZ 2 EMP 175 K20 and White Haricot) Seeds were equally infested with four sexed pairs of newly emerged insects and incubated for four months

Results and discussion

Results clearly indicated that there were highly significant differences among varieties in terms of adult emergence Adult emergence from RAZ 2 was negligible after four months (Table 1)

Table 1 Storage test results Uganda 120 days after infestation

Variety	Total number of adults emerged[1]	% bean damage[2]
K20	1029 8 (6 94)	16 4 (0 41)
RAZ 2	9 6 (2 26)	0 0 (0 00)
White Haricot	1173 6 (7 06)	16 0 (0 37)
EMP 175	740 0 (6 60)	4 4 (0 20)

Figures in parentheses are log[1] and arcsin x 100[2] transformations

Tests in Uganda confirm that RAZ 2 is highly resistant to *Z subfasciatus* and the degree of resistance is consistent with previous laboratory assessments (Cardona *et al* 1990) The resistance of RAZ 2 therefore provides adequate protection against *Z subfasciatus* and can be recommended for use in situations where conventional pest control procedures can not be utilized

SOLAR HEAT DISINFESTATION OF BEANS

Materials and methods

Equal batches of beans (K20) were infested with 40 pairs of *A obtectus* Two incubation treatments were imposed incubation for 20 days and all insects removed and incubation for 7 days and no adults removed The solar heat treatments were exposure to direct sunlight (T1) exposure to sunlight covered (top) with clear polythene and (bottom) with black polythene sheet (T2)

Trays were placed in the sun and seed temperatures recorded at hourly intervals Total and live/dead adults were counted at weekly intervals for five weeks

Results and discussion

Temperatures of 65 and 64 were recorded in T2 while the highest recorded temperature in T1 was 45 5°C After five weeks all adults in T1 had escaped while in T2 90 2% had died Only 5 6% mortality was recorded in the control (Table 2)

Table 2 Mortality of *A obtectus* in two solar treatment methods

Treatment	T0 (control)	T1	T2
Adult mortality (%)	5 5	0[a]	90
Escapes (%)	0	100	0

T0 = control all escaped

After 5 weeks incubation mean adult emergence was 16 7% in T1 15 8% in T2 and 100% in control

Two factors were suspected to be responsible for the overall reduction in *A obtectus* emergence in T1 and T2 direct mortality due to solar heat in T2 and the exclusion effect whereby adults escaped due to heat and sun glare while at the same time eggs loosely laid among the beans were naturally sieved off This suggests that both the direct killing effect of the sun and the exclusion effect due to sieving could play roles in the control of *A obtectus*

BEAN SIEVING - A CONTROL METHOD FOR *A obtectus*

The effect of sequenced sieving of beans were investigated in K20 infested with *A obtectus* The beans were sieved at seven day intervals for a period of 49 days

Results and discussion

The results clearly demonstrate that sieving provides total control of *A obtectus* irrespective of duration of storage and previous infestation (Table 3) Very severe damage was recorded in unsieved beans Repeated sieving of beans drastically reduces bean damage by *A obtectus* The method would be ideal for small scale subsistence farmers where coffee drying trays are available

Table 3 Percentage of seeds of K20 damaged by *A obtectus* at two pre and two post treatment storage durations following light and heavy infestation with and without sieving

Storage period (days)	Infestation: Light[1]		Heavy[2]	
	Unsieved	Sieved	Unsieved	Sieved
0	0 00d	0 00d	9 26cd	8 75cd
50	0 40d	0 02d	62 70b	13 62c
110	7 67cd	0 02d	69 67b	13 47c
170	60 40b	0 05d	88 80b	13 57c

[1] initial light infestation of stored beans none pre storage [2] initial heavy infestation of stored beans 50 days pre storage means followed by common letter do not differ significantly at P<0 05 according to Duncan s Multiple Range Test

Sequenced bean sieving is most successful where eggs are laid loosely in the grains adults live outside the grains and where the biology of the pest is accurately known Even where such criteria are not absolutely met a certain amount of damage could be avoided by sieving at regular intervals Combined with appropriate solar disinfestation sieving could considerably extend storage durations by reducing rate of bean damage by *A obtectus*

OTHER CONTROL METHODS

Other control methods currently being investigated include the use of agents such as *Gynandra gynandropsis Melia azdrach* and shea butter oil

ALTERNATE HOSTS OF *A OBTECTUS*

Materials and methods

Seeds of suspect host plants were collected throughout Uganda The species collected were *Macroptilium atropurpureum M lathyroides Lablab purpureus L niger Centrosema pubescens*

Crotalaria incana Cajanus cajan Cassia spectabilis C tora C grandis C petersiana Desmodium lassiocarpum Bauhinia punctata Leucaena leucocephala Caesalpina pulcherrima Piliostigma thonningii Acacia elata Rhynchosia spp *Glycine javanica* tepary beans *Vigna unguiculata* and two yet unidentified legume species The legume seeds were allowed to incubate for one month and insect emergence noted then infested with eggs of *A obtectus* They were allowed to incubate until adult emergence

Results and discussion

In most seeds the larvae died soon after penetration In two legume species *M atropurpureum* and *M lathyroides* there was larval development but due to the small size of the seeds food supply was exhausted and most larvae/pupa died within 28 days A few adults emerged but they were very small and died soon after emergence Complete development of insects and adult emergence were noted in *C cajan V unguiculata* tepary beans and the two unidentified species Alternate host plants of *A obtectus* were therefore found among legume species already domesticated by man

A METHOD OF SEXING A obtectus

Material and methods

The significance of the hues and colours and density and patterns of bristles on the pygidium of *A obtectus* adults was investigated Adult populations with brown pygidia (Variation 1) were separated from populations with brown and grey patterns on the pygidia (Variation 2) and sexed using male genitalia

Table 4 Sex of insects exhibiting pygidium variations

	Variation 1		Variation 2	
Operator	Males	Females	Males	Females
1	33	2	2	62
2	54	1	0	45
3	49	0	0	51
4	49	2	1	48
Total	185	5	3	179
Percentages	97 4	2 6	1 4	98 6

Results and discussion

The dissections indicate that the variations in the hues and patterns of coloration on the pygidium are clear forms of sexual dimorphism that will aid sexing of *A obtectus* males exhibiting Variation 1 and females Variation 2 (Table 4)

TRAVELLING WORKSHOP AND SURVEY

In collaboration with SADC Great Lakes and CIAT scientists a travelling workshop was organized and undertaken in Uganda Tanzania and Zimbabwe in September 1992 It included entomologists agronomist and breeders from CIAT Uganda Tanzania Burundi Zimbabwe and Ethiopia

The aim of the survey was to investigate farmers perceptions of bruchid damage and control determine actual damage levels and species composition and collect germplasm The results are being compiled

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SURVEY OF THE PESTS AND CURRENT CONTROL MEASURES OF MAJOR PESTS OF FRENCH BEANS

J H Nderitu and J.J Anyango

Department of Crop Science University of Nairobi Nairobi, Kenya

ABSTRACT

A survey was conducted in 99 of about 1000 French bean farms in Mwea Division in Kirinyaga District The survey was carried out mainly to determine the pest problems and their solutions in farmers fields and the rates and frequency of application of pesticides on bean farms For various reasons knowledge of how to spray use of protective clothing use of pesticides for specified pests proper rates of application formulations and concentrations are either little or at all applied by farmers The survey is discussed in detail

INTRODUCTION

French beans (snap beans) is one of the major horticultural export crops of Kenya In 1989 10 thousand ha were under French bean cultivation producing a total of 20 thousand t of fresh beans of which 15 thousand t were air freighted to Europe earning the country US$ 600 thousand (Anon 1991a) The same amount of French beans was exported to Europe in 1991 and 1992 (Anon 1993) While there is an increasing demand for French beans by the processing industry local demand for fresh beans is relatively limited They are normally grown off season under intensive irrigation during the peak export period in the months of September to April

Various workers have identified pests as one of the major production constraints of common beans The main pests of French beans in order of their economic importance are bean stem maggots *Ophiomyia* spp flower thrips *Megalurothrips sjostedti* (Trybom) bean aphid *Aphis fabae* (Scopoli) red spider mites *Tetranychus* spp African bollworm *Helicoverpa (Heliothis) armigera* (Hb) whitefly *Bemisia tabaci* (Gen) leaf miner *Liriomyza trifolii* (Burgess) and spiny brown bugs *Clavigralla (Acanthomia) horrida* (Germ) and *C tomentosicollis* (Stal) (Anon 1991a, 1991b) There is some available information on the survey biology and control of *Ophiomyia* spp *Aphis fabae* *Megalurothrips sjostedti* *Helicoverpa armigera* and *Tetranychus* spp Present measures of controlling pests on French beans mainly involve use of insecticides The ineffectiveness of chemical control of some pests and the damage of some chemicals as residues of French beans and to the environment have been reported by the farmers and consumers The objectives of the survey were to describe and evaluate the current use of pesticides in French bean production

MATERIALS AND METHODS

Area of study

The area of study was Mwea Division in Kirinyaga District The area of the division is 1161 square km The division has four locations namely Tebere Murinduko Nyagathi and Mutithi The area is a lower midlands (LM_4) zone with a mean temperature range of 22 0 21 2°C (Jaetzold and Schmidt 1983) The soil is mainly black cotton which is moderately fertile The agricultural land per household of 5 8 persons is about 3 8 ha which is marginal in this area Normally the first rains start at the end of March and the second rains at the end of October

Surveys

The survey was carried out in 99 of the 1000 French bean farms in Mwea Division Kirinyaga District It was conducted mainly to determine the pest problems and their solutions in farmers fields the types of pesticides and their rates and frequency of application on bean farms Other information collected was on how to spray use of protective clothing use of pesticides for specified pests proper rates of application formulations and concentrations The data collected were analysed using a statigraphic computer package The information is presented as piecharts graphs and percentages

RESULTS

General observations of crop production with emphasis on French beans

The main crops grown in the area are maize sorghum millet cowpea, bean chickpea, green pea greengram soya bean dolichos bean sweet potato and pigeonpea The major cash crop in the area has been cotton while rice is grown under irrigation Maize and dry beans are the most important subsistence crops The yields of dry beans range from 569 to 896 kg/ha in monocrop and 318 to 512 kg/ha in intercrop with maize It is recognized that it will only be possible to cope with population growth if both intensification of and innovations in agriculture (e g cultivation of improved varieties) can be successfully introduced to local farmers Horticultural crops such as French beans and tomatoes have been successfully introduced in the last ten years

The production of French beans is mainly in Tebere Mutithi and Nyagati locations of Mwea Division French bean farming started in the area in 1982 and has continued expanding since that time At any one time the area of French beans is 250 ha with a production of 1 500 t at a yield of 6 t/ha There are about 1 000 French bean farmers with an average of about 0 2 ha ranging from a few square metres to about 5 ha Most farmers are small scale growing less than 0 5 ha of horticultural crops

Farmers use mainly draught animals for ploughing French beans are grown throughout the year solely for export They are grown under rainfed conditions during the long and short rainy seasons and under furrow and sprinkler irrigation during dry periods of the year Of farmers who irrigate 50% use furrow irrigation and 5% use sprinkler irrigation Irrigation water is from rivers originating from Mt Kenya and converging in this lowland area Most farmers grow French bean under rainfed conditions although they are not very marketable during the period There are no well-organized marketing systems and the farmer has to negotiate prices with middlemen who then sell the produce to exporters

Farmers apply recommended husbandry methods and use fertilizer new seeds and plant protection methods in French bean production The adoption rate for the use of pesticides on French beans is very high The cost of pesticides is continuously increasing and the proper use of pesticides has to be emphasized to minimise the cost of production Farmers experience a number of problems during the production of French beans Knowledge of how to spray use of protective clothing use of certain pesticides for specified pests proper rates of application formulations and concentrations is rarely applied by farmers either due to ignorance or its limitations There is already a GIFAP project in the area to train agricultural extension officers and farmers in the proper use of pesticides Although it is illegal under the Pest Control Products Act to prepackage a pesticide product this is normally done by stockists in the area There is a high level of adulteration of pesticides during prepacking by addition of non active ingredients Stockists are also known to make a concoction of a product with no active ingredient but labelled and marketed as a popular pesticide Therefore although there are general complaints of ineffectiveness of some pesticides for control of certain pests it is difficult to prove in the field whether such complaints are genuine because the pesticides may be adulterated or may not have been used for the recommended pest but as a general pest control The cheapness of a pesticide and its availability is often all that causes a farmer to use it on his crop Farmers did not mention consistently a certain pesticide being effective against a particular pest While some farmers mentioned how ineffective a certain pesticide was against a particular pest others observed that it was the most effective

Pesticides from neighbouring countries have often been stocked in shops in the area There are pesticides provided to those countries by donors as aid Such pesticides include Ambush from Uganda and Tanzania and Selecton and Kocide for control of cotton and coffee pests in Tanzania With the popularity of Ambush farmers have often been provided with an adulterated product which has no Ambush active ingredient Furadan granules provided to farmers by the National Irrigation Board for rice production have been applied to French beans as a foliar spray or seed dressing or by drenching the ground around bean seedlings immediately after germination Farmers claim that they use smaller quantities of Furadan granules when they spray than when they apply to the soil Furadan is very expensive and that is why farmers have resorted to such methods of application However such methods should be discouraged because of toxicity to the farmer

Farmers knowledge of pesticides is very good Most farmers are young people who have either been to primary or secondary schools or agricultural colleges On some occasions as contracted farmers they have been advised on pesticides to use Through use of different pesticides over time each has identified his own pesticide package which he considers effective It is difficult to obtain the same opinion on the effectiveness of a pesticide from many farmers Only a few farmers monitor pests and spray according to the pest population Most young farmers are very knowledgeable about pests and often describe them by their common names and by the nature of the damage they cause

Most farmers felt that the pesticides they are spraying are unable to control whiteflies and *Acanthomia* While whiteflies infest the crop throughout the growing period *Acanthomia* infests the crop during flowering and podding Most farmers are pest doctors who prescribe pesticides whenever they see even a very low population of a pest or no pest in the crop In most cases the prescriptions are wrong and they use the wrong pesticides

Surveys

The crops grown by the farmers in Mwea Tebere in order of their importance were French beans maize tomato vegetables and dry beans 42 4% of farmers had successive plantings of French beans in their farms while 57 6% had single plantings Most farmers planted at two weekly intervals

Farmers ranked the insect pests on French beans in order of their importance 1 bean stem maggot 2 whiteflies 3 mites and bollworms 4 thrips bugs and aphids (Figure 1) Interviewers noted the insect pests on French beans and ranked them in the following categories 1 bean stem maggots and whiteflies 2 thrips 3 bugs 4 mites 5 bollworms and leafminers 6 aphids (Figure 2) Diseases on French beans were ranked by farmers in order of their importance 1 rust and angular leaf spot 2 anthracnose 3 bean root rot halo blight and bean common mosaic virus (Figure 3) Interviewers ranking of diseases were 1 rust angular leaf spot and anthracnose 2 halo blight root rots and bean common mosaic virus (Figure 4)

Figure 1 Main insect problems of French beans - farmers at Mwea Tebere

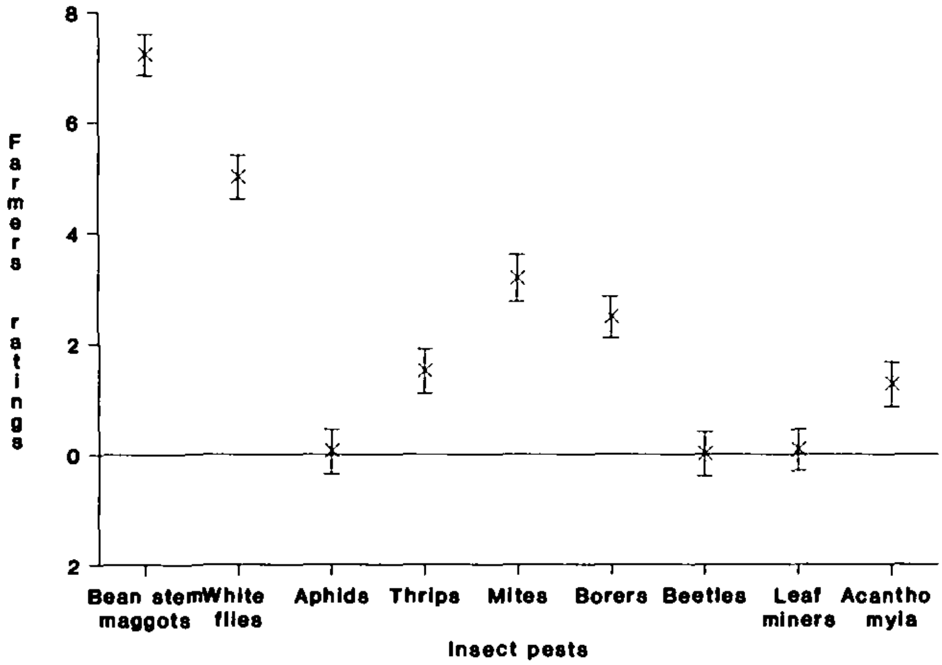


Figure 2 Main insect pest problems of French beans interviewers at Mwea Tebe

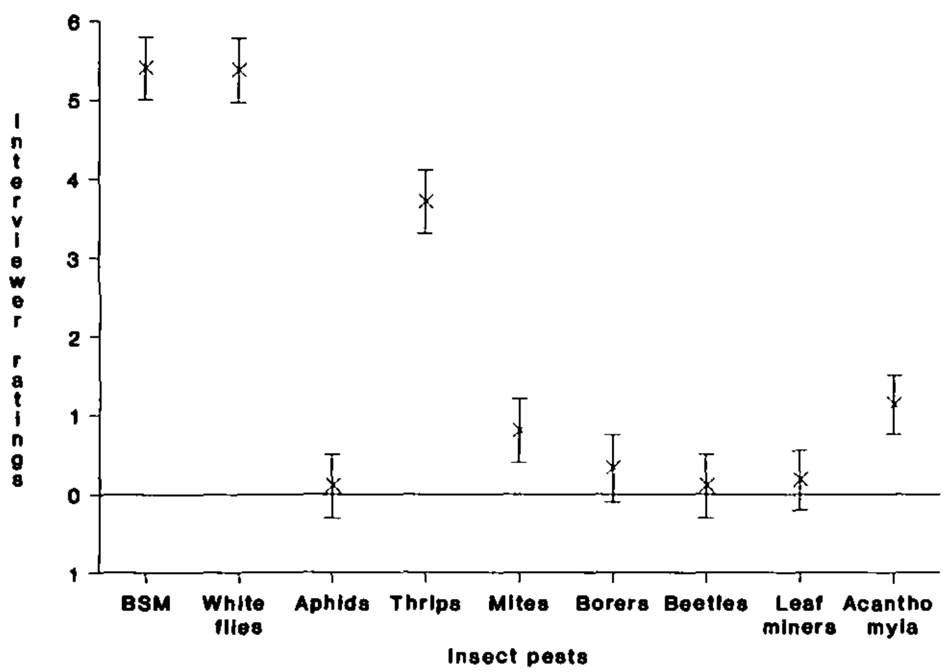
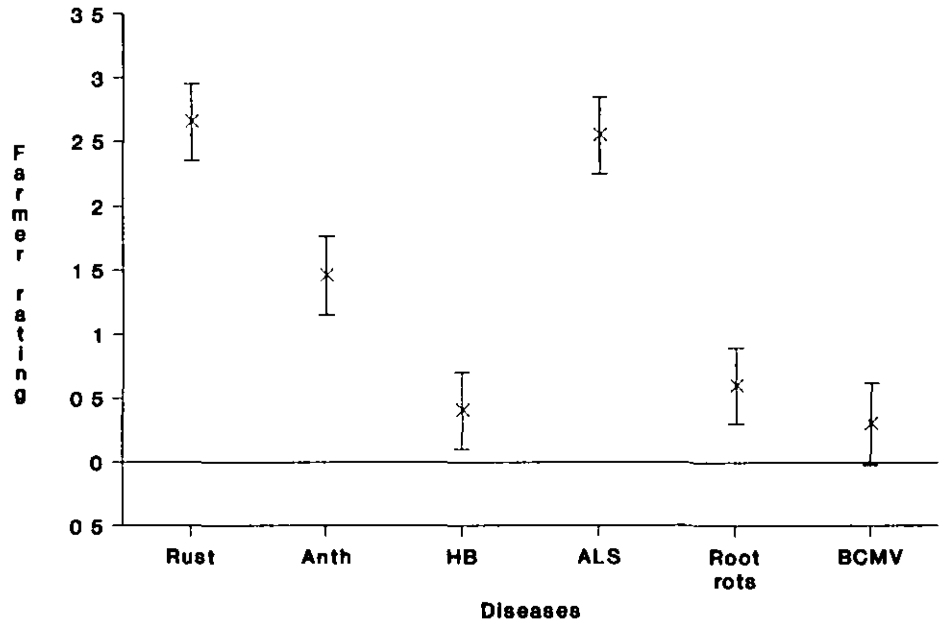
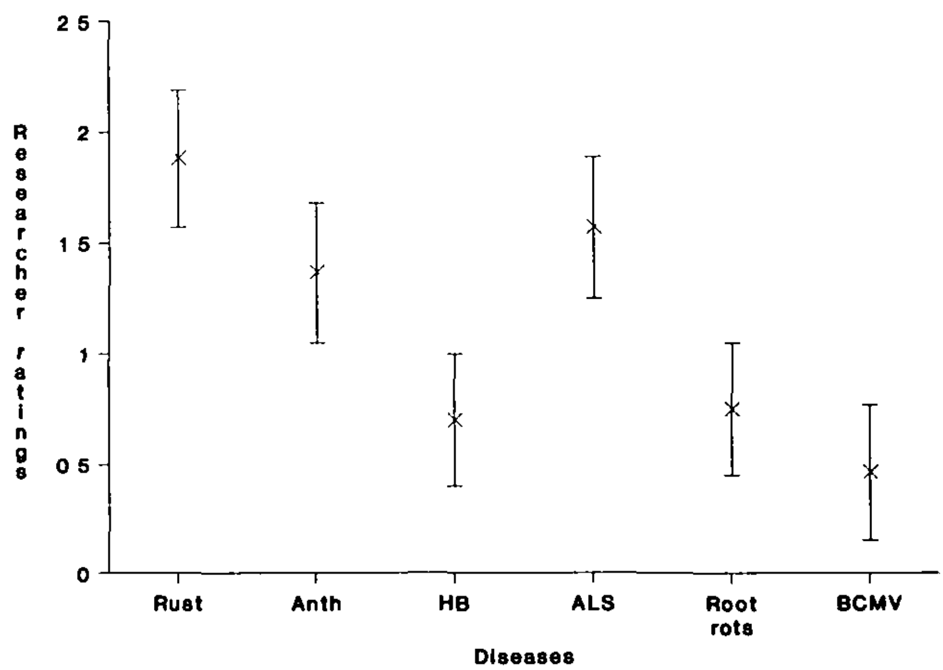


Figure 3 Main diseases of French beans farmers Mwea Tebere



Anth anthracnose HB halo blight
ALS angular leaf spot

Figure 4 Main diseases of French beans researchers at Mwea Tebere



Farmers suggested solution to insect pest control was mainly chemical all of them using insecticides while only 6 8% used cultural practices in addition to insecticide The cultural control methods used were ridging frequently for bean stem maggot control use of ash for soil insects control and ploughing as soon as possible after the end of harvesting period The farmers did not mention any method of disease control except the use of fungicides Thus there was no biological physical/mechanical or varietal method used for control of insect pests or diseases Farmers used only hand tools for weeding and did not use herbicides for weed control Most farmers had some knowledge of pests diseases and weeds and their control Farmers perceptions and actions on insect pest problems were greater than on weed or disease problems Farmers indicated that there was more yield loss without insect control than with diseases or weeds

Table 1 Insecticides and miticides used by farmers in the surveyed area

Trade name	Common name	Chemical base[1]	Type[2]	Mode of action[3]	No of farmers using
Ambush	Permethrin	SP	I	C	342
Selecron	Profenofos	OP	I+M	C+I	303
Furadan	Carbofuran	C	I+A+N	S	244
Rogor E	Dimethoate	OP	I+M	C S	185
Sumithion	Fenitrothion	OP	I	C	146
Karate	L-cyhalothrin	SP	I	C	127
Diazinon/ Basudin	Diazinon	OP	I	C NS	128
Decis	Deltamethrin	SP	I	C I	89
Thiodan	endosulfan	OP	I+M	C St NS	710
Azocord	Cypermethrin + monocrotophos	SP OP	I+M	S C I	711*
Ripcord	Cypermethrin	SP	I	I C	612
Durban	Chlorpyrifos	OP	I	I C VA NS	613
Brigade	Befenthrin	SP	I+M	C	514
Kelthane	Dicofol	OP	M	NS	415
Lebaycid	Fenthion	OP	I	C I	416
Marshal	Carbosulfan	C	I	S	317
Eralux	Quinalphos	OP	I+M	C I	218
Malathion	Malathion	OP	I+M	NS C	219
Folimat	Omethoate	OP	I+M	S	220
Mutano 221	OmitePropargite	S	M	S	222*
Polytrin	Cypermethrin	SP	I	I C	223*
Sherpa	Cypermethrin	SP	I	I C	124
Hostathion	Triazophos	OP	I+M	I C	25
Bancol	Bensultap	n	I	I	1

[1] OP = organophosphorus SP = synthetic pyrethroid C = carbamate S = sulfite n = nereistoxin analogue [2] I = insecticide M = miticide A = acaricide N = nematicide [3] C = contact I = ingestion S = systemic NS = non systemic St = stomach VA = vapour action * = same product

Tables 1 and 2 show the pesticides used to control diseases and pests of French beans Most pesticides were not used for specific pests or diseases However Furadan was used mainly against bean stem maggot and Selecron against mites Although Antracol Dithane and copper were used for controlling all diseases Antracol was emphasized for control of angular leaf spot and Dithane and copper for leaf rust Whenever a farmer was using a pesticide he only mentioned its good performance in disease or pest control A few pesticides like Furadan Ridomyl and Benlate were considered efficient by the farmers but they were not used extensively because they were regarded expensive

Farmers make a schedule immediately after the first spray and spray routinely Only a few farmers assess pest abundance or check for pest damage before they apply insecticides Most farmers spray once per week and apply pesticides over 12 times per season Most farmers do not get advice from any source on the use of pesticides However 20 2% get recommendations of pesticides from the extension officer and 21 2% from shopkeepers 77 8% of farmers mixed insecticides and fungicides 51 5% mentioned that they apply the same pesticide products they use on French beans to other crops and 49 5% responded that they do spray French beans when they spray other crops

Most farmers made their own decisions on the date of application of pesticides and actually sprayed the pesticides themselves While 83 8% of the farmers do not take precautions during spraying 61 6% of the farmers mentioned feeling intoxicated after applying pesticides All farmers said that they do not smoke drink eat or wear masks or gloves when applying pesticides They use old rags and only a few wear gum boots and protective coats They are all aware of the need for protective clothing but the cost prohibits its purchase They all mentioned that they wash themselves after applying pesticides

Table 2 Fungicides used by farmers in the surveyed area

Trade name	Common name	Chemical base	Mode of action[1]	No of farmers using
Antracol	Propineb	Dithiocarbamate	P	462
Copper oxychloride	Copper oxychloride	Copper	P	363
Dithane M-45	Mancozeb	Dithiocarbamate	P	254
Bayleton	Triadimefon	Conazole	P C S	115
Ridomil	Matalaxyl	Acylalanine	S	26
Kocide	Copper hydroxide	Copper	P B	17
Pencozeb	Penconazole	Conazole	S	28
Plantrav	Oxycarboxin	Anilide	S	19
Nova	Myclobutanil	Canazole	S	110
Rabcide	Phthalide	Phthalide	RS	111
Polyram	Metiram	Dithiocarbamate	NS P	112
Miliraz				

[1] P = protective C = curative S = systemic B = bacteriocide RS = specific to rice diseases NS = non systemic

In most cases farmers grew their French beans as a monocrop They commonly used D A P fertilizer during planting and most farmers apply foliar fertilizer frequently before and after flowering of the bean plants

DISCUSSION

As elsewhere in the world pests and diseases of French beans in Kenya are mainly controlled by use of pesticides (Cardona and Corrales 1990 Velasquez and Prada 1990 Anyango *et al* 1989) The large number of types of pesticides used at Mwea in the Tebere area may cause the build up of resistance of pests to pesticides and water pollution in canals There is already an indication that whiteflies are uncontrollable and may be resistant to a wide range of pesticides being used The reported ineffectiveness of some pesticides may be due to the high rate of adulteration of pesticides or use of pesticides against the wrong pests This may facilitate the development of resistance to pesticides The effects of pesticides on farmers who are normally unprotected should be of great concern and the current project to train farmers in the area on the safe use of pesticides is along the right lines

Farmers should be made aware of other control methods to encourage them to reduce their overreliance on chemical control The scheduled treatment normally carried out by farmers left no beneficial insects in the bean crop The complete eradication of pests seemed to be the aim of farmers which never happened with pests such as whiteflies and *Acanthomia* To encourage farmers to reduce the wide range of pesticides and number of sprays national pest control packages should be drawn up and released to farmers Such a package could be a seed dressing+soil insecticide (e g carbofuran) applied at sowing (Kibata, 1990) a systemic insecticide (e g dimethoate endosulfan fenitrothion) applied as first foliar spray two weeks after plant emergence (Kibata 1980 1990) a synthetic pyrethroid or any other pesticide of low toxicity that can be applied during flowering and podding Such a control package could be tested and the pest control and level of crop damage noted in the field Farmers should be given packages of pesticides which each one of them can choose to use to control the pests They should be encouraged to vary the pesticides depending on the pest to control The effectiveness of mixtures of insecticides and fungicides should be tested on insect pests and diseases since it is a common practice to mix such pesticides

Bean stem maggot and rust may completely destroy the crop Other pests and diseases cause mainly quality reduction and farmers and consumers should be encouraged to accept some minimal quality loss The main pests causing high pod quality reduction are thrips and *Acanthomia* The best pesticides for thrips control in Kenya have been reported (Muriuki 1988 Anyango 1990 1991a 1991b) These chemicals should be evaluated for their effectiveness against *Acanthomia* The actual losses caused by pests and diseases of French beans should be investigated Otherwise farmers will continue to exaggerate the losses due to pests and diseases and apply pesticides more frequently than necessary It is necessary to reduce the large number of sprays used in French beans This can only be done if the farmers are convinced that there are alternative methods or there are methods that could be combined with insecticides to effectively control pests This should reduce the chemical hazards to the farmers and consumers and pollution to the environment

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DISEASE AND PEST CONTROL BY SMALL SCALE FRENCH BEAN FARMERS IN KENYA

Mercy W Wanjiru

National Horticultural Research Centre Thika Kenya

ABSTRACT

This paper discusses pest control practices by small scale French bean farmers and their socio economic implications The study covered small scale farmers in the Central Province of Kenya A formal survey was carried out in which 120 farmers randomly selected from the main French bean growing areas were interviewed The commonly grown varieties of snap beans in Kenya are poorly adapted to tropical environments and so are highly susceptible to disease and pest attack Twenty diseases and 13 pests have been reported to attack beans and most of these are of economic importance Chemicals are the most commonly used pest control method among snap bean growers Farmers sprayed their crops up to 16 20 times per cropping cycle On average pesticides cost Ksh 7 253 per ha ranging up to Ksh 28 000 for some farmers While the mean rate of return per Ksh spent on pesticides was found to be high (Ksh 2 96) and farmers were found to be efficiently allocating expenditure on pesticides these chemicals were accounting for a significantly high percentage (10 20%) of total variable costs This increases to 30% when labour for spraying is included The susceptibility of locally available snap bean varieties to pests and diseases and the high rate of return have been the main catalysts to farmers frequent usage of pesticides

INTRODUCTION

The snap bean industry plays a vital role in the Kenyan economy in terms of foreign exchange earnings employment opportunities and provision of much needed income especially to small scale farmers In Kenya, as in other developing countries snap beans are produced mainly by small scale farmers as a high input/high output market oriented crop Average farm size ranges between 0 37 and 2 7 ha Farmers allocate only a small proportion of land to snap beans not more than 29% in the majority of cases Even though the allocation is small farmers rank snap beans very highly in terms of income generation when compared with other farm enterprises Most of Kenya s produce estimated at 12 15 tonnes per annum is destined for the export market either in the fresh state or processed form (Horticultural Crops Development Agency)

The main varieties grown are Monel Super Monel and Bobby (bush type) Most varieties being grown by the snap bean farmers are poorly adapted to tropical environments and so are highly susceptible to pest and disease attack Over 20 diseases and 13 insect pests have been reported to attack beans in Kenya The ones of most economic importance are halo blight anthracnose rust root rots bean stem maggots and other insects (Omunyin 1983)

Halo blight is seed borne but there is no practical method of control by seed dressing Foliar chemical sprays are also not always effective so farmers are advised to sow clean certified seed Breeding for resistance to the disease is a promising control method Anthracnose is also seed borne The causal organism survives in soil for several years on dead plant material As a control measure farmers are advised to plant clean certified seed and to practice crop rotation Chemical foliar sprays are not always effective but chemical seed treatment is a recommended practice Breeding for resistance is a promising control method Rust is an airborne disease and can cause up to 50% loss in yield The recommended control measures are crop rotation field sanitation and the use of chemical foliar sprays

Root rots are soil borne and may cause up to 60% yield loss Control measures include crop rotation and breeding for resistance

Bean stem maggots can cause total crop loss Crop rotation field sanitation certified seeds and seed dressing are the recommended control measures Breeding for resistance is another possibility Other insect pests of economic importance include aphids thrips mites and African bollworm

This study discusses pest control practices amongst small scale snap bean growers and their socio economic implications

METHODOLOGY

The data used in this study is from a survey conducted in 1991 on snap bean production in the Central Province of Kenya A sample of 120 small scale farmers was randomly selected from three administrative divisions in the Central Province With the help of enumerators a formal survey was carried out The data collected was mainly on snap bean acreages input and output data cultural practices prices and markets

RESULTS AND DISCUSSION

Small scale French bean farmers in Kenya were found using various methods to control diseases and pests attacking their crop The methods are described below

Crop rotation

Even though small scale French bean farmers are aware of the importance of crop rotation as a means of reducing disease and pest incidence only a few follow the practice For those who do snap beans are still grown in the same plot after one or two seasons Most farmers are not able to carry out the practice for three reasons

1) the small farm size that characterizes French bean farmers Mean farm sizes were 0 37 ha in Kandara Division 1 85 ha in Makuyu and 2 7 ha in Mwea Division Hence farmers are not able to practice crop rotation in the recommended manner

2) farmers lacked improved irrigation technologies which can enable them to grow beans remote from water sources so are restricted to growing French beans around or along water sources such as rivers and

3) since snap beans generate high incomes especially during the off season (October May) the farmers count it as a loss when they can not fill every plot with snap beans

These reasons have often caused a build up of diseases and pests along or around the water source

Clean certified seed

The source of snap bean seed planted by farmers varied depending on

1) whether the farmers were well informed about the importance of using clean certified seed as a means of protecting their crop against diseases and pests

2) the availability of the seed at the right time and place

3) the price of the seed when compared to other sources and

4) the past experience that the farmer has had after buying from a particular source in terms of germination percentage plant vigour and yields obtained

For these reasons practices differed among areas In Mwea Division most farmers (80%) planted seed which they had bought from appointed dealers (supposedly certified) while in Makuyu the majority of farmers (68%) bought seed from their neighbours or used their own seed

Seed dressing

This is a common practice by seed companies and by farmers who are engaged in selling seed to others but was not very common with those farmers who planted their own seed

Resistant varieties

The survey showed that the main variety grown by small scale farmers was Monel This variety has been shown to be susceptible to diseases and pests as it is poorly adapted to Kenyan environments

Foliar chemical control of diseases and pests

Pests are most commonly controlled by chemicals by French bean farmers in Kenya because chemicals are fastest in action reliable and give the most predictable results All farmers in the sample sprayed their crop with insecticides while only four used no fungicide The pesticides were mainly sprayed on a routine basis i e at one or two week intervals although a few farmers sprayed only after sighting the pest in the crop (Table 1) When spraying the crop farmers usually mixed together an insecticide a fungicide and a foliar feed to save labour

Insecticides In Mwea the majority of farmers sprayed the crop with two insecticides interchangeably whereas most farmers in Kandara (69 2%) and Makuyu (90%) were found to be spraying their French bean crop with only one type of insecticide throughout the crop cycle (Table 2) This dependence on one insecticide has often led to the build up of resistance by pests and hence to the use of higher dosages and more potent chemicals and a financial drain on farmers Ambush which is a permethrin was the most widely used insecticide in all three regions Other commonly used insecticides include Ripcord Kelthane Brigade Malathion Diazinon and Rogor E (Table 3)

Farmers started spraying with insecticides as early as one week after emergence of the bean crop However the majority started when the crop was 1 5 2 weeks old The spraying of some chemicals started as late as 8 weeks after emergence The data collected indicated that 71% of farmers sprayed 1-4 times whereas only 20% sprayed 8 9 times with one chemical (Table 6) This means that some farmers who sprayed the crop with two insecticides sprayed up to 16 times

Fungicides Most farmers were found to be using one fungicide throughout the crop cycle although interchanging between two fungicides was practised to a certain extent in Mwea and Kandara Divisions (Table 1) Seven different types of fungicides were being used during the survey period the most common being Dithane Kocide Antracol and Bayleton (Table 5)

Table 1 Numbers of farmers spraying insecticides and fungicides at one and two week intervals and on sighting the pest in three divisions in Kenya, 1991 survey

	Insecticides				Fungicides		
	Spray intervals				Spray intervals		
	One week	Two weeks	On sight		One week	Two weeks	On sight
Makuyu Division							
Ambush CY	17	5	4	Dithane	21	5	4
Polytrin	1	2		G copper	3		1
Decis	1		1	Baycor	1		2
Rogor E	3		3	Kocide	1		
Diazinon			1	Benlate			1
Karate	1						
Kandara Division							
Ambush CY	7	7	1	Antracol	4	1	3
Fentrothion	1		1	Dithane	6	3	1
Lebaycid	1			Bayleton	2	1	3
Decis			1	G copper	7	5	5
Rogor E			3	Baycor	2		
Diazinon	1	1		Kocide		1	
Sumithion	1	1		Moduna		1	
Malathion	4		1				
Folimat	1	1					
Marshall	1						
Thiodan			1				
Kelthane	1	1	2				
Ripcord	1						
Mwea Division							
Ambush CY	7	5		Antracol	4	3	
Kelthane	2		3	Dithane	3	1	
Lebaycid		1		Bayleton	1		2
Rogor E	1		4	G copper		2	
Marshall	4		1	Kocide		1	
Brigade	1	1	1				
Sumicidin		1	1				
Ripcord	1						
Grand total	58	26	29		55	24	22

Some farmers started spraying fungicides one week after emergence of the crop but the majority started spraying when the crop was 1 5 2 weeks old The majority of farmers sprayed the chemicals 7 10 times so farmers using 2 3 fungicides achieved 8 20 sprays per crop cycle

Table 2 Percentages of farmers using one two three or four insecticides on French beans in M w e a Kandara and Makuyu Divisions of Kenya in 1991

Number of insecticides	Mwea	Kandara	Makuyu
One	33 3	69 2	90
Two	59 0	20 5	10
Three	7 7	7 7	0
Four	0	2 6	0

Table 3 Percentages of farmers using different types of insecticides on French beans in Mwea Kandara and Makuyu Divisions of Kenya

Insecticides	Mwea	Kandara	Makuyu
Ambush	62	69	73
Fentrothion	5	3	8
Kelthane	18	8	0
Lebycide	0	5	3
Decis	0	8	5
Rogor E	0	8	15
Diazinon	0	10	3
Karate	3	0	3
Sumithion	0	8	0
Malathion	3	13	0
Folimat	0	5	0
Ripcord	23	3	0
Thiodan	5	3	0
Sumicidin	3	0	0
Brigade	18	0	0
Azocord	8	0	0

Table 4 Percentages of farmers using one two or three fungicides on French beans in Mwea Kandara and Makuyu Divisions of Kenya in 1991

Number of fungicides	Mwea	Kandara	Makuyu
One	67	67	67
Two	28	23	5
Three	3	0	3

Table 5 Percentages of farmers using different fungicides in French beans in Mwea Kandara and Makuyu Divisions of Kenya in 1991

Fungicide	Mwea	Kandara	Makuyu
Anthracol	36	21	0
Dithane	41	28	83
Bayleton	21	15	0
Kocide 101	33	39	15
Baycor	0	5	8
Benlate	0	0	3
Moduna	0	3	0

Cost of disease and pest control Pesticides accounted for 20 10 8 and 12% of the total variable costs respectively in Mwea Makuyu and Kandara Divisions these costs increasing to 15 30% of the total variable costs if the labour for spraying chemicals is also included The costs of chemicals were second highest after labour costs which accounted for 58 78% of the total variable costs Farmers were found to be spending an average of Ksh 7 253 on pest and disease control in French bean production However some farmers used only Ksh 230 while others used up to Ksh 28 000 The rate of return to every Ksh spent on pesticides varied among farmers but the mean rate of return was Ksh 2 96 32 5% of farmers had rates of return less than one but majority (66 7%) had rates of return greater than two This would imply that returns to pesticides in French bean production are high and this is what encourages the farmer to spend large amounts of money on chemicals

DISCUSSION

Chemical control is repetitive in nature because it has to be applied afresh with each pest outbreak The chemicals also rarely kill all pests and the few that survive usually give serious problems by development of resistance The planting of varieties ill adapted to the environment has led to heavy reliance on pesticides in the snap bean industry In order to be able to sell any of his output the small scale farmer is faced with

1) many different pests and diseases attacking the snap bean crop
2) lack of knowledge of appropriate pesticides and their use and
3) high and escalating cost of pesticides

Table 6 Number of farmers spraying French beans 1 10 times in Mwea Kandara and Makuyu Divisions of Kenya in 1991

	Number of sprays									
Divisions	1	2	3	4	5	6	7	8	9	10
Makuyu	3	10	10	7	2	1	2	1	3	0
Kandara	15	6	4	7	2	1	1	2	2	3
Mwea	2	1	0	4	1	0	1	3	5	0
Total	20	17	14	18	5	2	4	6	10	3

The high cost of controlling diseases and pests illustrates the financial drain that results from the current pest management methods being used by farmers in Kenya Apart from the high monetary costs the high pesticide applications have dangerous repercussions on human health and the environment in general There is therefore an urgent need to seek alternative strategies to recommend to snap bean farmers who are trapped in the vicious cycle of chemical control pest management practices

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HOST PLANT RESISTANCE AGAINST BEAN STEM MAGGOTS A PROGRESS REPORT

Tsedeke Abate, Amanuel Girma and Gashawbeza Ayalew

Institute of Agricultural Research, Nazreth Ethiopia

ABSTRACT

This paper reviews research progress made in host plant resistance against bean stem maggots (BSM) *Ophiomyia* spp F_2 populations of crosses of several accessions that had been identified to have medium to high levels of resistance to BSM with commercial cultivars were tested in the 1990 and 1992 crop seasons crosses of the CIAT accession G 5773 (ICA Pijao) showed consistently high levels of resistance against both *O phaseoli* and *O spencerella* whereas crosses of G 5253 were promising against *O phaseoli* Of 14 F_2s of large seeded cultivars tested in 1992 AND 829 x AND 867 and AND 829 x AFR 486 were most promising against *O spencerella* while AND 888 x AND 867 and AND 867 x I RK 29 were least damaged by *O phaseoli* Single plant and bulk selections from the most promising crosses were multiplied during the off season (Sep 92 Jan 93) and the F_4s are being tested Of ten lines tested in a reconfirmatory nursery in the 1990 crop season ZPv 292 G 5773 A 55 G 2005 and G 2072 were most resistant G 5253 did not maintain the high resistance shown in previous experiments this was attributed to the increase in importance of *O spencerella* (which was rare in the past) in 1990 and subsequent years A total of nearly 1200 accessions was screened for BSM resistance at Awassa in 1990 and Awassa and Areka in 1992 Top performing entries (about 20% of the total) are being assembled to form the 1993 BSM resistance nursery for testing at both locations

INTRODUCTION

Bean stem maggots (BSM) *Ophiomyia* spp are the major pests of haricot bean in eastern southern and the Great Lakes regions of Africa where the crop is produced largely by subsistence farmers Total crop failure may occur in susceptible cultivars under severe conditions of damage by BSM (Tsedeke Abate 1990a) Seed dressing with insecticides such as endosulfan may give some degree of control (Tsedeke Abate 1991) but is not practical under small farmer situations If bean cultivars with acceptable levels of resistance can be identified they can be utilized as a major component of an integrated pest management programme with no direct cost to the small farmer

Although host plant resistance has been in use against BSM and related agromyzids in mungbean and soybean (Talekar *et al* 1988 Chiang 1984) little information was available regarding haricot bean until recently Tsedeke Abate (1990b) identified several sources of resistance including CIAT accessions G 5773 and G 2072 these were crossed with commercial varieties and the resulting progenies are being evaluated at two locations in southern Ethiopia Moreover further attempts are being made to establish BSM resistance nurseries by screening germplasm obtained from CIAT

This paper summarizes progress in host plant resistance research at the Ethiopian Institute of Agricultural Research since 1990

MATERIALS AND METHODS

Segregating materials

Twenty four F_2 populations were evaluated at Awassa in 1990 Each population was sown on 7 June in three rows 8 m long with 60 cm between rows and 20 cm between plants Stands were counted at emergence Dead seedlings (due to BSM) were counted and rogued at least twice weekly starting about 4 weeks after planting and the numbers pooled to calculate cumulative percent seedling mortality Number of BSM per dead plant was also recorded at about 7 weeks after planting Visual scores were taken on a 1 9 scale (1 = excellent 9 = extremely poor) at 6 and 9 weeks after planting The number of surviving plants was recorded just before harvest and seed yields were determined

Two sets of F_2 populations ET9103B (22) and ET9110B (14) were obtained from CIAT in 1992 and were evaluated at Awassa (sown 9 May) and at Areka (sown 21 April) The plots were single rows 4 m long with 40 cm between rows at Areka and 60 cm at Awassa and 10 cm between plants Other cultural practices and data collection procedures were similar to those in 1990

Germplasm evaluation

Nurseries of 600 white pea bean medium-coloured and large seeded beans were included in the breeders Nursery I at Awassa and/or Areka in 1990 and 1992 Seedling mortality caused by BSM was the major selection criterion Plant vigour was a supplementary criterion in some instances

Reconfirmation nursery

A BSM Resistance Reconfirmatory Nursery of 10 cultivars obtained from other bean growing regions in Africa and Taiwan through the CIAT Regional Programme on Beans for Southern Africa (Table 1) was evaluated at Awassa in the 1990 crop season Endosulfan treated and untreated seeds of each entry were sown on 7 June in a split plot design with seed treatments as main plots and cultivars as sub plots Blocks main plots and sub plots were separated by 2 1 5 and 1 m alleys respectively Sub plots were 3 m x 3 m with 60 cm between rows and 15 cm between plants The bean variety Red Wolaita was included as a local check Procedures for data collection and cultural practices were as in previous experiments Data were subjected to analysis of variance

Table 1 Bean entries tested in BSM Resistance Reconfirmatory Nursery at Awassa in 1990

Entries	Seed colour	Seed size
EMP 81	cream/blue	small
G 2072	black	small
G 2005	black	small
G 5253	black	medium
G 5773	black	small
Ikinimba	black	small
BAT 1373	black	small
A 74	yellow	medium
ZPv 292	purple	medium
A 55		small
Red Wolaita	red	small

RESULTS AND DISCUSSION

Segregating materials

All the 24 crosses tested in 1990 were superior to the local check in terms of seedling mortality plant vigour and seed yield (Table 2) Seedling mortality ranged between 34 0% in BAT 338 x G 5773 and 95 1% in Red Wolaita BSM per living plant were fewest for WAF 109 x EMP 81 and most for A 776 x G 5253 and A 40 x G 5773 similarly BSM per dead plant were fewest for WAF 29 x EMP 81 and most for Black Dessie x G 5253 The crosses Black Dessie x G5253 and A 410 x G 5773 were the most vigorous of all the test material and the local check The largest yielding crosses were A 410 x G 5773 PAN 132 x ICA Pijao Ex Rico 23 x ICA Pijao and Black Dessie x G 5773 even though they were not the least damaged nor exhibited fewest BSM per plant

Table 2 Seedling mortality vigour rating BSM per plant and dry seed yield of F_2s of haricot bean at Awassa 1990

	Seedling mortality (%)	Vigour score (1 9)	BSM/plant		Dry seed yield (g/plot)
			Dead	Living	
BAT 338 x G 5773	34 0	3 5	5 5	4 2	750
WAF 109 x EMP 81	36 2	4 0	5 7	1 0	540
Black Dessie x G 5253	37 2	2 0	10 0	4 0	720
A 176 x G 5253	37 6	3 0	6 3	6 6	750
PAN 132 x ICA Pijao	37 9	3 0	4 5	3 0	1195
DOR 335 x Argentino	38 9	4 5	7 3	2 4	750
Carioca x EMP 81	40 2	4 0	5 6	4 8	565
A 410 x G 5773	40 5	2 0	7 2	6 6	1400
WAF 29 x EMP 81	44 2	4 0	3 9	5 6	620
Ex Rico 23 x ICA Pijao	44 7	3 5	7 7	3 6	1190
BAT 338 x EMP 81	45 5	4 0	6 0	3 6	675
Ex Rico 23 x EMP 81	47 4	4 5	6 7	2 8	480
DOR 335 x BAT 1373	47 5	5 0	4 5	4 2	660
A 410 x EMP 81	48 0	4 0	7 0	3 4	840
Black Dessie x G 5773	49 5	3 0	8 7	5 4	1050
Carioca x G 2072	49 5	4 0	6 0	3 8	505
DOR 335 x TMO 101	50 0	4 5	7 1	6 0	750
A 176 x G 2072	50 4	3 0	5 6	3 4	735
Ex Rico 23 x EMP 81	52 4	5 0	5 9	4 2	650
XAN 76 x BAT 85	56 9	5 5	5 8	5 4	465
XAN 76 x A 74	57 8	5 5	5 3	5 0	540
Mexican 142 x EMP 81	69 0	7 0	4 5	3 6	310
PAN 132 x EMP 81	78 9	6 5	5 3	1 4	280
Mexican 142 x G 2072	80 4	7 0	4 5	2 8	115
Red Wolaita (local check)	95 1	8 5	7 0	3 6	35
Mean	50 8	4 4	6 1	4 0	663
S E (±)	3 0	0 3	0 3	0 3	63 6

Bean stem maggot populations were 65 5% *O phaseoli* and 34 5% *O spencerella* The average BSM per plant was 6 1 Correlations between seedling mortality and vigour score (r=0 76) and between seedling mortality and seed yield (r=0 71) were highly significant (P<0 001) whereas seedling mortality and BSM per dead plant (r=0 23 P=0 276) and BSM number and yield (r=0 36 P=0 008) were not significantly correlated

Of the 22 crosses (ET9103B) tested at Awassa and Areka in 1992 A 410 x G 5773 showed a high level of resistance at both locations (Table 3) Other least damaged crosses at Areka were BAT 338 x G 5773 XAN 76 x A 74 A 176 x G 2072 and Carioca x EMP 81 whereas at Awassa the crosses A 176 x G 5253 and Black Dessie x G 5253 were least damaged by BSM

Table 3 Seedling mortality vigour score and plant survival in 22 F_2 populations (ET9103B) of haricot bean at Awassa and Areka, 1992

	Mortality (%)		Score		Survival	
Cross	Areka	Awassa	Areka	Awassa	Areka	Awassa
A 410 x G 5773	3 7	6 9	1	1	92 6	65 3
BAT 338 x G 5773	3 8	26 9	2	5	84 6	65 4
Mexican 142 x G 2072	12 0	24 1	6	3	72 0	65 5
Black Dessie x G 5253	24 0	10 7	5	3	56 0	71 4
XAN 76 x A74	7 4	35 7	2	5	81 5	60 7
A 176 x G 5253	27 3	10 0	8	2	18 2	90 0
A 410 x EMP 81	22 2	44 4	2	4	70 4	55 6
WAF 29 x EMP 81	29 6	23 1	4	2	29 6	65 4
ExRico 23 x ICA Pijao	15 4	46 4	4	5	80 8	46 4
A 176 x G 2072	11 1	44 8	4	5	66 7	51 7
DOR 335 x Argentino	29 6	33 3	3	6	48 1	59 3
DOR 335 x TMO 101	32 0	27 6	4	6	52 0	55 2
Black Dessie x G 5773	32 1	33 3	2	4	67 9	44 4
WAF 100 x EMP 81	26 9	33 3	4	4	42 3	55 6
Carioca x EMP 81	14 3	65 4	2	7	71 4	53 8
XAN 76 x BAT 85	24 1	57 1	3	6	72 4	28 6
BAT 338 x EMP 81	37 5	30 8	7	6	43 8	53 8
Mexican 142 x EMP 81	32 0	58 6	4	5	60 0	20 7
DOR 335 x BAT 1373	40 0	33 3	9	5	0 0	53 3
PAN 132 x EMP 81	29 6	51 7	5	4	25 9	41 4
ExRico 23 EMP 81	34 6	50 0	5	7	53 8	19 2
Carioca x G 2072	63 0	61 5	5	7	29 6	30 8
Mean	25 1	36 8	4	4	56 1	52 4
S E	2 9	3 6	0 4	0 4	5 2	3 6

BSM per plant averaged 3 2 at Areka and 2 4 at Awassa at Areka, bean stem maggot populations were entirely *O spencerella* whereas at Awassa they were entirely *O phaseoli* Correlations between seedling mortality and vigour rating at Awassa (r=0 75 P<0 001) were greater than those at Areka (r=0 50 P=0 017)

Table 4 summanzes data for the 14 crosses (ET9110B) AND 829 x AND 867 followed by AND 829 x AFR 486 was the least damaged and most vigorous entry at Areka at Awassa AND 888 x AND 867 AND 867 x AND LRK 29 CAL 113 x AND 867 and AND 888 x AND 829 were the most promising entnes As in ET9103B the correlation between seedling mortality and vigour rating (r=0 95 P<0 001) was greater at Awassa than at Areka (r=0 76 P = 0 001) Mean BSM per plant was 4 6 at Areka and 2 3 at Awassa *O spencerella* constituted 100% of the bean stem maggot population at Areka and at Awassa 95 2% was *O phaseoli*

Table 4 Seedling mortality vigour score and plant survival in 14 F_2 populations (ET9110B) of hancot bean at Awassa and Areka 1992

	Mortality (%)		Score		Survival	
Crosses	Areka	Awassa	Areka	Awassa	Areka	Awassa
AND 888 x AND 829	22 2	11 1	3	1	66 7	70 4
AND 829 x AER 486	14 8	50 0	2	6	74 1	13 3
AND 888 x LSA 310	29 6	15 4	4	2	70 4	61 5
AND 829 x AND 867	0 0	37 9	1	6	88 5	48 3
AND 867 x LSA 30	38 5	10 7	5	2	38 5	78 6
AND 888 x AND 867	40 0	3 6	6	1	45 0	67 9
AND 867 x LRK 29	58 3	3 7	5	2	37 5	88 9
AND 829 x LRK 29	20 8	50 0	2	6	70 8	30 0
AND 867 x AFR 500	30 8	26 1	3	5	57 7	56 5
CAL 113 x AND 829	36 4	23 3	5	2	54 5	60 0
CAL 113 x AND 867	48 0	3 8	4	1	36 0	76 9
AND 829 x LSA 30	29 6	48 3	4	7	51 9	31 0
AND 829 x AFR 500	30 8	58 3	3	7	50 0	29 2
AND 867 x AFR 486	59 1	28 0	4	4	45 5	52 0
Mean	32 8	26 4	4	4	56 2	54 6
S E	4 3	5 2	0 4	0 6	4 2	5 9

Seeds of single plant selections (a total of 365 from ET9103B and 235 from ET9110B) and of bulked rows from Areka were planted in single 4 m rows with 10 cm between plants and 60 cm between rows on 28 September at the Melkassa field of Nazreth Research Centre and grown for seed increase under irrigation BSM damage was too light (<5% dead) to select for resistance (3 8 BSM/dead plant) Population composition was 75 9% *O phaseoli* 14 9% *O spencerella* and 9 2% *O centrosematis* Seeds of the single plant selections and bulks that yielded adequate seeds (314 of ET9103B and 102 of ET9110B) were advanced for further screening in 1993 Tables 5 and 6 show the number of single plant selections and their agronomic characteristics for the two sets of experiments mentioned above

Nurseries

Of 571 entries tested in Nursery I in 1990 at Awassa RIZ 88 RIZ 109 RIZ 100 CIFAC 81025 and AND 720 were the least damaged and most promising The overall seedling mortality of the test entries ranged between 2 5 and 100% (mean = 39 4±0 9) the range (and mean) percent seedling mortality for the check entries were 10 5 63 6 (27 9±2 7) for A 176 and 8 3 75 (39 9±3 2) for Red Wolaita BSM per dead plant was 4 8 with *O phaseoli* and *O spencerella* constituting 58 3 and

47 7% respectively The seedling mortality of 608 accessions at Awassa in the 1992 crop season ranged between 0 and 100% with a mean of 65 1±0 5 At Areka (and Awassa) mean seedling mortality for the checks was 46 7±6 1 (23 9±3 9) for Red Wolaita 54 1±5 3 (12 2±2 0) for Roba 1 and 80 1±2 4 (11 7±2 4) for Brown Speckled

Table 5 Number of F_4 entries (ET 9103B) and their agronomic characteristics Melkassa, 1992/93

Cross	No of lines advanced	Days to harvest	Pods/ plant	Weight of 100 seeds (g)	Yield per row (g)	Yield per plant (g)
A 410 x G 5773	18	104	16	28 2	481	16
BAT 338 x G 5773	17	108	21	20 4	462	21
Mexican 142 x G 2072	20	105	15	22 0	256	15
Black Dessie x G 5253	15	106	16	28 0	222	16
XAN 76 x A 74	18	108	18	22 7	592	18
A 176 x G 5253	26	107	22	26 7	302	22
A 410 x EMP 81	15	104	14	29 7	357	14
WAF 29 x EMP 81	14	109	16	34 8	209	16
Ex Rico 23 x ICA Pijao	12	109	16	21 6	367	16
A 176 x G 2072	16	105	17	24 1	356	17
DOR 335 x Argentino	16	110	20	25 1	380	20
DOR 335 x TMO 101	15	104	20	28 0	338	20
Black Dessie x G 5773	13	106	18	21 4	485	18
WAF 100 x EMP 81	13	110	15	28 6	178	15
Carioca x EMP 81	14	101	17	21 9	511	17
XAN 76 x BAT 85	8	111	21	23 8	662	21
BAT 338 x EMP 81	15	106	21	19 1	246	21
Mexican 142 x EMP 81	7	103	17	21 2	381	17
DOR 335 x BAT 1373	17	109	18	30 4	257	18
PAN 132 x EMP 81	11	113	24	23 3	415	24
Ex Rico 23 x EMP 81	6	107	15	21 1	362	15
Carioca x G 2072	8	108	24	25 6	549	24
Mean/total	314	107	18	24 9	380	18

Reconfirmatory nursery

Appreciable differences in damage between treated and untreated plots were found only for these cultivars that were coated with endosulfan and a few drops of water just before seeding The seeds of other cultivars had been treated with endosulfan before receipt and there were no noticeable effects of the treatment Comparison among means was therefore made only for the untreated plots Highly significant differences were observed among cultivars in terms of percent seedling mortality BSM per plant and seed yield

About 20% of the most promising accessions from each test will be advanced and will form the 1993 bean stem maggot resistance nursery (BSMRN)

Table 6 Number of F_4 progenies and their agronomic characteristics Melkassa, 1992/93

Cross	No of lines advanced	Days to harvest	Pods/ plant	Weight of 100 seeds (g)	Yield per row (g)	Yield per plant (g)
AND 888 x AND 829	5	109	8	46 9	83	11
AND 829 x AFR 486	3	108	7	43 0	137	13
AND 888 x LSA 30	10	107	10	51 6	142	17
AND 829 x AND 867	9	104	11	40 8	162	17
AND 867 x LSA 30	15	105	11	46 3	141	16
AND 888 x AND 867	3	113	10	47 0	51	15
AND 867 x LRK 29	8	105	9	48 9	112	17
AND 829 x LRK 29	3	106	9	48 3	83	13
AND 867 x AFR 500	2	118	9	46 0	55	12
CAL 113 x AND 829	14	107	9	46 4	148	16
CAL 113 x AND 867	13	105	11	46 7	186	15
AND 829 x LSA 30	5	106	9	46 7	133	12
AND 829 x AFR 500	6	113	10	44 0	155	15
AND 867 x AFR 486	6	111	10	47 4	90	15
Mean/total	102	108	10	46 4	120	15

Percent seedling mortality ranged between 13 7 in ZPV 292 and 86 8 in Red Wolaita, a local check (Figure 1) All test entries were superior to Red Wolaita The most resistant entries were ZPv 292 G 5773 A 55 G 2005 and G 2072 The overall BSM number per plant (from a random sample of living plants) was 5 9±0 3 with *O phaseoli* and *O spencerella* accounting for 79 8% and 20 2% respectively BSM numbers were fewest in G 2072 and most in Ikinimba (Figure 2) It should be noted here that there was no direct correspondence between seedling mortality and BSM numbers (r=0 02 P=0 053)

Seed yields ranged between 65 kg/ha in Red Wolaita and 1159 kg/ha in G 2005 (Figure 3) Although there was a highly significant relationship between yield and seedling mortality (r=0 83 P=0 001) BSM numbers and yield were not correlated (r= 0 370 P= 0 260)

These results confirm previous conclusions (Tsedeke Abate 1990b) that tolerance is the major mechanism of resistance in the cultivars tested

Figure 1 Percentage seedling mortality of entries in BSM Resistance Reconfirmatory Nursery at Awasa in 1990

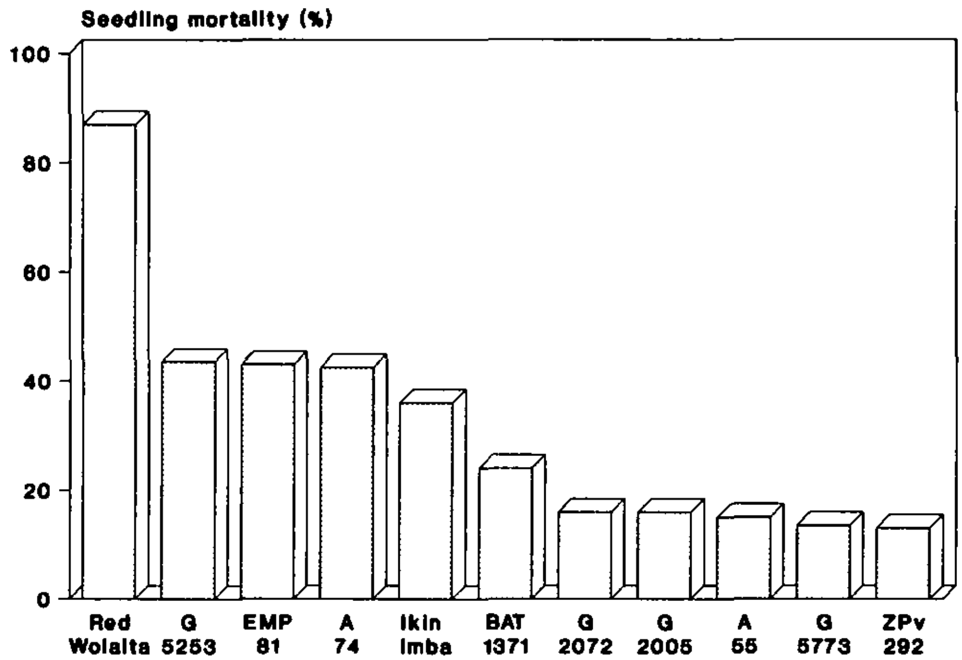


Figure 2 Number of BSM larvae and pupae in entries in BSM Resistance Reconfirmatory Nursery at Awasa in 1990

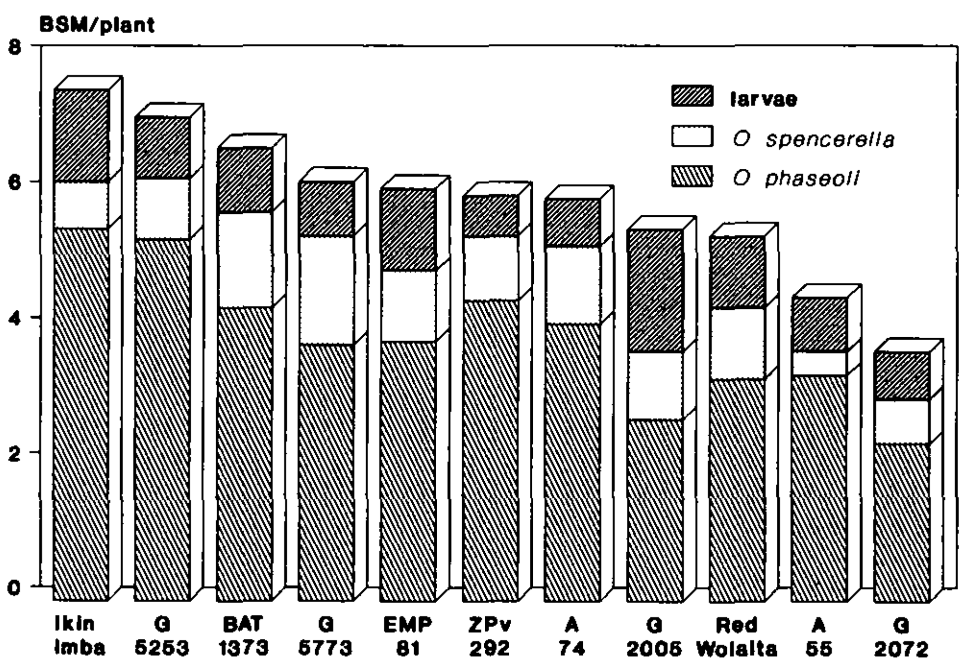
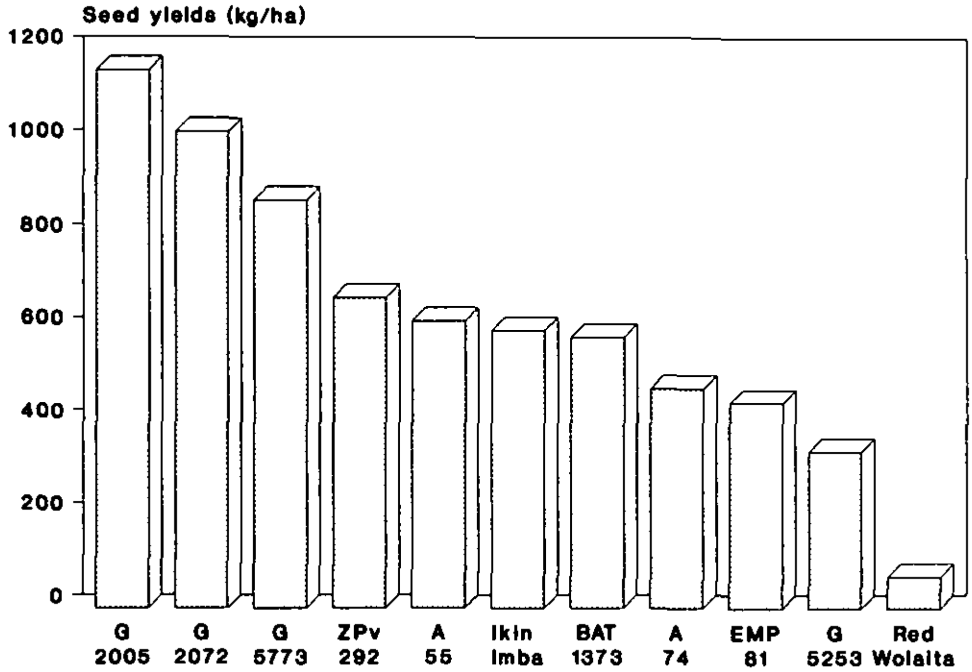


Figure 3 Seed yields of entries in BSM Resistance Reconfirmatory Nursery at Awasa in 1990



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TOWARD AN INTEGRATED STRATEGY FOR MANAGEMENT OF BEAN STEM MAGGOTS (*Ophiomyia* spp)

J K Ampofo

CIAT, Selian Agricultural Research Institute Arusha Tanzania

ABSTRACT

Various control tactics are being studied for incorporation in an overall strategy for the management of bean stem maggots (*Ophiomyia* spp) in beans These include host plant resistance cultural practices and chemicals chiefly as seed treatment Moderate sources of resistance have been identified and these are in use in breeding programmes to incorporate resistance into local varieties An evaluation of various cultural methods such as earthing up mulching and improved fertility indicate that mulching of field plots reduced plant mortality from BSM attack by 38% compared to the control and that mulching combined with improved soil fertility reduced plant mortality even further Foliar application of certain botanical pesticides such as alcohol extract of neem seed powder and aqueous extract of *Tephrosia* leaves also reduced infestation by BSM and increased yields Field evaluations of these and other tactics in an integrated system are now in progress in small scale farmer situations

INTRODUCTION

Bean stem maggots (BSM) (*Ophiomyia* spp) are considered the principal insect pests constraining bean productivity in many of the crops growing environments in Africa and Asia Three species *O phaseoli O spencerella* and *O centrosematis* are known to attack the crop but their distribution and importance vary with location and season The nature of damage caused by the different species is quite similar Young plants wilt and die In older plants stems crack and lodging may ensue Damage is most severe when seedlings are attacked and in stress situations (infertile soils drought or disease) BSM often causes total crop failure

Various methods have been proposed for the control of bean stem maggot (BSM) in beans These include chemical application notably lindane or endosulfan seed dressing (Lays and Autrique 1987) cultural practices including earthing up (Moutia 1944) and increased plant population (Tsedeke Abate 1990) and change of sowing dates The efficiency of these methods varies with time of application and environmental conditions and some of them may be incompatible with the traditional practices of some communities Sources of resistance exist in various germplasm accessions but have not been adequately utilised at farm level

A principal objective of the entomology network in the CIAT regional bean programmes is to develop IPM strategies with adequate flexibility for use by resource poor bean growers Many chemicals for BSM control have been reported but they are unavailable to farmers in many circumstances and in other situations their use is often incompatible with farmer practice which makes cultural control methods more appropriate to the systems of resource poor farmers This paper reports on progress in identifying components for possible IPM strategies for bean stem maggots

HOST PLANT RESISTANCE

Over three thousand germplasm accessions and CIAT breeding lines largely comprising materials in store at the Selian Agricultural Research Institute Arusha Tanzania have been screened for BSM resistance Methodology is based on infestation levels and plant mortality due to BSM attack As BSM population activity varies over time populations were monitored through trapping and inspection of field plants Test entries were sown to coincide with pest infestation of about 4 insects/plant and plants were monitored regularly for infestation and damage Resistance was categorized by the distribution of the means and multiples of the standard deviation

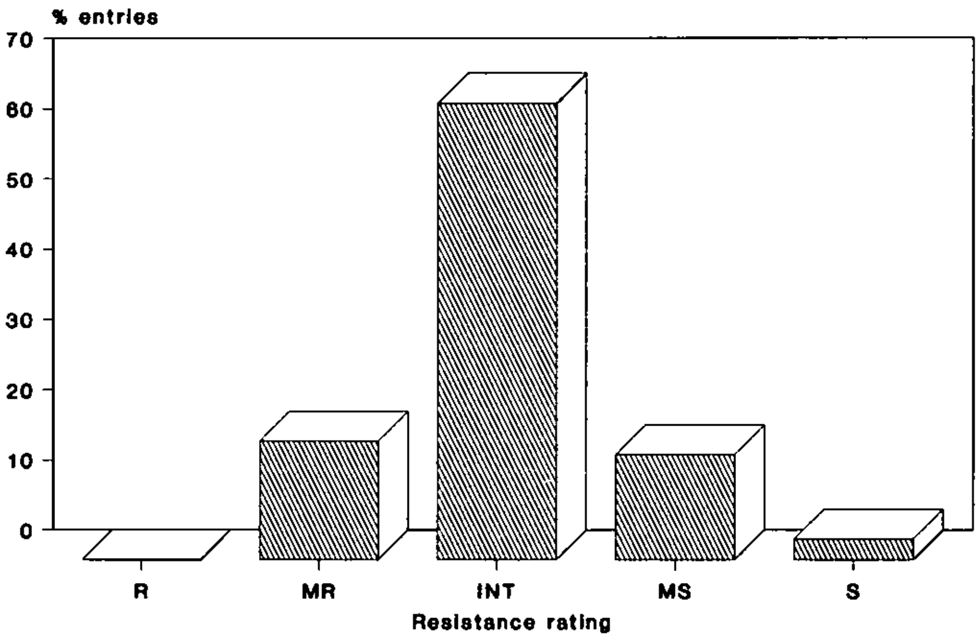
Results from the preliminary evaluation indicated that only low to moderate levels of resistance exist in this set of materials (Figure 1) The performance of materials categorized as moderately resistant was compared against *Lyamungu 85 treated* with endosulfan (Table 1) While the susceptible check (Lyamungu 85 untreated) suffered 34% mortality due to BSM several of the test entries (G 12670 x G 4727 2 7126/DR 670 x G 5701/D 145 Montcalm 4 86 EP 5022 B and TMO 126) performed similarly to the resistant check

Table 1 Emergence stand counts (STE) total seedling mortality (TSM) number of bean stem maggots/dead plant (BSM/DP) and total (TM) and percentage (%M) mortality of most resistant entries in preliminary evaluation at Selian

Entries	STE	TSM	BSM/ DP	TM	%M
G 12670 x G 4727 2	22 0	0 7	0 0	3 3	3 3
7126/DR 670 x G 5701/D 145	37 5	1 5	4 0	4 4	4 4
Montcalm 4	21 0	1 5	2 5	5 6	5 6
G 13936 x A 487	29 0	2 0	4 3	7 2	7 2
TMO 237	25 5	2 0	3 9	7 5	7 5
86 EP 5022 B	27 5	2 5	4 5	8 7	5 3
81 CC 62 x Horsehead	40 0	3 5	2 3	8 9	7 7
Royal Red x Canadian Wonder 2	22 0	3 0	3 6	10 3	8 6
TMO 126	31 5	3 5	6 1	10 8	3 4
BAT 1337 x G 6592 2	34 0	4 0	0 0	12 0	12 0
ACV 8331	23 5	3 5	4 5	15 0	15 0
Checks					
Lyamungu 85	37 2	16 5	8 3	44 4	34 4
Lyamungu 85 + endosulfan	37 5	1 8	3 0	4 9	4 0
ZPv 292	38 0	10 8	3 3	28 9	23 4
Mean	28 2	9 3	4 6	33 4	29 6
LSD (P<0 05)	9 4	9 7	5 0	32 6	22 6

In other trials (for example the BSM Resistance Reconfirmatory Nursery 2) which comprised selections from a set of putative sources of resistance entries were evaluated in a split plot design with treatments (with and without endosulfan seed dressing) as main plots and varieties as sub plots Entries such as ZPv 292 and Sinon performed well in terms of plant survival and subsequent yield loss (Table 2) Several entries suffered high seedling mortalities (>15 plants/plot) in both treatments but mortalities due to BSM alone were only about 50% of the total Also the numbers of BSM per dead plant were relatively few suggesting an interaction between BSM and other factors in the expression of damage observed

Figure 1 Relative levels of resistance
in germplasm evaluated at Arusha



R resistant MR moderately resistant
INT intermediate MS moderately
susceptible S susceptible

Table 2 Total seedling mortality (TSM) mortality due to bean stem maggots (MBSM) number of bean stem maggots/dead plant (BSM/DP) percent plant infestation at five WAE (%PI) and seed yields/plot in BSM Resistance Reconfirmatory Nursery at Selian

	TSM		MBSM		BSM/DP		%PI		Yield	
Entries	--	+	--	+	-	+		+	--	+
G 5773	15 7	15 0	10 7	9 7	4 9	4 7	86 7	86 7	1430	1411
G 2072	14 0	12 0	5 7	6 3	4 2	3 8	80 0	93 3	1501	1380
Sinon	7 0	2 0	5 3	1 7	5 2	2 3	93 3	86 7	1733	1621
G 6725	19 3	7 0	16 0	4 3	7 3	2 0	93 3	73 3	1214	1341
G 3844	17 7	15 0	10 7	7 7	3 0	5 8	100 3	86 7	1325	1619
ZAA 12	13 0	7 0	4 0	3 0	6 9	2 2	86 7	93 3	1606	1894
BAT 1373	9 7	11 0	5 3	5 0	3 6	2 3	93 3	80 0	1379	1507
ZPv 292	4 0	1 0	2 0	0 3	0 8	0 0	93 3	100 0	1921	2136
LY 85	18 7	1 3	16 7	1 0	3 9	0 7	93 3	73 3	1655	1859
Mean	13 9	8 6	8 9	4 6	4 3	2 7	90 7	86 0	1504	1574
LSD	4 3		3 9		2 3		12 6		698	

= without endosulfan seed dressing + = with endosulfan seed dressing

Our other studies show strong interactions between BSM infestation and root disease infection on severity of damage expression This was confirmed in a screenhouse study where bean plants were grown on soil infested with *Fusarium oxysporum* and exposed to BSM when plants were in the V1 stage in a factorial design Plant mortality was significantly increased in plants exposed to both adversaries than to either alone (Figure 2) To remove this confounding interaction protection against root disease and other adversaries is recommended when assessing BSM infestation

Crosses between resistant accessions and adapted cultivars have been initiated at both CIAT and in Tanzania through a Regional Collaborative Research Sub project Early results indicate that the resistance is transferable

CULTURAL CONTROL

Various cultural control methods (time of sowing crop rotation planting density earthing up and mulching) that are used by farmers were considered and some of these were evaluated for their potential in BSM damage control The treatments were (i) heaping of soil at the base of plants during first weeding 2 3 WAE (earthing up) (ii) mulching with chopped banana leaves (iii) application of inorganic fertilizer at recommended rates (enhanced fertility) (iv) endosulfan seed dressing at 5 g of 47% WP per kg of seed (v) control (seeds sown on the flat without any of the above treatments) and (vi) various combinations of these treatments

In general none of the treatments affected plant emergence significantly even though mulching seemed to induce etiolation of seedlings Mulching also induced slight yellowing of the leaves but these symptoms disappeared before the plants reached growth stage V4 Plant mortality began as early as 16 DAE and continued until about 40 DAE after which mortality was significantly reduced (Figure 3) BSM infestation (5 insects/dead plant) and subsequent plant mortality (11 plants/plot) were moderate Treatments with chemical seed dressing showed the most effective control of BSM Mulching was the only single non-chemical treatment that reduced plant mortality significantly below that of the control Total plant mortality was reduced in all the mulch treatments even though mulching did not reduce infestation *per se*

BOTANICAL PESTICIDES

Certain plant extracts reputed to have insecticidal properties were evaluated alongside endosulfan seed dressing for their performance against BSM These were (i) neem (*Azadirachta indica*) seed extract (NSE W) in aqueous solutions (ii) NSE AL in alcohol (iii) *Tephrosia* leaf juice solution and (iv) maize leaf juice The extracts were diluted to 10% and sprayed on to the plants until dripping at three day intervals from emergence to flower bud initiation Plants were monitored for feeding/oviposition punctures (as an index of BSM adult activity) BSM infestation levels plant mortality and yield

Endosulfan seed dressing had no effect on adult BSM activity but reduced infestation (Table 3) NSE AL and *Tephrosia* juice reduced oviposition/feeding puncture counts indicating a deterrent effect from these substances These reductions in BSM activity on test plots were reflected in infestation levels plant mortality and yields Maize juice and NSE in water had no effect on BSM There were direct and significant correlations between BSM activity and infestation levels plant mortality and yield

Figure 2 The effects of the interaction between BSM and Fusarium wilt on bean plant mortality

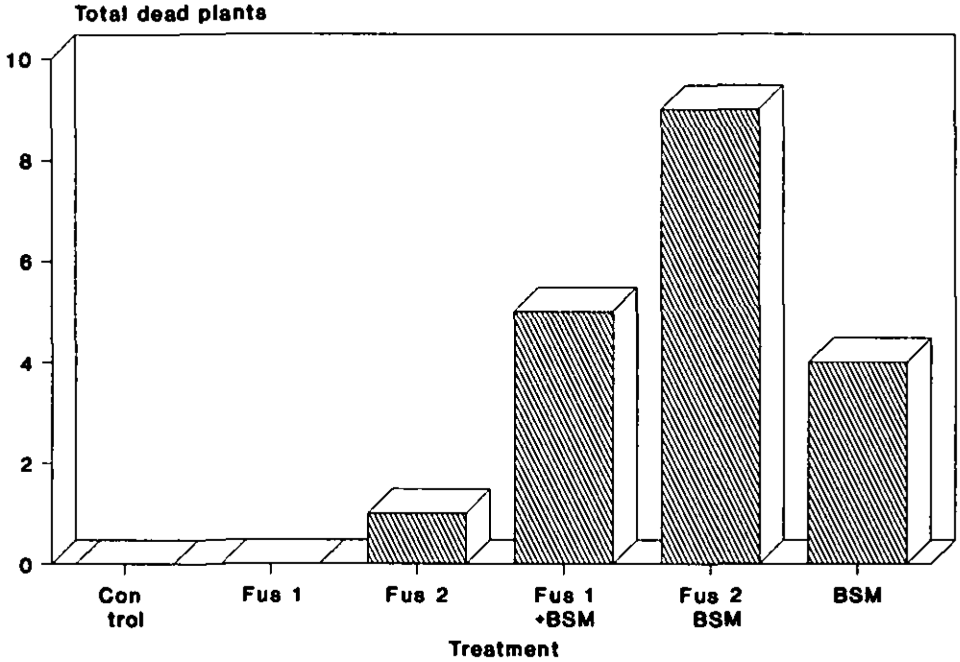
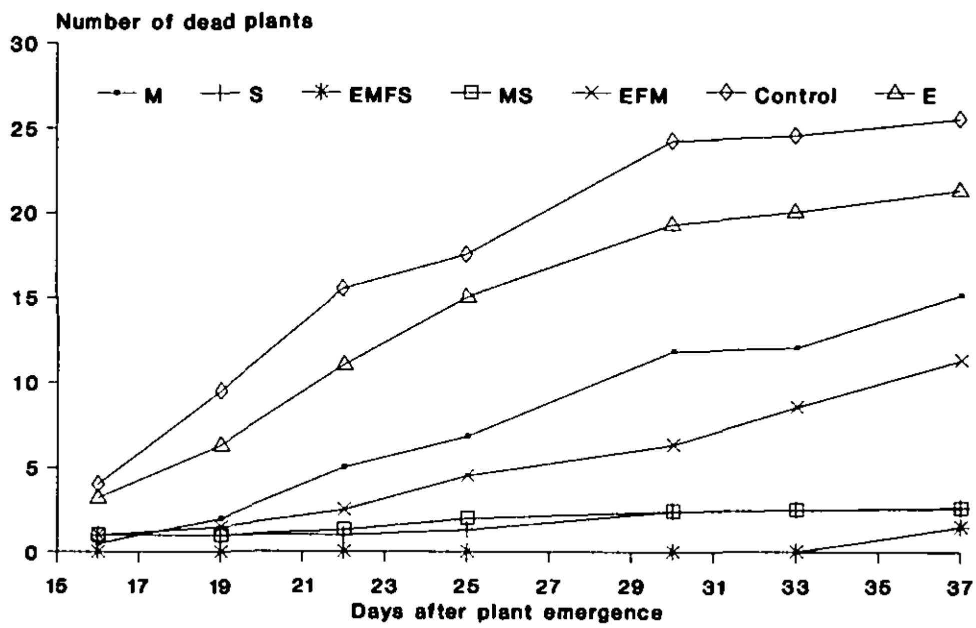


Figure 3 Effect of cultural practice on plant mortality due to BSM



E earthing up M mulching
F fertilization S seed
dressing

Table 3 Effects of botanical pesticides on BSM oviposition and infestation plant mortality and yield

	Oviposition/ feeding punctures	BSM/ plant (R5)	Cumulative BSM score	Total plant loss	Yield/ plot (g)
Control	90 3a	7 3	430	38 3	191
Maize juice	88 3a	9 5	376	41 5	177
Tephrosia juice	47 7b	6 1	300	32 7	232
NSE W	85 0a	7 8	324	35 5	174
NSE AL	43 2b	7 3	240	25 0	274
Endosulfan	94 8a	3 5	66	7 2	338

DISCUSSION

Most bean farmers are resource poor and do not rely on purchased inputs in their pest management tactics Such farmers are unlikely to adopt rigid packages but will select components that they can readily afford Any integrated management strategy developed for use by farmers should therefore be flexible with options for step by step adoption of individual components The key components considered in the present study were host plant resistance cultural control and botanical pesticides all these are renewable within the farm environment and farmers do not need extra financial resources to acquire them They would however need education in their use and management Some of the components need modifications to improve their efficiencies and consideration needs to be given to other components in different farming systems

In this study there were significant correlations between oviposition (feeding punctures) infestation levels plant loss and yield levels These relationships may be evaluated further for use across varieties in predicting potential yield loss and to determine the economic threshold levels needed to justify the cost of inputs or operations as well as serving as a basis for scheduling measures aimed at reducing pest damage Indices such as oviposition/feeding punctures would also help farmers recognise early signs of attack and make management decisions

Other components that would fit into a management strategy include (i) prophylactic treatment (e g seed dressing) in areas where the pest is endemic (such chemicals need systemic qualities and to be relatively persistent) (ii) remedial application of chemicals (such chemicals would essentially be systemic or at least penetrative in nature to reach the pest which spends its entire developmental stages within the plant tissue) (iii) sowing date adjustment in areas where periods of peak occurrence of damaging populations are well known to avoid plant exposure to these populations

The effect of cropping systems on the incidence and damage caused by BSM needs highlighting The interactions of soil infertility and root disease with BSM attack on the severity of damage expression suggest the need for a multidisciplinary approach to the development of IPM strategies for BSM

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DISCUSSION SESSION IV INTEGRATED MANAGEMENT OF DISEASES AND PESTS

Chair W K Rono   Rapporteur F Makini

Paper by Habtu Assefa

Question Is 20% of a desirable susceptible component with 80% of a less desirable resistant variety an acceptable practice as evaluated by farmers?

Response Of the two varieties in this trial Mexican 142 and Negro Mecentral only Mexican 142 is acceptable to farmers This trial should be tried again with an acceptable resistant variety but the study does show the proportion of susceptible and resistant that would be needed

Buruchara The proportion of the susceptible component in the mixture is influenced also by farmers preferences Studies conducted in Zaire to incorporate resistant components in farmers mixtures showed that farmers had no objection to 25% of the resistant component incorporated but objected to 50%

Paper by A Rabakoarihanta and G Rakotomalala

Sengooba It may be good to harmonize the grading scale so that the range from immune to very susceptible is consistent in the tables in your paper In the grading scale 1-6 the numbers 1 to 6 were arbitrarily assigned to different diseases to classify them in order to get an overview of their relative importance Number 1 means first in importance because of its high frequency and severity whereas the grading scale 1 9 which is a standard scale for evaluating a reaction to a particular disease was used to classify the host plants These two grading scales have nothing in common

Question There seems to be considerable variability in disease scores for each cultivar i e rated susceptible in one area and resistant in another Do you attribute this to variable environmental conditions or variability in pathogen?

Rabakoarihanta I think the variability is due both to environment and the pathogen

Buruchara In your evaluation of the 25 varieties it does appear that at two sites (Namsana and Ambatobe) disease levels were high but in the other two disease levels were low or the race constitution is different Ikinimba is resistant in all your sites whereas it is very susceptible in Rwanda This suggests differences in races between the two countries

Paper by A F Opio and S Musaana

Question You indicated that much of the resistance to CBB comes from tepary bean (*P acutifolius*) You also indicated maternal effects if tepary bean is used as female How crossable are the two i e *P vulgaris* and *P acutifolius*? Did you have any problems in the F_1 and F_2 generations?

Answer The two sources used were interspecific hybrids made in Brazil and sent to us from University of Nebraska Using them as females gave a higher frequency of resistant genotypes

Paper by R Buruchara, U Scheidegger and L Sperling

Tesfaye Beshir As you know root rot attacks crops in patches how do you keep the uniformity of the pathogen in the soil during evaluation?

Buruchara We use fields where inoculum levels are high and uniform But we also carry out artificial inoculation to verify resistance

Ajanga What is the mechanism by which application of organic manure reduces root rot problems in beans? Is it the effect of microbial activity or increased fertility due to the organic matter?

Buruchara We think that microbial activity is increased when we add organic amendments and some of the microbes have an antagonistic effect to soil borne pathogens Some of the organic amendments (e g agroforestry leguminous species) increase soil fertility while others (e g sawdust) do not It depends on the type of organic matter

Question Did you find any of the organic amendments aggravated root diseases or did all of them improve the situation? Did you check the composition of the organic amendments you used?

Buruchara We used organic amendments in the form of green manure of agroforestry species Those used had either positive or no effects but none aggravated root rot diseases The composition of some of the organic amendments were checked

Paper by M S Nahdy

Kirkby The plants found to be used by farmers in bean storage should be identified by a botanist (e g Nairobi Museum provides a service)? Total control of *Zabrotes* can be achieved through use of a single gene for resistance and this paper shows that excellent control of *Acanthoscelides* can be achieved by sieving Both results are from research stations I suggest that the working groups address the issue of acceptability to farmers and transfer of the technology to achieve impact in order to orient the sub project for future activities?

Nahdy Some of the plants were from Tanzania we will arrange to collect them for identification On farm trials will begin and acceptability will be tested Solar heat disinfestation should however be continued on station to arrive at safe temperatures and exposure times that do not render the seeds inviable?

Question You mentioned several traditional herbs and methods used in control of bruchids? Do you have plans to investigate and quantify their effectiveness in the control of bruchids? How effective are they compared to commercial insecticides?

Nahdy Yes Most are however just repellents and therefore not effective in killing bruchids

Salih In some countries chemical control of bruchids proved to be very effective I wonder why you have not tried to use such a method?

Nahdy Limited availability of chemicals at the on farm level cost often too high shelf life limited insecticide misuse sowing in parts of Uganda involves putting seeds in the mouth and spitting and insecticide use is dangerous

Ampofo Chemicals are sometimes incompatible with farmer practices In some areas farmers put seed in their mouth and spit out during sowing Chemical application will poison them The objective here is to develop components that the farmer can use to control bruchid damage i e chemical and non chemical

Ampofo Two methods are being compared here solar heat treatment and sieving In essence they are the same Solar heat allows adults to escape and when the beans are rebagged eggs are left behind Sieving directly removes both adults and eggs from the beans Mechanical sieving explains the mechanism of bruchid (*Acanthoscelides obtectus*) removal through solar heating

Mulagoli What control measures should be instituted to prevent or minimize field infestation by bruchids? Sieving may be laborious and time consuming

Nahdy Frequent sunning soon after harvest

Question Some farmers mentioned that debris reduces bruchid infestation How much debris was in your unsieved beans?

Nahdy Unsieved beans had no debris Debris does not reduce bruchid infestation

Nderitu What losses occur during sieving?

Nahdy Minimal losses

Paper by J H Nderitu and J.J Anyango

Wortmann Your survey has yielded much information on farmers current pest management/control practices What are the implications for future research? What role will farmers play in this research

Nderitu Develop an IPM package On farm trials on IPM to involve farmers in the development of a package

Aberra Deressa One of the slides indicated that farmers have more knowledge than extension agents (if I correctly understood) Why is it so?

Nderitu No The slide attempted to show a different aspect It is the farmers source of knowledge queried as farmers never went to extensionists for information

Question Where do farmers obtain their French/snap bean seed? Are the beans under irrigation or are they rainfed ?

Nderitu They mainly obtain their seeds from seed companies Beans are grown under irrigation during the off season and under rainfed conditions during the two rainy seasons

Michieka You indicated that farmers spray snap beans more than 15 times Don t you think this will affect Kenya s markets especially in Europe?

Nderitu Yes and as result we should teach our farmers what to spray and when This can be done through extension staff of the Ministry of Agriculture

Tenaw Workayehu Farmers spray many tımes before flowerıng Thıs seems costly What was the response of farmers towards the cost and tıme when ınterviewed?

Nderıtu They complaıned about the cost of chemıcals but the crop seemed profitable to them The farmers have no other actıvıtıes except farmıng and thus never complaıned about the tıme

General dıscussıon

In the final general dıscussıon ıt transpıred that damage due to some ınsects (e g mıllıpedes cutworms bollworms) ıs underestımated These can cause up to 100% loss (e g cutworms at emergence) It was mentıoned that dıeldrın and aldrın were very effectıve agaınst soıl pests but have been wıthdrawn due to theır toxıcıty and ıt ıs because of thıs the problem has ıncreased Dıazban (ınsectıcıde) ıs recommended to farmers for soıl pests Pawpaw ımpregnated wıth furadan can be used agaınst gıant mıllıpedes Furadan can also be used agaınst other bean maggots

Methods of assessıng yıeld losses related to partıcular dıseases or pests were dıscussed Two approaches were descrıbed The first ınvolved controllıng all other factors except the one beıng studıed and performıng multıple regressıon analyses ıncludıng all problems The analysıs assumes components are uncorrelated and thıs ıs usually ıncorrect Therefore sub sets of uncorrelated components should first be examıned Another approach ıs to consıder the dıstrıbutıon of dıseases One area may have one or two dıseases and the losses they cause can be assessed Dıseases vary from season to season and the losses can be assessed accordıng to the dıseases present at the tıme However ıf prıorıtızıng dıseases ıs needed then losses must be assessed ındıvıdually Susceptıble ıntermedıate and resıstant genotypes should be used to estımate potentıal losses Note that the same genotype can be resıstant ın one envıronment and susceptıble ın another Envıronments also have a role e g ın a fertıle area losses wıll be less than ın an ınfertıle area even ıf there ıs ınfestatıon Therefore ıt ıs not a foolproof exercıse

Chemıcal usage was also dıscussed Chemıcals have to be ımported are costly and are health hazards It was suggested that an ıntegrated approach ıs best Resıstance ıs most effectıve but cultural methods should be ıncluded and chemıcals are preferably avoıded

Root rots may be ımportant ın regıons other than the Great Lakes A speaker was ınterested to know whether CIAT ıs ınterested ın doıng work sımılar to that ın the Great Lakes ın other regıons Symptoms caused by root rots can also be caused by other factors e g BSM If there are ındıcatıons of a root rot problem CIAT wıll assıst Makıng beds for the control of root rots may ıncrease BSM damage In northern Rwanda where raınfall ıs hıgh thıs practıce ıs common In southern Rwanda where BSM can be a problem there ıs less raınfall and raısed beds or rıdges are not used For BSM control grasses and weeds can be burıed ın the rıdges Thıs ımproves the soıl and ıncreases fertılıty and reduces losses because the plant ıs more vıgorous but does not reduce BSM ıncıdence

Rust resıstance was dıscussed ın relatıon to the race sıtuatıon and to the dıfferent types of resıstance avaılable When workıng wıth a pathogen ısolates should be collected from beans throughout the regıon of ınterest and used for evaluatıon Greenhouse studıes are desırable to dıstınguısh vertıcal and partıal resıstance Another approach ıs to test a nursery of susceptıble ıntermedıate and resıstant genotypes across countrıes Ikınımba ıs a susceptıble check ın Uganda and Rwanda but ın Madagascar ıt ıs resıstant Sımılarly for BSM Ikınımba was the best varıety ın Burundı but worst ın Shangwa (Taıwan) but thıs was maınly an adaptatıon problem

Breeders are concerned when they obtain a very resistant genotype as its resistance is probably governed by a single gene and is likely to break down sooner or later Other traits which have to be considered are seed type and yield

There was concern with the stage at which farmers become involved KARI s emphasis is to start with the farmer before any research is done With bruchids farmers were involved However some technology has to be tested before farmer involvement There are advantages and disadvantages in early or late participation of the farmers With root rots farmers were involved early and this was advantageous because practices unacceptable to farmers were discarded after one season and substituted by acceptable practices This led to early adoption of the technology It was pointed out that both farmers and *extensionists* should be targets It was concluded that too much time should not be spent on station and that farmers should be involved early

Problems of germplasm exchange were noted This should be addressed by Directors of Research of affected countries and it was agreed that CIAT should produce an updated annotated check list of pathogens and pests for every country in Africa This is in progress and will be compiled published and sent to quarantine services to help alleviate this problem

EVALUATION OF BEAN GENOTYPES AND RHIZOBIA STRAINS FOR NITROGEN FIXATION POTENTIAL ON TWO SOIL TYPES IN ETHIOPIA

Mitiku Haile

Alemaya University of Agriculture, Dire Dawa Ethiopia

ABSTRACT

Four different experiments were conducted to evaluate the nitrogen fixation potential of bean genotypes and rhizobia strains on Alfisols and Vertisols In an evaluation of four bean cultivars sole and in association with two sorghum varieties inoculation increased the yields of Black Dessie 73% in association with the tall sorghum and by 100% in association with the short sorghum All cultivars responded to inoculation when sole cropped although the responses were small In the rhizobia screening all 20 strains increased bean dry matter and N content and most improved nodulation on both soils Seven strains induced better yields than the uninoculated control on the Alfisol and four on the Vertisol The application of N increased bean dry matter and N content but depressed nodulation We examined the responses of nine bean genotypes on an Alfisol and ten others on a Vertisol to inoculation with a mixture of rhizobia strains Inoculation improved the nodulation of all genotypes on each soil Yield responses varied among genotypes Application of 46 kg ha^{-1} N increased the yields of Mexican 142 by 26 % on an Alfisol and by 30% on a Vertisol both increases being highly economic Further screening of strains and genotypes under different cropping systems and of strains for persistence and competitiveness is recommended

INTRODUCTION

In Ethiopia haricot bean is commonly grown in the 1 400 2 000 masl range including the Rift Valley Except in limited areas where it is grown in monoculture the cultivation of beans is mainly in association with other cereals coffee and fruit crops The average national yield is very poor when compared with the yield obtained on research stations (Amare Abebe 1987 Mitiku Haile 1990) due to losses through diseases pests and poor soil fertility (Tsedeke Abate 1990) and smallholder farmers can not afford to apply fertilizer (Storck *et al* 1991) Previous studies showed the agronomic benefits of growing beans in association with cereals and demonstrated the need for investigations of nitrogen fixation (Dagnew Selassies 1981 Amare Abebe and A Birhanu 1984)

Like any other legume beans fix atmospheric nitrogen Exploitation of biological nitrogen fixation through inoculation with rhizobia would be a cheap alternative to nitrogenous fertilizers which are unavailable to smallholders Inoculation of field beans with rhizobia rarely increases grain yield in Africa (Davis 1982) or Latin America (Graham 1981) However although beans are poor nitrogen fixers (LaRue and Patterson 1981) inoculation with some strains of rhizobia has produced yields comparable with those obtained from application of high levels of nitrogen (Kipe Nolt and Pineda 1988) Variability in nodulation and yield of genotypes inoculated with specific strains of *Rhizobium* has also been observed (Kipe Nolt and Pineda 1988) The objective of this study was to evaluate and screen rhizobia and bean genotypes suitable for contrasting soil types in different cropping systems

MATERIALS AND METHODS

The effects of inoculating haricot beans intercropped with sorghum

The experiment was conducted on a Rhodustalf (low N pH and available phosphorus) in a split split plot design replicated three times Four released varieties of beans (Mexican 142 Ex Rico 23 Black Dessie and local) and two sorghum varieties (ETS 2752 tall and IS 9333 short) were intercropped in plots of 4 5 x 4 4 m Peat based inoculant of Strain 274 was applied at planting At 50% flowering six plants were sampled for nodulation count At maturity grain yield was determined at 14 percent moisture content

Screening of rhizobia for nodulation and yield

The experiment was conducted on two soil types (Ustert degraded Haplustalf) in a randomized complete block design replicated five times Twenty strains of rhizobia obtained from CIAT were compared with the application of 100 kg N ha^{-1} and without N The inoculants were all peat based and applied at planting to Ex Rico 23 The beans were planted in furrows spaced 40 cm apart and 20 cm between plants In the +N plots urea was applied in four split applications of 25 kg N ha^{-1}

Sorghum was sown on each side of the bean furrows two weeks prior to planting beans to deplete soil nitrogen At pod filling six bean plants were sampled from each furrow for scoring nodulation and shoot dry matter (DM) determination At harvest grain yield was determined at 14 percent moisture Grain N was determined by the micro Kjeldahl method

The effects of mixed rhizobia on the nodulation and yields of bean genotypes on two soil types

Nineteen genotypes obtained from CIAT were evaluated for nodulation and grain yield in a split plot design replicated three times The main plots were mixed strains (613 652 and 274) N and +N Sub plots were genotypes Nodules were counted at 50% flowering Grain yield at harvest was adjusted to 14 percent moisture

The effect of different levels of nitrogen on the yield of Mexican 142 on two soil types

Nitrogen in the form of urea at 0 23 46 and 69 kg ha^{-1} was applied at sowing on plots of 4 5 x 4 4 m Mexican 142 a released cultivar was planted in rows of 40 cm and 10 cm between plants in RCBD with three replications on a Rhodustalf and a Vertisol Nodule numbers were evaluated at 50% flowering Grain yield was recorded at harvest adjusted to 14 percent moisture content

In all experiments standard analysis of variance procedures were applied using MSTAT C

RESULTS AND DISCUSSION

The effects of inoculating haricot beans intercropped with sorghum

The results of the inoculation experiments under intercropping are summarized in Table 1 Uninoculated plants developed abundant but small ineffective nodules Inoculated plants developed large effective nodules Ex Rico 23 developed fewer nodules than the other cultivars sole-cropped and in association with sorghum Black Dessie produced the most effective nodules when inoculated in both systems Inoculation depressed the yield of Ex Rico 23 Local and Mexican 142 in association with both tall and short sorghum The yields of Black Dessie were improved by inoculation in association with both sorghum varieties All varieties responded to inoculation and produced their best grain yields in monoculture The variation in yield of the varieties may be attributed to their compatibility for intercropping Competition for nutrients by sorghum reduced bean yields

Table 1 Effect of inoculation on nodule number and grain yield of four varieties of beans intercropped with two varieties of sorghum grown on a Rhodustalf

Cultivars		No of	Yield (kg/ha)		Inoculation efficiency
Sorghum	Bean	nodules	I	+I	(%)
ETS 2752	Ex Rico 23	80	514	243	111 5
ETS 2752	Black Dessie	95	429	743	+73 2
ETS 2752	Mexican 142	98	312	331	+6 1
ETS 2752	Local	100	647	307	110 7
IS 9333	Ex Rico 23	56	542	775	+21 0
IS 9333	Black Dessie	123	660	1326	+101 0
IS 9333	Mexican 142	104	1248	721	73 0
IS 9333	Local	88	950	1345	+42 0
	Ex Rico 23	64	841	1002	+19 1
	Black Dessie	176	785	929	+18 3
	Mexican 142	136	950	1274	+34 1
	Local	128	1379	1606	+16 5
SE (+)		30 2	193 0	327 7	

I = uninoculated +I = inoculated

Screening of rhizobia for nodulation and yield

Application of N depressed the nodulation of beans (Table 2) Maximum nodulation was obtained by inoculation with strain 899 on both soil types All strains enhanced DM production compared with the N control Application of N increased plant nitrogen contents Strain 2 increased N in beans by 438% on the Alfisol and Strain 632 by 225% on the Vertisol The grain N contents of uninoculated (N) plants were less than fertilized (+N) plants This shows that indigenous rhizobia are ineffective in fixing nitrogen Four strains (879 2 7100 and 144) produced 2 15% more grain than the yield obtained with the application of 100 kg N ha^{1} on the Vertisol On the Alfisol seven strains (2 7100 144 113 151 5 7033) increased the yield of Ex Rico 23 by up to 43% Except for Strain 640 all strains produced higher grain yields than the negative control (N) on the Alfisol but only nine strains outyielded the N control on the Vertisol Strains performed better on the Vertisol than on the Alfisol supporting the need for further screening

Table 2 The effect of different rhizobia strains on dry matter (DM) N content and nodule number of Ex Rico 23 grown on a degraded Alfisol

	Alfisol				Vertisol			
Strains	DM g/3 plants	N (%)	Nodule no /6 plants	Seed yield (kg/ha)	DM g/3 plants	N (%)	Nodule no /6 plants	Seed yield (kg/ha)
113	9 11	0 131	85	756	10 14	0 123	136	2144
45	8 55	0 162	48	636	15 77	0 126	39	1286
899	7 95	0 142	104	621	15 53	0 119	125	1740
7033	7 04	0 135	85	727	11 14	0 129	72	1504
2	6 72	0 172	65	1026	15 24	0 119	61	2217
879	6 48	0 151	66	638	15 15	0 161	66	2459
144	6 31	0 114	71	786	15 08	0 119	45	2189
151	6 28	0 121	68	738	14 05	0 140	86	2004
5	5 84	0 113	54	771	11 67	0 108	56	1806
115	5 83	0 116	41	606	12 14	0 127	58	1771
+N	5 53	0 210	31	718	13 37	0 251	31	2146
274	5 33	0 131	69	565	12 62	0 154	72	1125
7136	5 11	0 128	89	643	17 72	0 138	89	1872
639	5 05	0 115	61	624	12 96	0 119	32	1914
7100	4 79	0 118	52	935	15 66	0 122	82	2199
949	4 63	0 135	59	538	11 22	0 175	52	1619
348	4 29	0 113	60	577	14 32	0 175	48	1733
632	4 00	0 044	74	419	13 47	0 198	40	1798
640	3 08	0 043	48	249	11 63	0 115	62	1619
N	2 05	0 032	47	413	5 58	0 061	47	1857
7202				568	16 13	0 142	44	1979
948				421	11 67	0 126	63	1752
SE (+)	1 33	0 011	13 8	96 8	2 304	0 024	16 5	258 2
C V (%)				34 1				31 2

+N = uninoculated fertilized with N N = uninoculated unfertilized

The effects of mixed rhizobia on the nodulation and yields of bean genotypes on two soil types

Significantly ($P<0\ 05$) more nodules were produced by inoculation with a mixture of rhizobia strains (Tables 3 and 4) Application of N fertilizer depressed nodulation and the nodules produced were small and non-effective BAT 1258 produced the most nodules on the Vertisol and Calima on the Alfisol Inoculation with the mixture of strains produced 255 kg ha^{1} more grain yield than the uninoculated (N) plants and 153 kg ha^{1} more than the uninoculated (+N) plants on the Vertisol On the Alfisol 148 kg ha^{1} more grain than the uninoculated (N) and 36 kg ha^{1} more than the uninoculated (+N) control were obtained from inoculation G 11060 *yielded best on* the Vertisol and G 13671 on the Alfisol

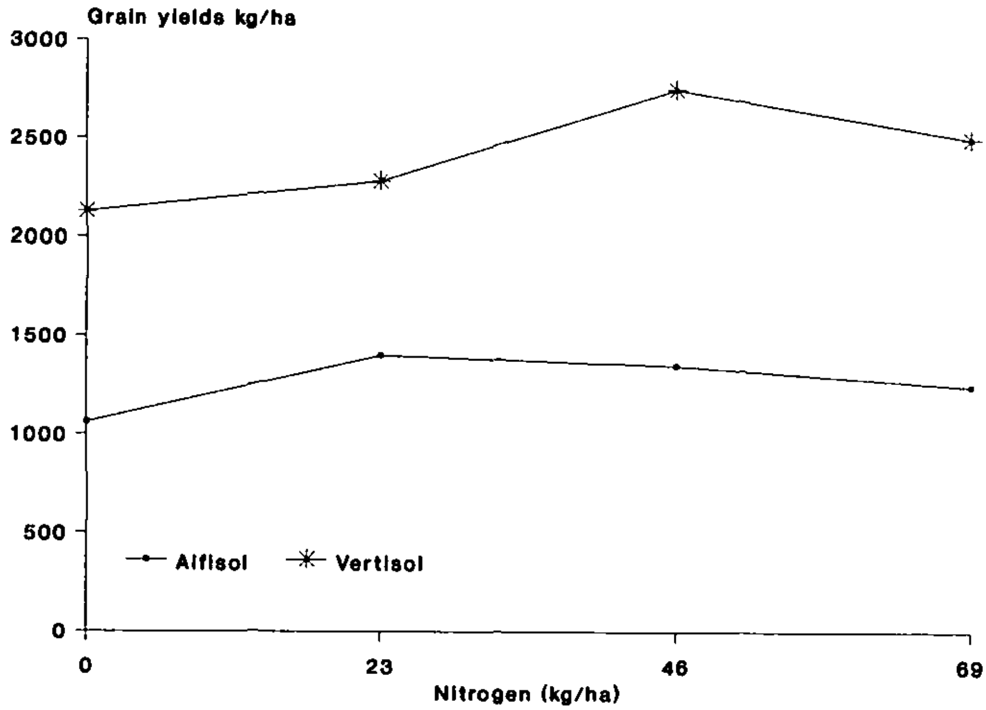
Table 3 The effect of mixed strains of inoculants and nitrogen on the number of nodules and grain yields of nine *P vulgaris* genotypes grown on a degraded Alfisol

	Number of nodules				Grain yields (kg/ha)			
Genotypes	+I	N	+N	Mean	+I	N	+N	Mean
Calima	255	199	100	158	2398	2580	2743	2574
Red Wolaita	236	106	62	135	1864	1129	1461	1485
G 13671	185	58	61	101	2678	2859	2773	2770
A 410	135	58	60	84	2058	2233	2101	2131
A 176	129	55	49	78	1748	1498	2085	1777
GLPX 92	122	34	39	65	1861	1986	1914	1920
G 2816	121	56	21	66	1635	1435	1802	1624
A 250	107	67	48	74	2524	1499	2001	2008
Ex Rico 23	82	49	44	58	1911	2128	1468	1836
Mean	152	54	60		2075	1927	2039	2014
SE(+) Main plots		15 3				268 9		
Sub plots		16 3				199 7		
LSD (5%)		80 4				983 5		
C V (%)						29 8		

Table 4 The effect of mixed strains of rhizobia and nitrogen on number of nodules and grain yields of nine *P vulgaris* genotypes grown on a Vertisol

	Number of nodules				Grain yields (kg/ha)			
Genotypes	+I	N	+N	Mean	+I	N	+N	Mean
BAT 1258	264	69	62	131	1447	1430	1879	1585
A 176	227	64	85	125	2259	1960	1982	2067
A 250	174	82	100	118	2259	1960	1982	2067
Red Wolaita	147	74	71	97	1748	1619	1509	1625
Neryat 138	145	46	49	80	2667	1982	2332	2327
BAT 1428	116	57	44	72	2684	1982	2280	2382
BAT 1225	116	50	60	75	2333	1860	1779	1990
BAT 304	110	33	52	65	1755	1387	1757	1633
G 11060	102	104	81	95	2684	2528	2933	2715
Ex Rico 23	64	58	37	53	1877	1849	1686	1804
Mean	146	63	64	91	2149	1894	1996	2013
SE(+) Main plots		23 6				226 5		
Sub plots		15 4				187 4		
LSD (5%)		75 6				920 3		
CV (%)						27 9		

Figure 1 Response of Mexican 142 to N application on two soil types at Alemaya



The effect of different levels of nitrogen on the yield of Mexican 142 on two soil types

Mexican 142 responded to the application of up to 23 kg ha[1] N on the Alfisol and up to 46 kg ha[1] on the Vertisol (Figure 1) Nodules were ineffective and scarce at high N levels Yields without fertilizer were 93% better on the Vertisol than on the Alfisol indicating the inherent variability of the soils With 46 kg N ha[1] the yield increase was 30% on the Vertisol and 26% on the Alfisol The monetary benefit from these increases amount to Birr 363 (US$ 175 at the official exchange rate) which is acceptable to an affording farmer With the increased demand for haricot beans and involvement of private large scale farms reliance on nitrogen fixation may not produce the required yield increases

CONCLUSIONS

Surveys of major bean growing areas of Ethiopia have revealed the large variability in nodulation and lack of effectiveness of the native rhizobia population Soil acidity low available phosphorus and removal of the biologically active top soil through erosion limit the potential of nitrogen fixation Nitrogen fixed by beans measured indirectly through increase in grain yield nitrogen content and number of nodules varied with strains genotypes soil characteristics and cropping systems Inoculated genotypes produced effective nodules and increased grain yields dry matter and nitrogen contents Further studies of competitiveness persistence strain and genotype selection for monoculture and intercropping systems are recommended

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ENHANCING COMMON BEAN YIELDS THROUGH BIOLOGICAL NITROGEN FIXATION AND IMPROVED N USE EFFICIENCY I SCREENING RHIZOBIAL STRAINS FOR N FIXATION POTENTIAL

Patrick K Jjemba

National Agricultural Research Organization
Kawanda Agricultural Research Institute Kampala, Uganda

ABSTRACT

The responses of the cultivars K20 and White Haricot to inoculation with 21 rhizobia strains from CIAT and one from NifTAL and to application of 40 kg/ha N were examined at low and high levels of soil fertility The low fertility treatment received no fertilizer and had alternate rows of finger millet (*Fleusine coracana*) to further deplete soil N the high fertility treatment received 25 kg/ha P (as TSP) and 30 kg/ha K (as MOP) There were substantial but non significant differences in shoot biomass between rhizobia strains at mid flowering (R6) At physiological maturity the seed yield of White Haricot was significantly better than that of K 20 Differences between strains were small Under low fertility the best seed yields per plant were obtained from K20 inoculated with CIAT 632 CIAT 45 and CIAT 949 in that order Under high fertility inoculation with CIAT 151 CIAT 7001 and CIAT 640 produced the best seed yields With White Haricot inoculation with CIAT 144 CIAT 45 and CIAT 112 produced the best yields Application of P and K increased the seed yield of the uninoculated control from 80 to 112% depending on the cultivar suggesting a need to provide nutrients even in the absence of inoculation Shoot N content showed similar trends

INTRODUCTION

Improvements in bean production in Uganda have resulted more from increased acreage than from production per unit area (Sengooba 1987) primarily due to the widespread lack of use of inorganic fertilizers Fertilizer trials in the past at a few locations have shown requirements for 26 43 kg/ha P_2O_5 more than 34 kg/ha N and 45 kg/ha K depending on location (Leakey 1970 Rubaihayo *et al* 1981 Stephens 1967) Of these nutrients nitrogen is most expensive and liable to heavy losses once applied Without fertilizer yields on farmers plots have remained as little as 700 kg/ha or less

A cost benefit analysis shows that application of the required heavy doses of fertilizers to the crop may not always be economic (Kisakye *et al* 1987) It is thus important to exploit the benefits accruing from the still unpopular practice of inoculating beans and other legumes to establish efficient symbiotic N fixation systems This requires identification of both bean cultivars and rhizobial strains which fix N most efficiently under Uganda conditions

Genotypic variation for N fixation has been reported in beans (Bliss 1985 Graham and Rosas 1979 Hardarson *et al* 1991) Extensive screening of bean landraces for N fixation has not been carried out in Uganda A previous study has shown beans to respond to N levels of over 80 kg/ha combined with inoculation (Jjemba unpublished) The present study was initiated to seek effective and competitive exotic rhizobial strains under field conditions It is also a future objective to evaluate the potential of inoculation technology in different agroecological zones and management regimes within Uganda

METHODOLOGY

Plots of single rows 3 m long of the bean cultivars K20 and White Haricot were established with finger millet (*Eleusine coracana*) on either side of each row to continously deplete soil N For beans the spacing was 10 cm within and 40 cm between rows The experiment was split into low and high fertility management The latter involved application of 25 kg P/ha (as TSP) and 30 kg K/ha (as MOP) Fertilizer application was by banding approximately 5 cm from the sowing positions at sowing Inoculation treatments were 22 rhizobial strains most of them with known attributes (Table 1) applied in 3 g of a peat based granular inoculant per plot at sowing In addition there were plus N (40 kg/ha) and minus N controls Six plants from each bean row were harvested at mid flowering (R6) 36 days after planting (DAP) for K20 and 42 DAP for White Haricot to determine shoot root and nodule dry weight Further harvesting was at physiological maturity (76 DAP for K20 and 89 DAP for White Haricot) to determine seed and shoot biomass and shoot N content

Table 1 Rhizobial strains used and their attributes

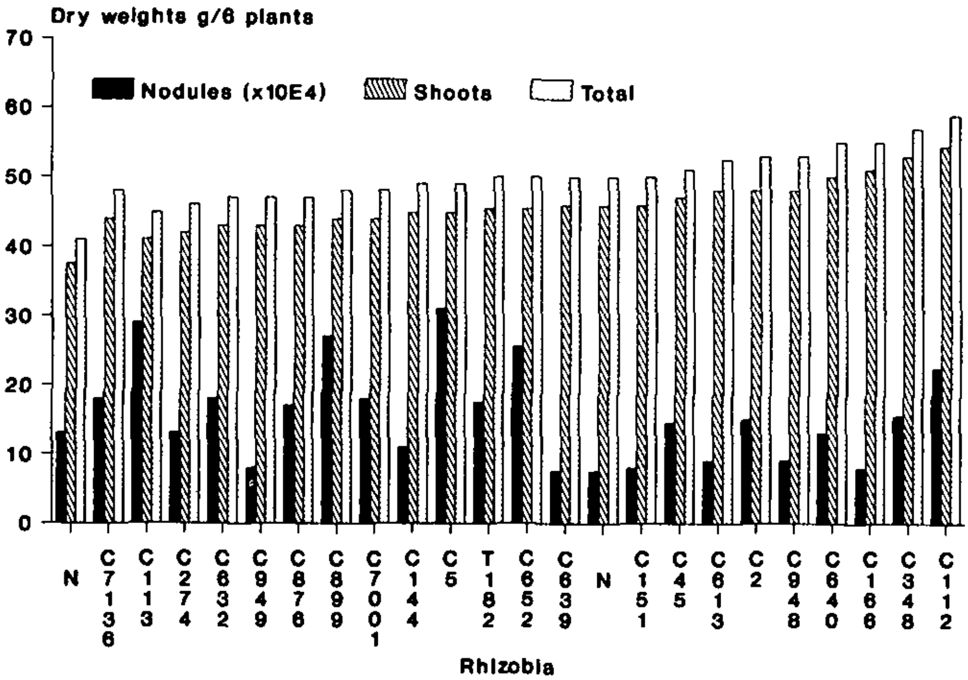
Strains	Adaptation	References
CIAT 2	NK	CIAT (1988)
CIAT 5	Cool climate	
CIAT 45	Warm climate	
CIAT 112	NK	NK
CIAT 113	NK	NK
CIAT 144	Acid soil/General	CIAT (1988)
CIAT 151	NK	NK
CIAT 166	Warm climate	CIAT (1988)
CIAT 274	NK	NK
CIAT 348	NK	NK
CIAT 613	Cool climate	CIAT (1988)
CIAT 632	General	
CIAT 639	Acid soils	
CIAT 640	Warm climate	
CIAT 652	Acid soil/General	
CIAT 876	Acid soils	
CIAT 899	Acid soil/General	
CIAT 948	NK	NK
CIAT 7001	Cool climate	CIAT (1988)
CIAT 7136	NK	NK
TAL 182	Effective	Somersegaran and Hoben (1986)

from Makerere University Inoculant Production Unit NK = not known

RESULTS AND DISCUSSION

At mid flowering there were no significant differences among treatments Inoculation with CIAT 112 CIAT 348 and CIAT 166 produced the largest biomass and no inoculation produced the least (Figure 1) CIAT 5 CIAT 113 and CIAT 899 induced the best nodulation which was not significantly correlated with shoot or total biomass Uninoculated plants had greater nodule biomass than several inoculated plants particularly those inoculated with CIAT 639 CIAT 151 CIAT 166 and CIAT 949

Figure 1 Shoot nodule and total dry weights of beans at mid flower after inoculation with various rhizobia



Application of both P and K significantly increased seed yield by an average of 17% The seed yield of White Haricot was significantly ($p<0\ 05$) greater than that of K20 With cultivar K20 inoculation with CIAT 632 CIAT 45 and CIAT 949 produced the best seed yields at low soil fertility status though these did not differ significantly from the yield of the uninoculated treatment (Figure 2) At high fertility inoculation with CIAT 151 CIAT 7001 and CIAT 640 produced the best seed yields but these were not significantly better than the yields from application of P and K alone For this cultivar there were no differences within strains following application of both P and K However strains CIAT 151 CIAT 640 CIAT 876 CIAT 899 and CIAT 7001 gave 73 7 59 7 48 6 53 and 80 9% more yield respectively on supplying P and K than where they were not supplied This indicates that seed yield would be greatly restricted on inoculating with any of these strains without supplying both P and K It is interesting to note that supplying both of these nutrients without inoculating significantly enhanced seed yield by 80% Application of 40 kg/ha mineral N only slightly increased seed yield compared to the uninoculated control under low fertility and there was no increase from mineral N P and K compared to the uninoculated control with the same fertility status

For White Haricot inoculation with CIAT 144 CIAT 45 and CIAT 112 produced slightly larger seed yields at low fertility and CIAT 7001 CIAT 144 and CIAT 112 at high fertility (Figure 3) In high fertility inoculation with CIAT 7001 gave a significantly ($p<0\ 05$) better seed yield than the uninoculated control Application of P and K increased the seed yields induced by CIAT 112 CIAT 113 CIAT 144 CIAT 166 and CIAT 7001 by 60 5 83 9 83 1 75 9 and 263 3% respectively Without inoculation P and K increased seed yields significantly by 112 2% over the control The uninoculated treatment which received both P and K gave a slightly better seed yield than supplying mineral N though this difference was not significant

Figure 2 The effects of inoculation with various rhizobia on the yields of K 20 with and without P and K

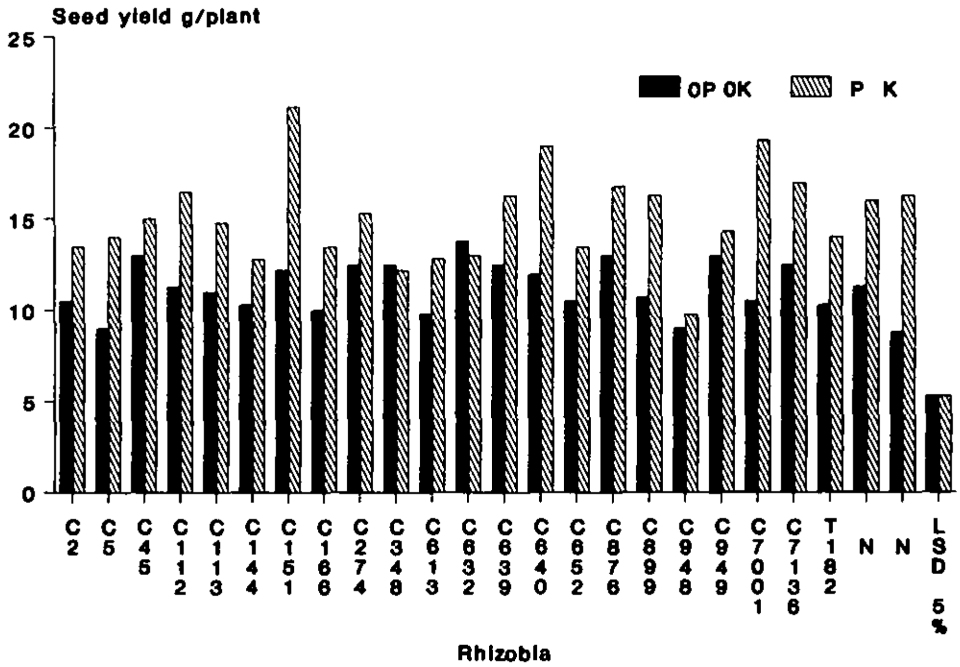
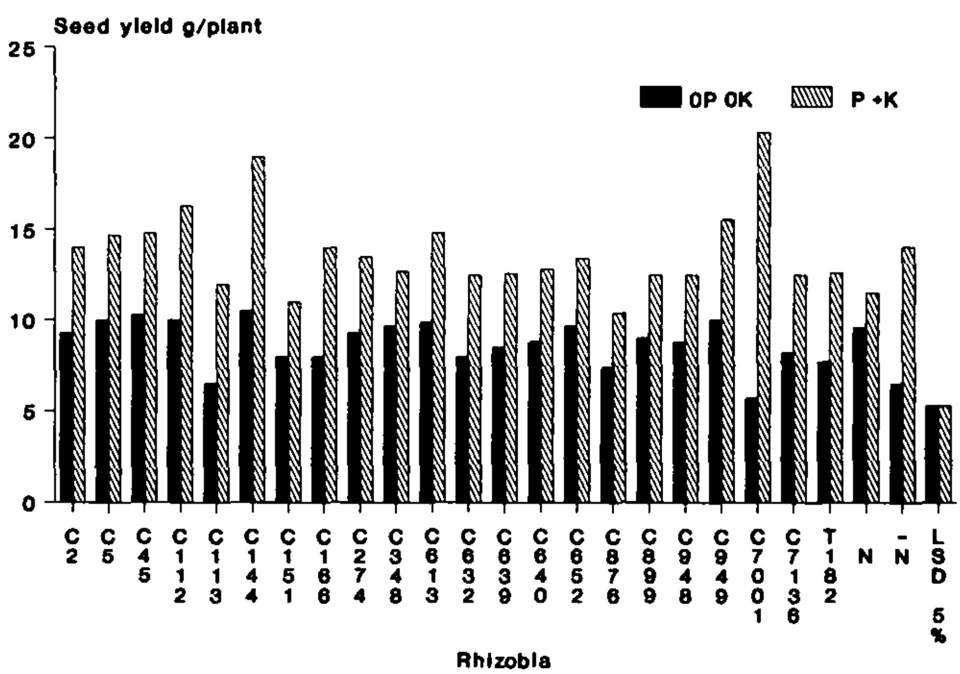


Figure 3 The effects of inoculation with various rhizobia on the yields of White Haricot with and without P and K



White Haricot (1 731 mg/plot) had significantly greater shoot N than K20 (1 402 mg) but there was no significant difference among strains none of the interactions was significant Application of P and K increased shoot N (Figures 4 and 5) but this was significant only with strains CIAT 144 151 and 639 inoculated on K20 and CIAT 151 and 949 on White Haricot Application of P and K to K20 without inoculation significantly increased shoot N (Figure 4) P and K with 40 kg/ha N greatly increased the shoot N of White Haricot but this was not significant (Figure 5) It should be noted that shoot N did not include pods and seeds which tend to accumulate N in the form of protein However since comparisons are within cultivars similar trends would be expected

The shoot N content of K20 was greater when inoculated with CIAT 112 632 and 348 when neither P nor K were applied while CIAT 613 151 and 632 slightly excelled following application of both these nutrients With White Haricot inoculation with CIAT 948 348 and 45 appears more promising in terms of shoot N content without P and K With P and K inoculation with CIAT 151 613 or 948 produced comparatively higher shoot N contents

A previous pot study has shown that rhizobial inoculation with less than 10^8 cells/g soil does not induce yield responses due to competition from indigenous rhizobia (Table 2 Figure 6 Jjemba in preparation) Preliminary studies (Figure 7 Jjemba unpublished) have shown conspicuous yield responses to inoculation and increasing levels of mineral N ranging from 0 to 80 kg/ha indicating that beans require N in the range of 80 kg/ha or more Edje *et al* (1975) also demonstrated responses of dry beans to N reporting yields of 3779 kg/ha when 200 kg/ha N was applied under irrigation Similar results have been reported by Keya *et al* (1982) from multilocational trials

Table 2 The effects of inoculum concentration and P on plant dry weight and N concentration in pots

Inoculum level (cells/ g soil)	P added P_2O_5 kg/ha	Dry weight (g/pot) Shoot	Root	Nodule	Total	Total N (mg/ pot)
10^0	0	3 63b	1 24	0 10bc	4 97b	80 1bc
	100	3 35bc	0 90	0 20a	4 46bd	84 8b
10^2	0	2 63cd	0 87	0 07c	3 58de	68 5bc
	100	3 31bc	1 07	0 18ab	4 56bd	83 8bc
10^4	0	2 89bd	0 86	0 10bc	3 86be	72 3bc
	100	3 69b	0 99	0 09c	4 78bc	81 4bc
10^6	0	3 64b	0 99	0 07c	3 66ce	57 7c
	100	3 64b	0 99	0 07c	4 72bd	74 6bc
10^8	0	5 74a	1 25	0 10bc	7 10a	124 6a
	100	5 45a	1 29	0 09bc	6 85a	114 5a
Peat	0	2 22d	0 71	0 07c	3 01e	57 3c
	100	3 23bc	0 85	0 06c	4 14be	74 1b
C V (%)		13 1	27 2	43 6	13 1	16 9
P level		**	NS	*	*	NS
I level		***	NS	*	***	***
P X I		NS	NS	NS	NS	NS

Means accompanied by the same letter within the column are not significantly different at P<0 05 according to Duncan s multiple range test

Figure 4 The effects of inoculation with various rhizobia on shoot N content of K20 with and without P and K

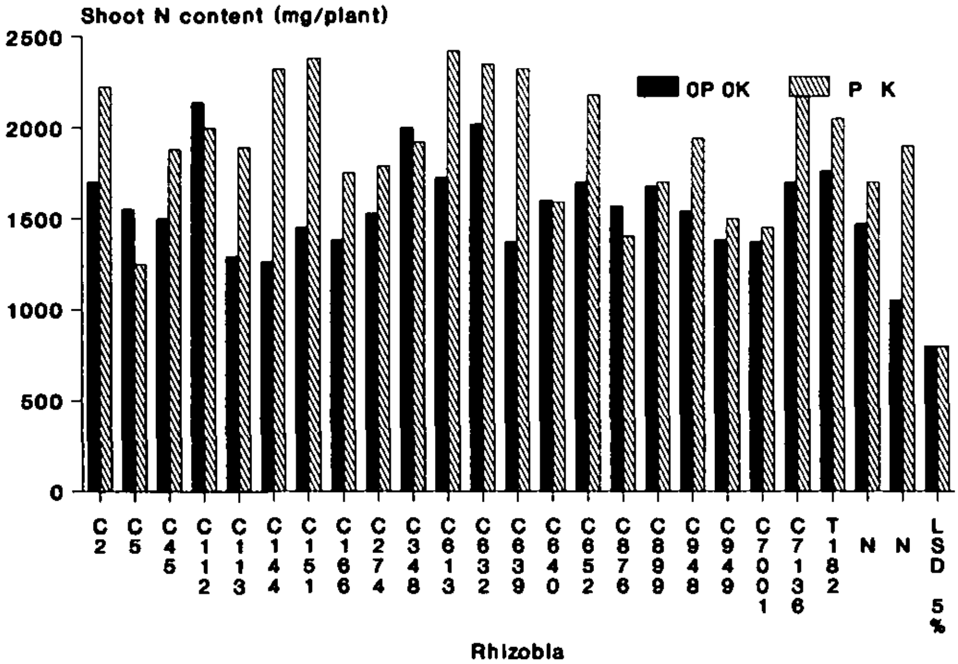


Figure 5 The effects of inoculation with various rhizobia on shoot N content of White Haricot with and without P K

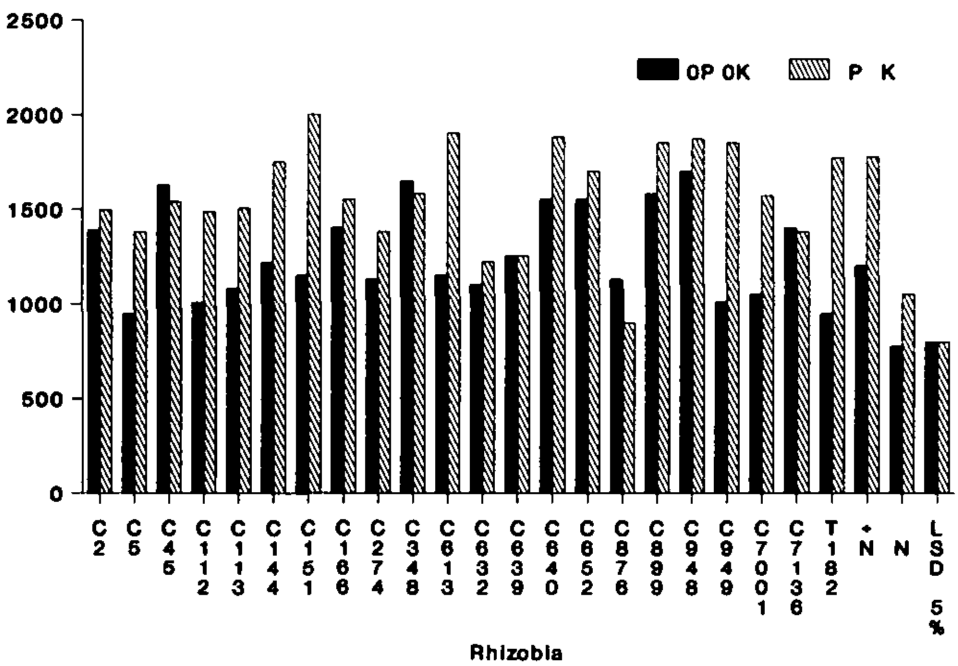


Figure 6 The effect of inoculation rate on total N fixed by beans

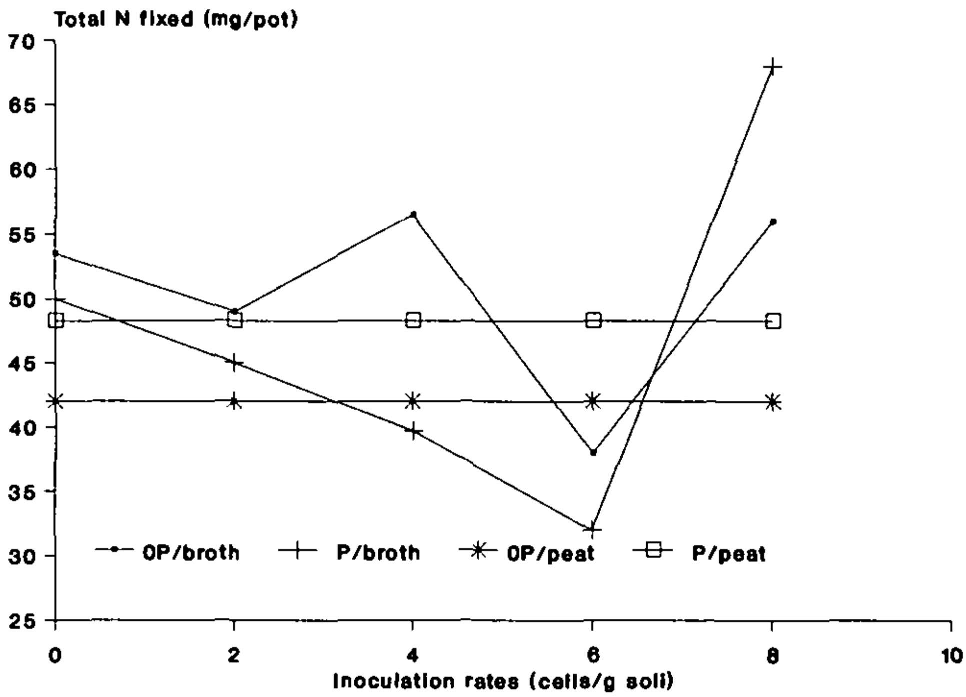
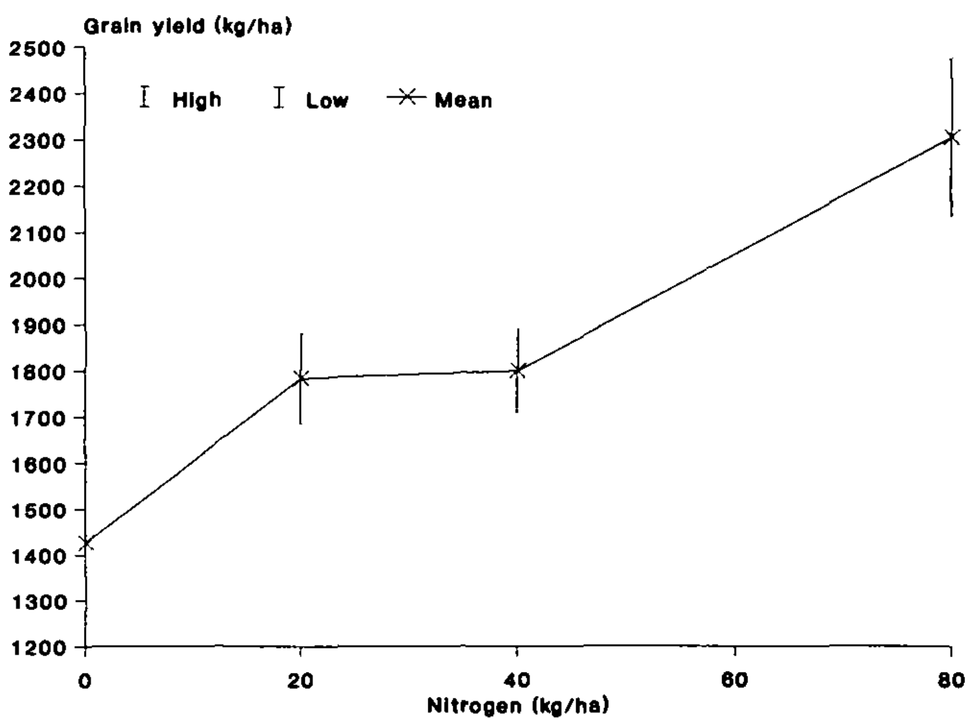


Figure 7 Response of K20 to mineral N



It seems therefore that beans require N fertilizer or establishment of a highly efficient symbiotic N fixation system for optimum yields Inoculation may fail due to lack of sufficiently high numbers of the desirable inoculant strain It is important to investigate the potential of indigenous rhizobial strains especially when their population levels are adequate to ensure good nodulation It is also of important to supply other limiting nutrients particularly P and K if biological nitrogen fixation programmes are to succeed Subsequent work will therefore include a comparison of fewer (9) promising exotic strains under field conditions with several indigenous strains that have been successfully isolated

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SCREENING BEANS FOR MANGANESE TOXICITY TOLERANCE IN UGANDA

Victor A Ochwoh

Department of Soil Science, Makerere University, Kampala

ABSTRACT

In samples from areas of Uganda thought to be high in manganese Mn concentrations of Mn varied from 200 to 640 ppm in soils and 100 to 842 ppm in leaves much greater than concentrations considered to be toxic to sensitive plant species Based on these surveys sites have been selected for screening for Mn tolerance Soil compaction has been shown to dramatically increase Mn concentrations of soils and leaves but furrowing had no consistent effect Application of major nutrients particularly K tended to depress soil Mn The effects of liming on soil Mn were erratic Mn tolerance scores were rather variable and rankings for Mn tolerance of 124 ANSES entries were inconsistent between seasons presumably because of the irregular field distribution of excess Mn MCM 5001 was among the best yielding entries across two seasons indicating that more recently released cultivars are better adapted to poor soils Genotypes with small seeds are more tolerant of excess Mn than large seeded genotypes conforming with findings in South America

INTRODUCTION

Manganese toxicity to plants is one of the principal soil fertility problems in Uganda It has been shown that excess manganese is the main cause of the patchy unproductive soils locally known as *lunyu* in Buganda and in major bean growing areas of south western Uganda High manganese is commonly associated with soil acidity However on some soils of Uganda problems of Mn toxicity occur where they are least expected (Le Mare 1977) Generally high Mn uptake is associated with low pH but is occasionally observed with poor drainage high organic matter or volcanic soils However Mn toxicity also occurs on soils of moderate pH and good drainage that are neither volcanic nor high in organic matter Such soils are found in areas where crush breccias (brecciated quartzose rocks) are common The breccias probably derived their iron and manganese from the laterites of the Buganda surface (Chenery 1960) Wayland (1921) reported that Mn was common in the lateritic ironstone of the Buganda surface Thus all soils derived from erosion of the Buganda surface are likely to contain much Mn but those below breccia ridges are probably richer as are the soils near veins and swamps derived from the breccia This would agree with the observation that *lunyu* soils are commonest near swamps

Excess Mn is harmful to many crops which differ widely in their reactions In particular legumes are more sensitive than non legumes (Foy 1976) In Uganda beans cotton banana, simsim and groundnuts have been shown to be very susceptible to Mn toxicity especially where water is not plentiful for example after a prolonged dry season In contrast tea sweet potatoes finger millet and soybeans are relatively tolerant (Chenery 1954 Jones 1976 Le Mare 1977) Andrew (1976) found 10 ppm Mn in solution to drastically affect plants within the sensitive group while moderately tolerant groups would thrive in concentrations of 20-40 ppm Howeler (1983) reported critical sufficiency and toxic levels of Mn in the youngest fully expanded leaf of beans during early flowing of <20 140 >200 ppm Mn respectively

MANAGEMENT OF SOILS WITH HIGH MANGANESE

It is recognized that oxidation and reduction of Mn compounds control the amounts of Mn available In Uganda mulch ash manure composts lime and adjustment of the P Ca ratio have been suggested for amelioration of the harmful effects of excess Mn (Jones 1976 Le Mare 1977 Zake 1986) Oxidation may reduce the availability of Mn to the extent that deficiency occurs while reducing conditions may lead to accumulation of toxic levels of Mn in soils Dobereiner (1966) found that both beans and soybeans developed nodules and fixed N satisfactorily at very low pHs provided Mn toxicity was not a limiting factor

Other factors influence the availability of Mn in soils The roots of some crops probably play an active role in promoting dissolution of Mn oxides through the expression of short lived reducing compounds (Bromfield 1958) Wortmann and Sengooba (1990) reported that beans intercropped with banana took up more Mn and were more affected than sole crop beans It is not yet ascertained whether excess Mn was washed down from banana leaves mulching with banana leaves led to subsequent release of Mn on decomposition mulching simply encouraged the availability of Mn and thus more uptake by beans or banana root exudate played an active role Compaction of soils is also known to raise the levels of available Mn Compaction seems to increase contact between the roots and Mn oxides or blocks the capillary movements of Mn

Mn also interacts with other elements within both soils and plants The elements which have been found to affect Mn nutrition include Fe P Ca and Mg and an excess of one can decrease the uptake of the other and cause deficiency There are also reports that P fertilizers increase Mn uptake by plants (Page 1963 Larsen 1964) This could be due to the acid solution that diffuses through the soil from a band of monocalcium phosphate which carries a high concentration of Mn (Lindsay *et al* 1959)

SCREENING BEANS FOR MN TOXICITY TOLERANCE

Following earlier observations (Neenan 1960) of varietal differences in the tolerance of wheat and barley to soil acidity Foy *et al* (1967) found similar varietal differences in dry beans snap beans lima beans cotton and tomatoes Foy *et al* (1973) showed that the differences were derived from variations in sensitivity to Mn and Al toxicity and the relative requirements of P and bases

Thus a rational scientific basis was established for the selection of lines adapted to a particular stress as well as breeding for tolerance which became viable options for improving production in the presence of toxic or deficient supplies of plant nutrients Efforts have been made elsewhere to select crop plants that tolerate adverse soil conditions usually toxic levels of exchangeable Mn and Al and deficient levels of exchangeable P and some bases Thus there is potential to screen and select bean genotypes that thrive well at toxic levels of Mn in Uganda This offers the possibility of reducing requirements for lime P and possibly other fertilizers for the production of bean crops on soils with Mn toxicity

OBJECTIVES

1 Screen 280 bean genotypes for tolerance to Mn toxicity

2 Verify and adapt a rapid laboratory technique for screening for Mn toxicity tolerance

3 Develop appropriate techniques for the control of Mn toxicity and associated problems

MATERIALS AND METHODS

The first cycle of the Afncan Network for Selection for Edaphic Stresses (ANSES) nursery compnsed 280 entnes contnbuted by participating national programmes in Africa Cnteria for the selection of these entnes was evidence for tolerance to one or more edaphic stresses and that they be well adapted varieties either released or in advanced stages of testing In 1991 the ANSES nursery was grown at Lyamungu in Tanzania (for low P evaluation) at Mulungu in Zaire (high Al) Buikwe in Uganda (high Mn) and at Nakasongola also in Uganda (low N P)

Selection for tolerance to high soil Mn availability was according to one of the six criteria high Mn yield 15 x stress symptoms at V4 (leaf coloration) high Mn yield 25 x stress symptoms at V4 (leaf coloration) high Mn yield 15 x stress symptoms at R7 (brown specks) high Mn yield 25 x stress symptoms at R7(brown specks) ratio of high Mn yield to adequate fertility (Nakasongola) yield Based on these cnteria, 124 entnes that appeared tolerant of Mn toxicity were selected Fourteen that appeared susceptible were selected to develop a rapid screening technique for tolerance to high Mn

Tnal design and layout

Number of entnes Season 1 (1991B) 280 Season 2 (1992A) 124 Season 3 (1992B) 36 Season 4 (1993A) 36

Design Randomized complete block of 2 replicates in Season 1 and 4 replicates in season 2 lattices of 4 replicates in Season 3 and 3 replicates in season 4

Randomization In Seasons 1 and 2 entnes were grouped as climbing or non-climbing and randomized within groups For the third and fourth seasons randomization was based on a square lattice

Plot size Plots were of two rows in Seasons 1 and 2 three in Season 3 and four in Season 4 all were 3 m long and spaced 0 5 m apart Plots were 0 8m apart Plants were 10 cm apart within rows

Paths Across the rows (between decks or ranges) 1 m in width

Check cultivars Canoca for non-climbers G 2333 for climbers Local checks have also been included

Evaluation includes emergence score vegetative vigour at V4 R5 Mn toxicity symptoms at V4 R5 brown specks at R7 diseases insects numbers of plants harvested and plot yield There will also be foliar analysis at R5 and R7 total above ground biomass and Mn uptake in shoot at R7 and soil nutnent status at R5 and R7

RESULTS AND DISCUSSION

Work so far includes

a) preliminary surveys of soils high in Mn

b) tnals on the management of expenmental sites and

c) ANSES collaborative research

Preliminary surveys of soils high in Mn (Experiment 1)

Soils and leaf samples were collected from areas indicated to be associated with (i) high Mn but moderate to high pH Kyebe Catena near Buikwe Koki Catena Buruli Catena (Wobulenzi) and Namulonge in the central Region and (ii) high Mn and Al with low pH Bushenyi and Kabale major bean growing areas of southwestern Uganda

Analyses of soil and leaf samples showed that available Mn varies between 200 and 640 ppm Moderately tolerant plants can accommodate up to 40 ppm Mn in the soil solution (Andrew 1976) Results of analyses are shown in Tables 1 2 and 3

Table 1 Chemical characteristics of soils with excess Mn and moderate pH

	pH	Mn (ppm)	P (ppm)	K me/100g	Ca me/100g	N %	OM %	Al me/100g
Buikwe								
(i)	5 7	640	36 7	0 58	3 13	0 18	6 55	na
(ii)	4 6	450	25 7	0 45	1 88	0 11	5 73	0 33
(iii)	5 2	320	30 8	0 26	1 56	0 21	8 19	na
(iv)	6 0	540	37 0	0 51	3 06	0 25	7 37	na
Namulonge								
Sendusu	6 0	200	55 2	1 22	5 94	0 18	6 50	na
Nalumuli	5 9	600	31 7	1 73	8 44	0 14	7 02	na
Kirimantungo	6 1	410	25 5	1 54	7 19	0 21	8 10	na
Nasirye	6 3	300	25 1	1 60	7 50	0 11	4 80	na
Luwero (Wobulenzi)								
Sempa I	6 1	510	23 5	0 58	3 75	0 25	4 00	na
Sempa II	6 2	380	42 9	1 60	3 13	0 22	4 51	na
Kyootamugavu	6 9	240	28 7	2 88	3 25	0 14	5 17	na
Wabiyinja	6 3	460	35 8	0 90	4 69	0 13	5 00	na
Koki (Rakai)								
Lwebula I	5 7	356	1 1	0 13	3 0	0 11	2 51	na
Lwebula II	5 9	502	4 3	0 26	5 5	0 21	6 04	na
Lulagala	5 6	560	1 1	0 13	4 0	0 18	2 96	na

na = not analysed

Table 2 Chemical characteristics of leaves from soils with excess Mn and moderate pH

Site	Crop	Mn ppm	P %	K %	Ca %
Buikwe					
(i)	Beans	842	0 31	1 0	0 68
(ii)	Beans	640	0 52	1 5	1 03
(iii)	Beans	450	0 47	0 7	0 59
(iv)	Beans	750	0 42	0 9	0 65
Namulonge					
Sendusu	Beans	290	0 73	1 00	0 77
Nalumuli	Soybeans	140	0 68	0 55	0 44
Kirimantungo	Soybeans	160	0 57	0 90	0 70
Nasirye	Groundnuts	190	0 52	1 20	0 92
Luwero (Wobulenzi)					
Sempa I	Beans	240	0 25	0 35	0 12
Sempa II	Beans	620	0 42	1 00	0 75
Kyootamugavu	Beans	340	0 57	0 80	0 62
Wabiyinja	Beans	100	0 31	0 65	0 53

Table 3 Soil analysis of soils with excess Mn and Al

	pH	Mn (ppm)	P (ppm)	K me/100g	Ca me/100g	N %	OM %	Al me/100g
Bushenyi								
Rubare I	4 7	301	15 5	0 13	4 00	0 11	3 79	na
Rubare II	4 6	314	11 0	0 30	3 50	0 18	2 63	na
Bushenyi D F I	4 0	247	2 7	0 05	1 00	0 21	4 11	1 95
Kabale								
Kachwekano I	4 3	240	0 9	0 38	3 70	0 25	12 83	3 30
Kachwekano II	5 2	320	0 0	0 33	3 70	0 28	10 73	na
Kachwekano III	4 2	480	0 0	0 17	1 45	0 14	6 66	2 10
Kachwekano IV	4 4	560	0 0	0 38	3 25	0 42	9 95	3 80

Trials on the management of experimental sites (Experiment 2)

On the basis of the results obtained in Experiment 1 a suitable area was selected in Buikwe (Kyebe Catena) where currently screening experiments are being carried out Another area has been secured in Sempa (Wobulenzi) to which screening trials will be extended in 1993A

Management of trials that have been conducted included compaction furrowing and NPK and lime application Preliminary results show that compaction greatly increases Mn concentration in the soil and the amount taken up by bean plants (Tables 4 and 5) Furrowing has not shown a clear response This could be due to heavy rain washing applied fertilizers from adjacent plots and concentrating them in the furrows making them more fertile than the surrounding plots Additions of NPK especially K appeared to counteract the adverse effects of Mn toxicity (Tables 4 and 6) Liming had no consistent effect (Table 7) but tended to decrease yield

Table 4 Effects of K application furrowing and compaction on soil chemical characteristics at Buikwe in 1991A

Treat ment	pH	Mn ppm	P ppm	K me/100g	Ca me/100g	Na me/100g	N %	Total P(ppm)
Experiment I (farmer's field)								
K	5 2	320	30 75	0 26	1 56	0 17	0 18	130
+ K	5 1	440	30 66	0 38	1 88	0 17	0 25	84
Experiment II								
Control	4 8	350	30 60	0 45	1 88	0 22	0 18	150
Furrowed	4 9	260	30 45	0 51	2 50	0 20	0 11	165
Compacted	4 6	450	25 66	0 45	1 88	0 22	0 11	160

Table 5 Effects of furrowing and compaction on bean leaf chemical analysis in Experiment II at Buikwe in 1991A

	%					ppm						
	N	P	K	Ca	Mg	Mn	Fe	Cu	B	Al	Zn	Na
Control	3 26	0 39	2 27	0 98	0 35	264	171	12	32	400	42	15
Furrowed	3 33	0 37	2 27	1 03	0 36	332	212	12	27	558	40	28
Compacted	2 96	0 29	2 34	0 97	0 27	842	336	10	21	887	34	15

Analysis by courtesy of Agricultural Analytical Services Laboratory Penn State University University Park PA 16802 U S A

Table 6 Effects of N P and K application on leaf chemical characteristics in Experiment I (farmers field) at Buikwe in 1991A

Treatments	%P	%K	%Ca	Mn(ppm)
NP 1	0 47	0 70	0 59	450
NP 2	0 31	0 50	0 50	340
NP 3	0 31	0 40	0 44	220
NP-4	0 37	0 50	0 50	250
NPK 1	0 47	0 70	0 56	300
NPK 2	0 52	0 80	0 92	160
NPK 3	0 25	0 85	0 68	350
NPK-4	0 31	0 70	0 59	340
NP 5	0 42	0 60	0 53	370

Table 7 Effects of liming on soil chemical characteristics at Buikwe in 1990B

Treat ment	pH	Mn ppm	P ppm	K me/100g	Ca me/100g	Na me/100g	N %	Total P(ppm)
LO	5 7	640	36 70	0 58	3 13	0 20	0 18	105
L1	6 2	320	36 75	0 70	4 06	0 20	0 18	250
L2	6 0	540	37 01	0 51	3 13	0 22	0 21	255
L3	6 7	170	38 72	0 58	4 38	0 22	0 18	165

A preliminary screening trial of 16 entries (Table 8) was carried out in Buikwe Severe symptoms of Mn toxicity were visible In terms of yield the best five entries were all small seeded and the seeds of three of these were black

Table 8 Effects of Mn on the yields of 16 entries and of lime and NPK on K20

Entries	Foliar Mn (ppm) R5	Variety mean yield (g/plot)	Visual score R5
Black Dessie	184	44 5	3
Rio *Tibaji*	151	89 7	4
IPA 7419	161	81 9	4
95059	164	76 8	2
Calima	164	48 9	3
A 283	207	59 5	1
ZPv 292	117	42 7	2
Pintado	129	37 4	3
AFR 88	126	18 7	2
EMP 84	142	49 3	1
BAT 41	156	61 0	4
BAT 271	180	37 0	4
BAT 477	137	60 1	2
94000	137	85 8	1
Porillo Sintetico	242	111 5	2
Carioca	120	60 8	3
K20 (L0)	104	417	
K20 (L1)		394	
K20 (L2)		418	
K20 (L3)	123	335	
K20 (NP)	320	326	
K20 (NPK)	440	425	

LO L3 = levels of lime visual ratings VO R5 i e from germination to preflowering yields of first 16 entries g/line for K20 g/plot

ANSES Collaborative Research Sub Project

Based on tests of 280 entries in 1991 124 entries (Table 9) were selected for the trial at Buikwe in 1992B The ranking of varieties for tolerance was inconsistent with the previous season SUA 90 and AFR 298 which ranked top and second for tolerance (determined by stress symptoms and yield) in 1991B were 22nd and 30th *in* 1992A This can be partially attributed to characteristic patchy distribution of excess Mn in the field In order to counteract such defects a similar screening experiment was sown in Sempa (Wobulenzi) this season (1993A) In this trial Carioca and Calima did not perform according to expectation and Rubona 5 out performed K20 among the varieties that have been released to farmers

Table 9 Bean genotypes selected from 280 promising varieties for tolerance to low P low N and high Mn (selection based primarilly on yield under stress over two seasons of testing

High Mn	Low P	Low N
CAL 32 (RAYT 18)	RWR 382	MCM 5001
AFR 542 (PYT LS 9)	RAB 482 (RIYT 43)	ZPV 292
RWK 5	RWK 8	NEPA 29
BAT 25	MMS 250 (RIYT 1)	Black Dessie
G 5053 (PYT 1-4)	PEF 6 (PYT LS 6)	OBA I
AFR 88	RWK 5	DOR 404
Em 40	CLK 13	PVA 774 (RIYT 36)
AND 61	PEF 14 (PYT LS 8)	PAD 126
AFR 300	MUS 97 (RIYT 5)	A 197
BAT 85 (VEF 79)	AFR 544 (PYT LS 4)	XAN 76 (RIYT 34)
RAB 445 (RAYT 8)	6088	AFR 378
A 321	MMS 224 (RAYT 9)	CAL 96
IZ 0201475	ZAN 76	Rubona 5
GLP 585	AFR 403 (RAYT 24)	SUG 69
XAN 76 (RIYT 34)	MCM 5001	AFR 531
Muyiga	XAN 76 (RIYT 34)	AND 871
RAD 52 (RAYT 8)	BRU 22	LRK 29
RAO 55 (RAYT 14)	Pintado	RWR 982
433	RAB 76 (RIYT 30)	IZ 0201240
DOR 375 (RAYT 30)	MMS 253 (RIYT 33)	Urugezi
PAD 114 (PYT MS 2-4)	Ikinimba	AND 829
OBA I	Porillo Sintetico	SUA 90
MUS 18 (RAYT 31)	RAO 55 (RAYT 14)	AFR 476
ZAN 76	OBA 1	RWR 980
Black Dessie	Calima	A 120 (VEF 80)
Carioca	433	AFR 544 (PYT LS 4)
MMS 243 (RIYT 11)	MMS 232 (RIYT 19)	AFR 13
PAI 112	NIC 116 (RIYT 10)	RWR 221
MMS 224 (RAYT 9)	Carioca	Urubonobono
SUA 90	BAT 85 (RIYT 27)	AFR 298
PEF 14 (PYT LS 8)	PAI 112	Lyamungu 85
BAT 85 (RIYT 27)	GLP 585	NEPA 38
RWR 382	RAO 52 (RIYT 8)	KID 34 (PYT LS 17)
AFR 544 (PYT LS 4)		

At Buikwe in 1992B the scores for brown speck and stress at V4 were rather variable (CVs of 44 7 and 54 7% respectively) and differences among entries were not significant However MCM 5001 which with CAL 96 has recently been released to farmers was the best yielder in 1992B (Table 10) and in 1992A indicating that recent releases are better adapted than previous varieties to poor soils However RWR 221 which is well adapted to poor soils in Rwanda does not perform well in Uganda but despite some inconsistences in performance small seeded varieties still show greater tolerance to Mn toxicity than large seeded varieties This conforms with findings in South America and especially Brazil

Table 10 Yields (g/line) of entries in high Mn ANSES Nursery at Buikwe in 1992B

Entries	Yields
MCM 5001	685
ZPv 292	411
NEPA 29	392
Black Dessie	542
OBA 1	403
DOR 404	327
PVA 774 (RIYT 36)	349
PAD 126	439
A 197	490
XAN 76 (RIYT 34)	753
AFR 378	462
CAL 96	369
Rubona 5	413
SUA 69	409
AFR 501	438
AND 871	542
LRK 29	338
RWR 982	457
IZ 021240	500
Urugezi	591
AND 829	309
SUA 90	280
AFR 476	386
RWR 980	446
A 120 (VEF 80)	657
AFR 544 (PYT LS-4)	306
AFR 13	260
RWR 221	674
Urubonobono	410
Lyamungu 85	417
MCM 2001	381
Carioca	333
NEPA 38	274
K20	252
RWR 382	670
KID 34 (PYT LS 17)	507
Mean	441
S E (±)	73 9
C V (%)	33 4

Work for seasons 1993A and B will continue according to the stated objectives

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SCREENING FOOD BEAN (*PHASEOLUS VULGARIS* L) GENOTYPES FOR TOLERANCE TO LOW PHOSPHORUS

G O Rachier, R M Otsyula and N Ambitsi

Kenya Agricultural Research Institute
Regional Research Centre Kakamega Kenya

ABSTRACT

Progress made in screening bean genotypes for tolerance to low soil phosphorus is described The soil P levels of a screening site at the Regional Research Centre Kakamega have been satisfactorily depleted by growing several crops with added N but no P A collection of 434 local bean germplasm lines has been obtained from the National Horticultural Research Centre at Thika and evaluated for their growth habits days to flowering seed sizes disease resistance and seed yields Three hundred lines have been selected for screening for tolerance to P deficiency

INTRODUCTION

The screening of bean cultivars tolerant to low phosphorus (P) availability in soils is part of a larger effort involving several national bean programmes in Africa to screen for tolerance to edaphic stresses including low P and N and high Al and Mn In Kenya screening for low P stress is conducted at the Regional Research Centre Kakamega This work started in the 1990 short rains (SR) and by the 1992SR cultivars had been identified for screening and the screening field had been sufficiently depleted to low levels of P The actual screening for low P tolerance will start in the 1993 long rains

MATERIALS AND METHODS

During 1991 and 1992 the screening field was depleted of P This was necessary since fields on the station do not show P deficiency due to continuous use of fertilizers The screening field is suitable to enable screening of many materials over a number of seasons A maize bean intercrop sorghum and soybeans were grown on the field and fertilized with nitrogen but not P and all above ground crop residues removed from the field Soil analyses indicate that soil P levels have been satisfactorily depleted (Table 1) and compare well with P levels in farmers fields

434 germplasm lines were acquired from National Horticultural Research Centre Thika in 1992 Seeds of these materials were multiplied in single rows of 3 m Diammonium phosphate fertilizer was applied at the recommended rate at planting Diseases and pests were controlled using Dithane M45 and Diazinon The materials were

(a) characterized for growth habit and seed size

(b) evaluated for reaction to common diseases on a scale of 0 5 and

(c) evaluated for general adaptability and yield

Table 1 P levels (ppm) of samples of top and sub soils from three points in evaluation field at Kakamega in 1991LR and 1992SR

	Sample					
	1		2		3	
Season	Top	Sub	Top	Sub	Top	Sub
--						
Evaluation field						
1991LR	13	13	9	13	13	11
1992SR	8	10	6	4	8	8
Farmers' field						
	8	6	10	6	8	6

RESULTS AND DISCUSSION

Of the 433 genotypes evaluated 205 (47 3%) were determinate in growth habit and 228 (52 7%) were indeterminate Time to flowering ranged from 40 to 52 days with the earliest to flower being concentrated among the determinate types (Table 2)

Table 2 Days to flowering of determinate and indeterminate genotypes at Kakamega

Days to 50% flowering	Growth habit	
	Determinate	Indeterminate
40 42	154	14
43-44	25	26
45-46	6	31
47-48	7	124
49 50	4	29
51 52	2	2
Total	198	226

Among the 409 genotypes evaluated for seed size 107 (26 2%) were characterized large seeded 245 (59 9%) were characterized medium and 57 (13 9%) were characterized small seeded The main diseases recorded during the season were rust and angular leaf spot followed by anthracnose Scores greater than than 3 were exhibited by 165 genotypes for rust and 67 for angular leaf spot

Seed yield ranged from zero to 534 g/3 m row (Table 3) A determinate genotype (GLPx 1206) produced the heaviest yield followed by the indeterminate GLPx 73 Among the first fifty best yielding lines 27 were indeterminate and 23 determinate

Table 3 Frequency distribution of seed yields (g/row) of lines grown during the 1992SR

Seed yields (g/row)	Number of lines
0 100	46
101 200	86
201 300	151
301 400	100
401 500	43
Over 501	3

CONCLUSIONS

Three hundred (about 70%) of the total 433 lines were selected as entries for screening for low P tolerance during the 1993 long rains The selection cut-off point was a yield of 201 g/row and above The selection criteria were

seed yield
general adaptability
disease reaction

Among the selected lines 156 (52%) were determinate and 154 (48%) were indeterminate Indeterminate genotypes performed relatively badly as shown by the percentage of total plants present at mid season (52%) compared to harvest (48%) and by the composition of the rejected materials (63 2% indeterminate and 36 8% determinate)

MAJOR CONSTRAINTS

(i) The funding of the sub project was highly appreciated since it enabled the work to start The US$ 500 provided for the period July 1992 March 1993 proved limited for the activities of the 1992SR and of the 1993LR which start at Kakamega in February/March

(ii) It was not feasible to obtain materials from outside Kenya due to stringent quarantine measures at Muguga

PLANS FOR 1993 (LR)

(i) To screen the local bean materials selected as entries for tolerance to low P

(ii) To participate in the multi location testing of the entries selected from the first cycle of the ANSES

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SESSION V GENETIC TOLERANCE TO SOIL CONSTRAINTS

Chair Silim Nahdy Rapporteur Wayne Youngquist

Paper by Amare Abebe (presented by W Youngquist)

Question Stability analysis identified two lines that had slopes a little above 1 05 Entries with slopes less than 1 00 perform better in poorer environments Did you find any such lines?

Youngquist Yes BAT 798 had a slope of 0 72 but its mean yield was light so that the two selected lines were better performers even in the poorer environments

Question It is possible to examine a stability analysis graph as arranged in four quadrants In which quadrants were the selected types found?

Youngquist The selected types would lie in the upper quadrants If however one looked at a plot of slope vs deviations from regression then the selected types would be in the quadrant of high slope and high deviations from regression which would indicate some difficulty for accurate predication of response to drought

Paper by Mitiku Haile

Question It appears from your Tables 7 and 8 that nitrogen levels of the soils are already high Wouldn't this adversely affect responses to seed inoculation?

Mitiku Haile No not really It is the interactions with the other limiting nutrients that are of more concern These need to be examined further

Question Have you been monitoring the changes that occur in the variation in the strains in your mixtures over time?

Mitiku Haile The mixture experiment compares competition among local strains to determine whether the strains persist over time One strain of note is 899 which seems to persist

Paper by Patrick Jjemba

Comment The effects of applying nitrogen and symbiosis with the Rhizobium are confused since they are applied together

Jjemba Since there was little effect of N fertilizer there was probably little interaction due to the application of fertilizer with the Rhizobium strains

Comment Kindly describe the fertilizer regime

Jjemba A low starter dose of N (10 20 kg/ha) was added to promote the growth of the beans prior to the onset of effective nodulation Phosphorus is added for much the same reason It is needed for effective nodulation and N fixation

Paper by Habtamu Admassu

Question Were soil samples taken to confirm that there was nitrogen deficiency in the experimental plots? You mentioned disease symptoms in the test materials Were N deficiency symptoms observed and if so how severe were they?

Habtamu Admassu Soil analyses have not yet been completed However nitrogen deficiency symptoms were seen in the preceding crops of maize

The site selected for the low N screening had been scheduled for soil tests several years ago Even though the maize crop showed deficiency symptoms it appears that the N level is too high or has a great degree of variability It would be useful to block out the site into higher or lower N level areas

Paper by Victor Ochwoh

Question It is interesting to note that the lines MCM 5001 and CAL 96 found tolerant to high manganese soil conditions in your trials are also the ones that have recently been released based on their superior performance on farm Perhaps it is desirable to conduct your testing at on farm sites?

Ochwoh This could be done We would then need to obtain soil analyses to confirm what the farmers are saying about the fertility of their farms

Question The steering committee may not be convinced that Mn toxicity is a serious enough problem to warrant investing more resources in it Do you have data on the extent of Mn toxicity problems?

Ochwoh One difficulty of obtaining such information is the unreliable nature of soil Mn tests The tests indicate low Mn levels due to the drying that is normally used prior to running the test procedure

Question What are the levels for concern of Mn in the soil?

Ochwoh There is no absolute answer to this question For some crops the upper level is 40 ppm but for beans we believe it may be as high as 200 ppm

Paper by Gideon Rachier

Question Is it possible to lay out the screening trials in blocks? This would help account for some of the variation that has been observed

Rachier Variability in the testing is high therefore some form of blocking may be of value in estimating this source of variation in the test results

Comment A nearest neighbours analysis may be more appropriate than some forms of blocking

Rachier The trials have already been planted for this year

Question How widespread is P deficiency in western Kenya?

Rachier It is a problem since the farmers tend not to use P fertilizers

Question Were there severe deficiency symptoms in your trials?

Rachier There were severe symptoms in sorghum and maize but not in beans

Comment Fertilizer applied to the maize is formulated for the maize It has been observed that by intercropping beans the beans use this fertilizer differentially and that the maize suffers as a result

General discussion of soil constraints

Hidden hunger It is often difficult for farmers to appreciate exactly the problems of poor soil nutrient availability On farm trials would help to educate farmers to become aware of the problems involved

Drought Physiologist have a wide range of tests that can be used to identify drought response in the field including pore tests water pressure and osmotic potential Would these be appropriate in identifying drought tolerant varieties?

These tests can be used but the primary point to remember is that manifestation of drought differs between bean growing areas In many cases drought tolerant lines are those that resist disease or insect pressures specific to dry conditions Physiological studies set up in one location where drought is experienced at differing times of the year and accompanied by high temperatures may be inappropriate to other areas where drought is associated with cool temperatures late in the growing season

Work has started to identify lines that are drought tolerant during four periods seeding to seedling stage seedling stage to flowering flowering to pod formation and grain filling This should help in identifying lines that have specific responses to drought

Current drought screening procedures have been haphazard It is important to identify specific critical periods and devise good repeatable screening methodology to evaluate material for specific stress conditions

Biological nitrogen fixation It is difficult to criticize work on BNF since it is such an important trait On the other hand results have been unimpressive and one wonders if more effort should be expended on this topic

Studies of nitrogen fixation with soybeans have shown positive responses to inoculation but with phaseolus beans the results have not been so clear Perhaps more studies need to be conducted of the competitive ability of local strains and less emphasis placed on exotic strains which may not be very competitive in local environments

Some bean varieties have been found to fix up to 100 kg N/ha though this is rare and not found in locally acceptable bean cultivars

Manganese If bananas are associated with the incidence of Mn toxicity problems in beans is the solution to stop growing so many bananas in western Uganda?

So far the results are not conclusive and such a reaction would be premature The rhizosphere of banana roots is typically of higher pH than the surrounding soil Since bean roots will grow in close association with banana roots it is in this zone that it is most likely that the bean roots are picking up the excess Mn One trial of 16 bean genotypes showed that the intercropped beans had twice the Mn levels of the bean genotypes in monoculture

Soil pathogens cause confusion in the proper identification of soil deficiency symptoms How can one avoid misdiagnosis?

It has been observed that there is an association between low K in the soils and the incidence of root rots It was found that the application of coffee hulls (source of K) to pots growing beans reduced disease incidence

SESSION VI INTEGRATED CROP AND SOIL MANAGEMENT

MINIMUM TILLAGE IN MAIZE BEAN PRODUCTION SYSTEMS IN KENYA

John G N Muthamia

K.A R I Regional Research Centre, Embu, Kenya

ABSTRACT

On farm research experiments on minimum tillage in maize and maize bean intercropping were carried out during the Short Rains (SR) of 1991/92 and Long Rains (LR) of 1992 in three agroecological zones (AEZs) of Upper Midland (UM2 UM3 and UM4) of Kiambu and Embu Districts of Kenya The effects of conventional tillage (two hand weedings) pre emergence alachlor post emergence bentazon farmers method and zero (no till) on crop performance and soil characteristics were evaluated and farmer assessment of the treatments obtained Drought affected the crop in both seasons Zero tillage improved the stands of maize and beans and produced greater biomass taller maize plants in less clayey soils more bean pods per plant and larger bean seed yield In addition crops were less affected by drought and soil erosion was minimal Farmers method was similar to conventional tillage in soil manipulations Plant densities were less with the farmers method but on clayey soils crops performed better with farmers method and conventional tillage than with other treatments Pre emergence alachor+linuron resulted in a good crop comparable to conventional tillage In beans post emergence bentazon application delayed maturity reduced pod number and caused swollen plant bases Maize plants were temporarily lodged their prop roots deformed and growth twisted However when moisture was available the problems in maize were overcome Bentazon gave poor control of grasses and *Galinsoga* and *Leonotis* spp

INTRODUCTION

Conventional crop production consists of primary and secondary tillage and one or two handweedings This ensures that the crop grows in a weed free environment Conventional tillage exposes and churns soil and subjects it to erosion by water and wind Because of the disastrous effects of erosion on soil productivity and the need to conserve moisture there is a general trend from conventional to minimum tillage Minimum tillage involves elimination of excessive tillage (Ross and Merril 1990) Excessive tillage not only accelerates erosion but also destroys soil physical properties (Lal 1976)

Minimum tillage has been observed to increase organic matter in tropical soils (Thomas *et al* 1983) to conserve moisture and reduce erosion On farm research on minimum tillage was initiated in Kiambu and Thika Districts after on station research confirmed that the tillage system was feasible for maize bean cropping systems

The objectives of minimum tillage on farm research were to

a) assess the applicability of tillage practices under farmer circumstances
b) understand farmers minimum tillage crop production systems
c) assess the importance of soil erosion
d) assess water infiltration and water storage in the soil
e) study crop growth and yield under different tillage methods and
f) assess the effects of tillage methods on soil physical and chemical characteristics

MATERIALS AND METHODS

An informal diagnostic survey was conducted in Kiambu and Embu Districts during the 1991/92 SR with the objective of learning the tillage methods practised by farmers and finding with farmers treatments for on farm trials that would minimize tillage operations and yet be feasible in farm situations The methods adopted for the trial had to be compatible with maize bean intercrops since the commodities are grown in association Weed management had also to suit intercrop culture

The treatments selected were

1) conventional practice (primary and secondary tillage and two handweedings)
2) primary and secondary tillage and post emergence bentazon application
3) primary and secondary tillage and pre-emergence alachlor application
4) farmers method and
5) zero tillage (no till) neither primary nor secondary tillage (use of glyphosate or paraquat to control initial vegetation and application of either pre-emergence or post emergence herbicide

A randomized complete block design was used with farms as replications Gross plot sizes were variable but net plots were 5 x 3 m The measured parameters were expressed on a hectare basis Maize hybrid 512 was planted in UM2 and UM3 spaced at 0 75 x 0 3 m Katumani composite was planted in UM4 spaced at 0 9 x 3 m Bean variety GLP 2 was planted at an intra row spacing of 0 1 m UM4 was planted with GLP 1004 (Mwezi moja) in two rows between two maize rows with an intra row spacing of 0 15 m Maize was fertilized with 250 kg/ha of 23 23 0 fertilizer while beans were fertilized with 100 kg/ha of DAP (18 46 0)

RESULTS AND DISCUSSION

Crop performance

During the 1991/92 SRs maize was affected by drought which occurred just before tasselling at all sites Maize wilted early in all treatments except zero tillage where wilting occurred much later No maize yields were realized though a few cobs were produced in zero tillage plots In UM4 (Munyu) on light soil the maize was eaten by squirrels except in zero tillage plots where trash protected the seedlings Farmers noted zero tillage as a solution to the squirrel problem

Beans were also affected by drought but some yields were realized Zero tillage treatment had vigorous crop growth despite the drought Post emergence application of bentazon adversely affected bean growth and development The farmers method resulted in poor stands and yields probably because of overcrowding of beans and low population

During the 1992 LRs maize performed well in all sites Weed control was satisfactory except in bentazon treated plots where grasses dominated Wild pigs porcupines and dogs destroyed the maize in UM4 Katumani Composite matured earlier than the farmers variety Farmers indicated that future varieties for the area should be H511 or H512 which they normally grow though the area is too dry for them In Embu maize was seriously affected by drought and the plants were used as cattle feed However zero tillage plots produced more biomass

Some bean yield was realised in UM2 and UM3 In UM4 beans failed due to drought after the first rains were followed by a dry spell Resown beans were damaged by bean stem maggots and the remainder were trampled by wild animals feeding on the maize

Plant height

Maize was slightly taller with zero tillage than with other treatments This confirms that zero tillage is more conducive to maize growth than other tillage practices as also observed by Blevins (1983) and Phillips and Young (1973)

In heavy clays the farmers method and conventional tillage treatment resulted in taller plants than other treatments Under zero tillage pre-emergence treatments caused large deep cracks which might have interfered with roots Blevins (1983) also observed that soils with slow interval drainage properties respond poorly to no tillage

Table 1 The effects of tillage on plant height (m) of maize grown in UM2 UM4 (light soils) and UM4 (clay soils) during 1991/92 SRs

	Light soils		Clay soil
Tillage method	UM2	UM4	UM4
Zero tillage	1 4	1 4	1 15
Conventional tillage	1 29		1 40
Pre-emergence alachlor	1 32		1 15
Post-emergence bentazon	1 28		0 87
Farmers method	1 35		1 35

Pods per plant

In UM2 pods per plant were most in zero tillage and fewest with the farmers method In UM4 the beans were almost a sole crop since most maize seeds had been removed by squirrels except in the zero tillage plots where all the maize grew Eight pods/plant were produced by pre-emergence alachlor and six by zero tillage No pods were harvested from post-emergence bentazon because of phytotoxicity

Table 2 The effects of tillage on number of pods per bean plant grown in UM2 and UM4 during 91/92 SRs

Tillage method	UM2(GLP 2)	UM4(GLP 1004)
Zero tillage	4 5	6
Conventional tillage	4 0	5 8
Pre-emergence alachlor	3 9	7 8
Post-emergence bentazon	3 2	0
Farmers method	3 2	2 9

Bean seed yield

Zero tillage produced the largest bean yields at all sites Post emergence bentazon produced poor yields because of phytotoxicity Pre-emergence alachlor resulted in larger bean yields than conventional tillage

Table 3 The effects of tillage practices on seed yields (kg/ha) of beans grown in different ecological zones during 1991/92 SRs

Tillage methods	UM2	UM3	UM4
Zero tillage	372	313	579
Conventional tillage	292	69	330
Pre-emergence alachlor	334	139	428
Post-emergence bentazon	129	69	
Farmers method	134	208	163

Infiltration rates

Infiltration rates were measured in UM2 and UM4 to determine the effects of tillage practices on water percolation and the potential runoff and erosion during rainstorms

Table 4 The effects of tillage practices on infiltration rate (mls/min) in UM2 and UM4 in 1991/92 SRs

	Farmers method		Pre emergence		Zero tillage		Post emergence		Conventional	
Time (min)	UM2	UM4	UM2	UM4	UM2	UM4	UM2	UM4	UM2	UM4
1	5 7	3 7	5 4	4 2	6 6	5 7	4 2	4 2	4 2	5 7
3	2 8	2 0	2 6	1 9	2 8	2 4	2 0	1 9	2 2	2 8
5	2 8	2 0	2 6	1 9	2 8	2 4	2 0	1 9	2 2	2 8
10	2 8	1 3	1 6	1 3	2 0	1 3	1 2	0 8	1 8	1 2
20	2 4	0 9	1 3	0 8	2 5	1 1	1 2	0 6	1 4	0 9
30	2 0	0 8	1 1	0 7	2 2	0 9	1 0	0 6	1 2	0 8
60	1 4	0 5	0 9	0 5	1 4	0 7	0 8	0 4	1 0	0 5

UM2 soils had higher infiltration rates than UM4 soils due to lower clay content Treatment effects were not very clear

Moisture assessment

Farmers participated in evaluation of effect of moisture deficits They reported that wilting occurred much later under zero tillage than other treatments and the plants were larger In clay soils conventional tillage and the farmers method resulted in larger plants

Agronomic assessment

This was how the farmer saw the crops growing weed assessment ease of operation convenience and requirement

Post-emergence bentazon treatment Farmers were sceptical about its adoption since it adversely affected the crop and did not control grasses and *Galinsoga*

Pre-emergence alachlor treatment Farmers were satisfied with crop performance and weed control They would like to see its effect on weed control during excessively wet seasons They thought herbicides were expensive especially when rains failed

Conventional tillage The farmers felt it was laborious at planting but easy to weed

Zero tillage Farmers felt it was easy technology resulting in a good crop but would like to see it *in a more favourable season Prices of herbicides and technical knowledge were a constraint to* adoption They said they can try it with proper advisory services The method deterred squirrels

Farmers' method They indicated that this was easy to plant but they lost in terms of yields labour in weeding and crop stand

Crop assessment

Varieties

a) Farmers did not want Katumani Composite in *UM4* because of early maturity associated with damage by wild animals

b) Farmers preferred GLP 2 to GLP 1004 recommended for UM4

Yields When asked their opinion about yields farmers indicated that zero tillage appeared best followed by pre-emergence conventional farmers method and then post-emergence Bean seed appearance followed similar trends

Soil erosion

Farmers observed that soil erosion was immense in all treatments involving primary and secondary tillage No erosion was observed with zero tillage

Soil properties

Soil analyses indicated that soils in all areas were low in nitrogen and phosphorus Potassium was partially sufficient Organic carbon was also very low and according to Thomas *et al* (1983) maintenance of organic carbon in tropical soils is important for crop production

CONCLUSIONS

1 Dunng penods of drought the crop ın zero tıllage plots performed very well
2 Bentazon was detnmental to both maıze and beans
3 Plant populatıons are low ın farmers fields
4 There ıs need for synchronızed maturıty to avoıd damage to crops by wıld anımals
5 Bean yıelds were best from zero tıllage
6 Post-emergence bentazon resulted ın low bean yıelds
7 Pre-emergence alachlor treatment out yıelded conventıonal tıllage by 30% ın bean yıelds
8 Zero tıllage outyıelded conventıonal tıllage by 83%
9 Soıls ın UM2 had faster ınfiltratıon rates than UM4 soıls
10 Zero tıllage resulted ın hıgher ınfiltratıon rate durıng the first mınute than other treatments than other treatments
11 Zero tıllage delayed moısture stress ımmedıately raıns ceased
12 Squırrels could not remove maıze seeds ın zero tıllage plots
13 Seed qualıty assessment revealed that zero tıllage resulted ın better bean seeds and post emergence wıth poor seeds
14 Soıl analysıs revealed that the soıls ın the two dıstncts were low ın total nıtrogen organıc carbon and phosphorus Potassıum was also lackıng

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EFFECT OF WATER HARVESTING SYSTEMS ON BEAN MAIZE INTERCROPPING IN ARID AND SEMI ARID LANDS OF KENYA

D O Michieka, A M Ndegwa and G W Mbugua

KARI National Horticultural Research Centre Thika Kenya

ABSTRACT

An experiment was initiated to investigate the effects of water harvesting methods in bean maize intercropping systems in arid and semi arid lands (A S A L) of Kenya The site selected for preliminary studies was a farmers field located in Agro Ecological Zone 5 in Gatuanyaga area of Kiambu District Central Province Four water harvesting methods were compared viz pit catchments contour and line tie ridges and farmers practice which was the control Bean and maize yields were significantly better in all water harvesting systems than in the control The heaviest bean yields (1 319 kg/ha) were recorded in the pit catchment system However construction of the pits was labour intensive Contour (974 kg/ha) and line tie ridging (933 kg/ha) also resulted in fairly good yields These treatments had an added advantage since the tie ridges were easier to construct These initial results indicate that the water harvesting concept can be utilized successfully in the A S A L s of Kenya and could be extended to other countries of eastern Africa The hypothesis will be further tested in subsequent seasons

INTRODUCTION

Dry bean (*Phaseolus vulgaris* L) produced on an area of 500 thousand ha is the most important pulse in Kenya National average yield is about 800 kg/ha while potential yield is approximately 1 500 kg/ha (Kangethe and Ngalyuka 1989) In most cases beans are intercropped with maize (Njuguna *et al* 1981) Drought stress has been identified as one of the major factors contributing to the wide gap between actual and potential yields especially in the arid and semi arid lands (A S A Ls) (Muigai and Ndegwa 1991) A S A Ls account for 80% of Kenyas land area and support about 25% of the population These areas act as a major water shed and therefore their management and use greatly affects the severity of droughts floods rate of erosion and siltation of streams rivers irrigation dams and reservoirs (Mule 1984) A S A Ls are characterized by poor and very erratic rainfall but are becoming increasingly important in crop production in Kenya and other countries of eastern Africa in general This trend has been caused by the increase in migration from the more productive highland zones The current development plan in Kenya recognizes the potential of A S A Ls to double their contribution to the country s growth target in agriculture (Anon 1989)

Annual rainfall in the A S A Ls is below 800 m and usually falls in storms characterized by high erosive power which degrades the soil and initiates erosion and run-off (Kiwele and Ulsaker 1984) The improvement of water infiltration reduction of loss by evaporation and conservation of residual moisture in the soil profile are some of the mechanisms which can contribute to the increased use of rain water by plants in A S A Ls

Water harvesting is one such concept whereby run-off rain water is collected and subsequently concentrated in an area for the purpose of improving plant production in A S A Ls At farm level the process entails the construction of simple structures on gently undulating topography to facilitate harnessing of rain water It is not an alien technology on the continent of Africa since many countries of sub Saharan Africa have a documented tradition of water harvesting techniques that have sustained crop production in arid and semi arid areas for ages For example in the Hiraan region of the central rangelands of Somalia which has an average annual rainfall of 250 mm the majority of farmers are agro pastoralists and their cropping system is based on a local tradition of water harvesting termed the *caag* system Sorghum and cowpea are usually grown on land where earth bunds have been hand constructed along the contour Local farmers claim that cropping is impossible without these structures Sudan is on record as possessing the richest tradition of water harvesting in Africa south of the Sahara Agro pastoralists in the Sudan utilize the *wadi* and *terras* systems In the former system the *wadi* beds are improved by water impounding bunds while in the *terras* system common on the clay plains of eastern Sudan a chequerboard arrangement of cropped plots is created by surrounding three sides with earth bunds to capture surface run-off from the catchment (Critchley 1989) Traditional water harvesting systems have also been observed in West Africa viz Burkina Faso Mali and Niger Attempts have been made to improve upon these traditional systems with some notable success (Critchley 1989)

Compared to these countries Kenya has very little history of water harvesting for cropping purposes Until recently activities in A S A Ls of Kenya were restricted to pastoralism but the situation has now changed as is evidenced by the many projects that have been initiated One such project in Turkana District entailed construction of trapezoidal bunds in farmers fields where sorghum and cowpeas were grown Sorghum yields up to 600 kg/ha were obtained compared to crop failure in farmers with no water harvesting structures The local people widely adopted the system (F A O 1988) Contour tie ridges and pit catchments were also tested in Baringo and Kuti Districts with a fair amount of success (Mbote 1989) In Baringo preliminary research on water harvesting systems under contour tie ridges line tie ridges semi-circular hoops (micro catchments) and water spreading (macro catchment) produced better yields of sorghum Katumani Composite B maize cowpeas green grams pasture and fodder species than the control (conventional method) (Anon 1989)

Due to the increased settlement of A S A L areas in Kenya by different ethnic communities with varying food preferences it was found necessary to initiate a project to investigate the feasibility of different small scale water harvesting methods in bean maize cropping systems The results from this project are expected to be beneficial not only to Kenyan farmers but also to the farming communities in similar zones in other countries of eastern Africa

MATERIALS AND METHODS

The experiment was initiated during the short rains season of 1992 The experimental site was a farmers field located in the transitional area of A E Zs 4 and 5 The farm is in Gatuanyaga/Munyu area, in Kiambu District Central Province and lies at 1°04 S and 37°06 E at an altitude of about 1400 masl The average annual rainfall in the zone is 700 mm and annual potential evaporation is about 1800 mm The dominant soil types in the area are Ferralsols Combisols and Vertisols which are generally low in nitrogen and phosphorus

Three water harvesting methods viz pit catchments line tie ridges and contour tie ridges were compared with farmers practice which was the control The treatments were replicated four times and assigned to plots of 20 x 14 m The four blocks traversed the slope Randomization was restricted by the nature of the treatments Beans and maize in the water harvesting treatments were planted according to the recommendation for the zone Maize was planted at a spacing of 90 x 30 cm (one seed/hill) and two bean rows were then interplanted between the maize at 30 x 15 cm In farmers practice maize was planted in rows spaced approximately at 90 x 30 cm and the beans were then interplanted at random at 2 3 seeds/hill Diammonium phosphate at 200 kg/ha was applied to beans at planting in all treatments except farmers practice Maize was planted using the compound fertilizer 23 23 0 at the rate of 250 kg/ha in all treatments

Data was collected from net plots of 10 x 10 m throughout the growth penod and was subsequently subjected to standard statistical analysis procedures Labour requirements for the various operations were also noted for each treatment

RESULTS AND DISCUSSION

Bean and maize plant stands were greatest in the line tie ridging system and smallest in the farmers practice The number of pods per plant did not vary significantly in the three water harvesting treatments but all these treatments had a significantly greater number of pods per plant than the farmers practice (Table 1) The bean pods were adversely affected by the unusually wet weather during ripening The number of bean seeds per pod ranged from 1 9 in the farmers practice to 3 7 in the pit catchment system Differences between treatments were not significant The percentage of rotten seeds was rather high and was attributed to the wet conditions that prevailed towards the end of ripening The largest bean seed was observed in the contour tie ridge system while the farmers practice resulted in the lightest seed In addition to poor moisture supply lack of fertilizer in the latter treatment could be another factor that contributed to low seed weight The pit catchment system resulted in the best bean yield (1319 kg/ha) This was significantly greater than in all the other systems Yield differences between the two tie ridge systems were not significant However the yields in the two systems were 60% higher than in the control

Table 1 Effect of water harvesting system on bean yields and yield components

Water harvesting system	Plants/ $100m^2$ at harvest	No of pods/ plant	No of seeds/ pod	Weight of 100 seeds (g)	Seed yield (kg/ha)
Farmers practice	157	2 8b	1 9	42 2	388c
Pit catchment	241	7 2a	3 7	57 8	1319a
Line tie ridges	248	5 2a	2 7	56 3	933b
Contour tie ridges	237	5 3a	2 9	59 5	974b
F ratio (treatments)	1 25ns	6 48*	2 04ns	2 6ns	13 0**
S E ±	54 36	1 02	0 70	9 97	150 87
C V (%)	34 8	28 2	35 5	27 5	23 6

Means followed by same letter not significantly different at P<0 05 according to Duncan s New Multiple Range Test ns * ** = not significant snd significantly different at P<0 05 and 0 01

Differences among treatments in number of maize cobs per plant were not significant Most plants had 1 cob/plant although incidence of 2 cobs/plant was also noted especially in the pit catchment system (Table 2) Maize grain sizes did not vary significantly between treatments though the pit catchment system resulted in the heaviest seed The maize yields in all the water harvesting treatments were significantly better than in the farmers practice but the differences among systems were not significant

Table 2 Effect of water harvesting systems on maize yields and yield components

Water harvesting system	Plants/ 100m2 at harvest	No of cobs/ plant	Weight/ 100 grain (g)	Grain yield (kg/ha)
Farmers practice	108c	1 11	36 1	780b
Pit catchment	179b	1 14	38 3	3015a
Line tie ridges	260ab	1 06	33 9	2857a
Contour tie ridges	230a	1 12	36 2	3007a
F ratio (treatments)	16 4**	2 50ns	0 72ns	6 57*
S E ±	23 30	0 03	2 59	602 40
C V (%)	17 0	4 0	10 1	35 3

Total yield figures indicated that the pit catchment system was the most productive recording a total maize and bean yield of 4 334 kg/ha (Table 3) The line and contour tie ridge systems had comparable total yields (3 740 and 3 918 kg/ha, respectively) The farmer s practice was the least productive with a total yield of 1 168 kg/ha Pit catchments were however very laborious to construct compared to tie ridges

Table 3 Effect of water harvesting systems on bean maize and total yields (kg/ha)

Water harvesting system	Beans	Maize	Total
Farmers practice	388c	780b	1168b
Pit catchments	1319a	3015a	4334a
Line tie ridges	933b	2857a	3790a
Contour tie ridges	974b	3007a	3981a
F ratio (treatment)	13 0**	6 57*	8 9
S E±	150 87	602 4	686 7
C V (%)	23 6	35 3	29 3

CONCLUSION AND RECOMMENDATIONS

These preliminary results indicate that the water harvesting systems being tested are quite promising The trial will be continued for at least three more seasons An additional site which is more representative of Agro Ecological Zone 5 will also be included in subsequent seasons

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THE EFFECTS OF SELECTED SOIL AMENDMENTS ON DRY BEAN YIELDS IN MAURITIUS

N Govinden, B Gowrea and F Ismael

Mauritius Sugar Industry Research Institute, Reduit, Mauritius

ABSTRACT

Poor dry bean yields have been frequently observed in variety trials on research stations in Mauritius Since there was no obvious cause trials were conducted in 1990 and 1991 to assess the effects on yields of nematodes the macronutrients N P and K the minor nutrients S and Ca the micronutrients B and Mo and organic matter (OM) In three trials in 1990 no responses were observed to B and carbofuran eliminating B deficiency and nematodes as causes of the poor yields The addition of OM in the form of sugar cane factory scums improved yields Greater levels of NPK than the recommended 46 kg N 73 kg P_2O_5 and 70 kg K_2O per ha had little effect on yields suggesting that macronutrient levels were adequate In two trials in 1991 neither Ca applied as lime nor elemental S applied at sowing had any effect though there was a slight positive effect of Mo The adequacy of recommended levels of N P and K and the positive effects of organic matter in the form of farmyard manure (FYM) or factory scums were confirmed On farm trials on seed quality the effects of green manure and the control of root rots are required before issuing recommendations on how to achieve consistently good bean yields

INTRODUCTION

Mauritius relies heavily on imports to supply its requirements of dry bean In 1983 the estimated annual requirement of dry bean was 1 600 t (Anon 1983) worth 28 million rupees while in 1984 production amounted to only 54 t (Anon 1985) Research on dry bean was started at the Mauritius Sugar Industry Research Institute in 1984 to select locally adapted heavy yielding commercially acceptable disease and insect resistant cultivars More than 500 kidney bean cultivars have been evaluated to date and a programme has been launched to produce clean seeds of promising ones

Since 1984 several bean cultivars producing better yields than the cultivar Long Tom have been identified in on-station trials but their grain yields are sometimes very poor (Anon 1988) Biotic factors such as seed quality insects diseases and abiotic factors such as soil fertility and climate may be responsible for the erratic yields Since the influence of climate insects and diseases in the trials will have been minimal because of uniform sowing date irrigation and pest control the implication of mineral nutrition or nematodes was suspected

It is known that nutritional imbalances both deficiency and toxicity lead to poor grain yields N is one of the chief yield limiting nutrients especially in soils of low OM content but the application of 50 100 kg/ha N is usually sufficient to correct deficiencies (Schwartz *et al* 1978) P deficiency is a common nutritional problem in many regions especially where soils are highly weathered Responses have been obtained to the application of 20-150 kg/ha P_2O_5 depending on the P fixing capacity of the soil (Mughogho and Wortmann 1989) K deficiency is rare in beans there being no response to K application on most soils (Wortmann and Zake 1989) but positive responses to 50 100 kg/ha K_2O have been obtained on infertile Oxisols and Ultisols

Several micronutrients have been shown to affect dry bean yields B deficiency occurs in soils low in OM and high in pH with poor native B contents B deficiency can be corrected by the application of 0 25 3 kg/ha B (Schwartz *et al* 1978 Wortmann *et al* 1989) S deficiency is observed in acid infertile Oxisols and Ultisols especially where they are remote from industrial centres (Bennett 1993) and can be corrected by the application of 10 20 kg/ha S Mo deficiency occurs especially in acid soils (Bennett 1993) Uptake is enhanced by the addition of P (Mughogho and Wortmann 1989) and deficiency can be ameliorated by the application of 18 36 g/ha Mo as a seed dressing (Wortmann *et al* 1989) Liming improves yields directly by raising soil pH and indirectly by improving P availability The rates of application required depend on soil type being greater on highly buffered soils (Wortmann and Zake 1989)

The root galls characteristic of nematode infection have been observed in a number of trials Nematodes decrease yields by reducing water and nutrient uptake but can be chemically controlled by the application of nematicides like carbofuran FYM improves yields by augmenting soil OM and providing macro- and some micronutrients (Mayona and Kamasho 1989) but is not readily available in Mauritius Sugar factory scums are abundant but are essentially cellulose and have poor nutrient status

The objective of this preliminary study was to determine which of these factors are responsible for poor and erratic bean yields in Mauritius

MATERIALS AND METHODS

In 1990 three trials were conducted on research stations where poor yields had been previously obtained one (at Reduit) in the first season and two (at Reduit and Belle Rive) in the second season The characteristics of the sites are summarised in Table 1

All were complete factorials in randomised complete block designs with two (first season) or four (second season) replicates Factorial designs provide simultaneous sets of results for the main effects of factors and the interactions among them At Reduit in the first season and Belle Rive the plot size was four rows of 6 m length of which 5 m of the two middle rows was harvested for yield assessment At Reduit in the second season the rows were 4 5 m long and a 4 m length was harvested The rows were 0 5 m apart and the intra row spacing was 0 1 m The herbicide Preforan was applied after sowing at 7 l/ha and insects were controlled chemically according to recommendations The grain yields of bean cultivar MCD 252 were expressed at 14% moisture content

The treatments were 355 and 455 kg/ha of 13 13 20 2 compound fertilizer 3 t/ha sugar factory scums and 14 kg/ha carbofuran all applied in the furrows at sowing 3 2 kg/ha of B as sodium tetraborate banded at the base of the plants one month after sowing and untreated levels of each factor The unfertilized treatment was not included at Reduit in the first season

Table 1 Climate and soil characteristics and agronomic practices at sites where the trials were grown in 1990 and 1991

	1990		1991	
	Reduit	Belle Rive	Reduit	Pamplemousses
Climate	humid	superhumid	humid	humid
Soil type	LHL	HFL	LHL	LHL
Soil analysis				
pH (water)	6 2	5 3	5 2	5 3
P_2O_5 (ppm)	133	166	157	166
K_2O (me%)	0 46	0 77	1 90	0 77
Ca (me%)		3 75	5 90	3 75
Mg (me%)		1 43	2 65	1 43
Irrigation	overhead	none	overhead	overhead
Sowing date	17/9	2/10	3/5	30/4
Harvest date	10/12	27/12	16/8	2/8

LHL = Low Humic Latosol HFL = Humic Ferruginous Latosol

In the first season of 1991 trials were grown at Reduit and Pamplemousses They were arranged as *fractional factorial designs* of four 1/4 replicates with the Mo and S treatments confounded with replicates Confounding reduces the degrees of freedom of the error term but enables additional comparisons with the same number of plots Reducing the replicate size increases the chances of plots being distributed more uniformly in the field (Mead 1984) The plots were four rows 4 5 (Reduit) and 6 m (Pamplemousses) long Spacings were the same as 1990 The cultivar Long Tom was sown using *locally produced* seeds Weeds were controlled by a pre emergence application of Linuron at 7 kg/ha followed by hand weeding where necessary Insects were controlled by appropriate insecticides

The treatments were nil basal dose (45 kg N 75 kg P2O5 70 kg K2O per ha) and basal dose plus 23 kg N or 28 kg P_2O_5 per ha 0 and 21 g/ha Mo in the form of Na molybdate 0 and 10 kg/ha powdered sulphur 0 and 3 t/ha of lime and 0 and 15 t/ha organic manure (FYM at Reduit and factory scums at Pamplemousses)

RESULTS AND DISCUSSION

In 1990 bean yields were heavy in all trials and there were no significant effects of treatments at Reduit in the first season (Table 2) The application of scums increased yields slightly and B decreased them which may indicate toxicity Carbofuran had no effect probably indicating the absence of nematodes Similar results were obtained from the second season trials (Table 3) The application of 335 kg/ha of compound fertilizer significantly improved yields but there was no additional effect of the higher rate This conforms with previous results which showed no yield response to more than 30 kg/ha N (Anon 1992) The application of OM improved yields and the effects of compound fertilizer and OM were greater on the poorer more highly leached soil of Belle Rive Since scums contain little readily available macronutrients their effects must be due to either micronutrients or physical improvement of the soil Again B depressed yields slightly at Reduit and carbofuran had no effect

Table 2 The effects of treatments on the grain yields (t/ha) of dry bean at Reduit in the first season 1990

Treatments	Levels	NPK (kg/ha) 355	455	Mean	Difference(%)
OM	0	2 23	2 33	2 28	
(t/ha)	3	2 68	2 49	2 59	+13
Carbofuran	0	2 30	2 59	2 45	
(kg/ha)	14	2 68	2 22	2 41	1
B	0	2 58	2 52	2 55	
(kg/ha)	3 2	2 32	2 30	2 31	9
Mean		2 58	2 41	2 43	
Difference (%)		2			

significant at P<0 10

In 1991 bean yields were greater at Reduit than at Pamplemousses presumably due to the better soil fertility (Table 1) or the presence of effective rhizobia at Reduit where beans had been grown several times in the past At both sites grain yields responded positively to the application of the basal dose of NPK but not to additional N or P (Table 4) confirming that the basal dose of NPK was adequate Lime had a slight non significant negative effect at both sites but since it was applied in the furrows at sowing and not incorporated the timing and method of application may have been unsuitable Excessive amounts of lime in the rooting zone can induce deficiencies of K Mg Fe Mn Zn and Cu (Grundon 1987) OM improved yields whether in the form of FYM (Reduit) or factory scums (Pamplemousses) It also interacted with inorganic fertilizer at Reduit where there was a small response to OM when additional P was applied suggesting that OM may help in providing or assimilating P FYM contains 0 15% P_2O_5 while factory scums contain only 0 04% Mo had a slight but non-significant positive effect on yield at both sites Since seed dressing with Na molybdate offers a relatively low cost method of increasing bean yields especially in acid soils these results will have to be confirmed S had no effect on yield at either site so is not the cause of the poor yields previously observed though Ca sulphate is a more suitable source of sulphur than elemental S especially on acid soils

Table 3 The effects of treatments on the grain yields (t/ha) of dry bean at Reduit and Belle Rive in the second season 1990

Sites	Treatments	Levels	NPK (kg/ha) None	355	455	Mean	Difference(%)
Reduit	OM	0	1 55	2 40	2 54	2 16	
	(t/ha)	3	1 63	2 60	2 75	2 33	8
	Carbofuran	0	1 78	2 48	2 48	2 25	
	(kg/ha)	14	1 41	2 52	2 81	2 25	0
	B	0	1 66	2 71	2 86	2 41	
	(kg/ha)	3 2	1 52	2 29	2 43	2 08	14*
	Mean		1 59	2 50	2 65	2 25	
	Difference (%)			+57***	+67***		
Belle Rive	OM	0	1 02	2 65	2 68	2 12	
	(t/ha)	3	1 47	3 36	3 68	2 84	+34*
	Carbofuran	0	1 14	2 90	3 26	2 43	
	(kg/ha)	14	1 43	3 10	3 11	2 52	+3
	B	0	1 14	3 00	3 22	2 45	
	(kg/ha)	3 2	1 35	3 00	3 14	2 50	+2
	Mean		1 24	3 00	3 18	2 47	
	Difference (%)			+141***	+156***		

* *** significant at P<0 05 and 0 001 respectively

CONCLUSIONS

The results of the two series of trials indicate that nematode infestation and Ca, S and B deficiency are not the causes of the poor bean yields sometimes observed on research stations The small yield increment from the addition of Mo suggests that deficiency of this micronutrient is not of major importance and recommended levels of N P and K appear adequate for good yields Only OM appears to be present in the soil in insufficient amounts Since FYM is not readily available in Mauritius and factory scums may be relatively ineffective other practical solutions such as green manures will have to be sought Further investigations are also necessary to examine the roles of transmissable diseases and root rots in depressing yields

Table 4 The effects of soıl treatments on dry bean yıelds (t/ha) at Reduıt and Pamplemousses ın the first season 1991

Sıte	Treat ment	Level	No NPK	Basal NPK	Basal NPK+N	Basal NPK+P	Mean	Dıffer ence (%)
Reduıt	OM	0	0 96	1 77	1 78	1 94	1 61	
	(t/ha)	15	1 70	1 96	2 13	2 10	1 97	+23**
	Lıme	0	1 13	2 08	2 17	2 02	1 85	
	(t/ha)	3	1 52	1 65	1 74	2 02	1 73	6
	Mo	0	1 19	1 82	1 85	2 03	1 72	
	(g/ha)	21	1 47	1 91	2 06	2 01	1 86	+8
	S	0	1 26	1 82	2 03	1 95	1 76	
	(kg/ha)	10	1 40	1 91	1 88	2 09	1 82	+3
	Mean		1 33	1 87	1 96	2 02	1 80	
	Dıfference (%)			+41**	+47**	+52**		
Pamplemousses	OM	0	0 66	1 08	1 25	1 31	1 08	
	(t/ha)	15	0 93	1 23	1 32	1 28	1 19	+11
	Lıme	0	0 80	1 12	1 36	1 37	1 16	
	(t/ha)	3	0 79	1 20	1 21	1 22	1 10	5
	Mo	0	0 78	1 18	1 23	1 17	1 09	
	(g/ha)	21	0 81	1 20	1 35	1 42	1 18	+8
	S	0	0 78	1 22	1 26	1 33	1 15	
	(kg/ha)	10	0 81	1 10	1 32	1 26	1 12	2
	Mean		0 80	1 16	1 29	1 29	1 14	
	Dıfference (%)			+46**	+61**	+61**		

** sıgnıficant at P<0 01

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THE EFFECTS OF SEASON ON GRAIN YIELDS AND SOIL NITROGEN CONTRIBUTIONS OF FOUR CULTIVARS OF BEANS (*Phaseolus vulgaris L.*)

R T Jasdanwala and A G Chege

Department of Botany, Moi University, Eldoret Kenya

ABSTRACT

The relationships among rainfall growth yield and plant and soil nitrogen were examined in four bean cultivars (GLP 1004 Mwezi Moja GLP 585 Red Haricot GLP 2 Rose Coco and GLP288 New Rose Coco) sown monthly between April and October at Moi University Farm at Chepkoilel in Eldoret The cultivars responded differentially to sowing dates in all characters measured In GLP 1004 and GLP 585 better yields were associated with greater leaf area and higher rainfall In GLP 2 and GLP 288 improved yields were associated with earlier initiation and longer duration of pod filling Soil nitrogen level decreased significantly between sowing and maximum leaf area with GLP 585 and GLP 288 but increased significantly by harvest with GLP 1004 and GLP 2 None of the cultivars would be expected to contribute to soil nitrogen unless residues were returned to the soil It was suggested that soil nitrogen balance is determined by the cultivar rainfall pattern residue management and seed yield

INTRODUCTION

Beans are widely grown in Kenya most often as a secondary crop and in association with maize Generally time of sowing of beans is not fixed as is the case with cereals Beans are sensitive to moisture level and temperature and responses differ among cultivars (Acland 1971 Hall *et al* 1979 Rice *et al* 1986) Rainfall of 300 500 mm rainfall is considered suitable for growth and yield of beans depending on other climatic conditions (FAO 1979) The National Horticultural Research Station (NHRS) at Thika has released several cultivars of varying yield potential and disease resistance but their responses to climate are not yet fully known Though the yield potentials of most of these cultivars are satisfactory actual yields obtained by farmers are very poor (Acland 1971) attributable to unfavourable planting seasons inappropriate choice of cultivars and lack of fertilizers and pest control It is important to understand the influence of climate on morphological and physiological charecteristics in order to interpret the variations in yield across seasons Beans fix nitrogen (Raychudhuri 1966 Summerfield 1980 Williams *et al* 1980 Sattaur 1989 Squire 1990) but the effects of cultivars and seasons on the quantity of nitrogen contributed are not understood

The main aims of the present research were to study

1 the performance of four more widely recommended cultivars across seasons

2 the morphological and physiological characteristics of beans affecting yield and

3 the soil nitrogen contributions of the four cultivars across seasons

MATERIAL AND METHODS

The experimental site was Moi University Farm at Chepkoilel in Eldoret Climatic conditions are summarised in Table 1 The soil was a ferrolic Cambisol of poor fertility and moderate pH (5 5)

(FURP 1987) Seeds of four cultivars of bean (*Phaseolus vulgaris* L) were obtained from NHRS Thika They were Mwezi Moja (GLP 1004) Red Haricot (GLP 585) Red Coco (GLP 2) and New Red Coco (GLP 288) Sowing was during the first week of every month from March 1992 to February 1993 Four replicates of each cultivar were arranged in a latin square design at each sowing date (Gomez and Gomez 1979) The plot size was 2 x 2 m and plant spacing was according to Ngugi *et al* (1978) Neither fertilizer nor pest control measures were applied according to local farming practice The field was maintained weed free by regular weeding

Two randomly selected plants were removed from each plot at 15 day intervals to determine leaf area by establishing enlargement quotients (Abdullahi and Jasdanwala, 1991) for each cultivar leaf area index (LAI) according to GLP (1983) and dry weights of leaves shoots roots pods and seeds after drying to constant weight At each plant sampling soil cores (30 cm long and 4 cm diameter) were taken 10 cm from the plant bases and thoroughly mixed and the oven-dried plant parts were separately ground to fine powder for nitrogen estimation by the Kjeldahl method (Hinga *et al* 1978) Only the results for emergence maximum leaf area and harvest stages are presented in this paper The number of plants flowering was recorded daily to determine time to 50% flowering At harvest plant population number of pods per plant and seeds per pod and weight of 100 seeds were recorded and yield (kg/ha) was calculated for each plot

Table 1 Monthly mean maximum (MXT) and minimum (MMT) temperatures (C) rainfall (RF) potential evapo transpiration (PET) and total rainfall during growing period (TRF) (mm) at Moi T C Meteorological Station from March 1992 to February 1993

Weather parameter	Month of sowing											
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
MXT	29 5	27 0	26 6	25 2	25 5	23 6	24 6	24 6	24 0	25 5	24 6	25 6
MMT	5 5	7 0	6 5	7 2	6 2	5 5	5 5	6 0	6 5	6 0	6 0	5 4
RF	18	126	63	113	231	207	61	94	36	12	16	26
PET	172	139	167	123	112	154	179	193	185	189	192	176
TRF	500	517	606	611	592	392	196	139				

RESULTS

Germination and harvest stand

Sufficient rainfall to support growth (500 mm per growing period) was recorded from March onwards but germination was delayed beyond 15 DAS for this sowing because of uneven rainfall (Table 2)

Germination improved in the April sowing and was excellent (over 90%) in all cultivars from May to August but gradually fell from September to November after which germination ceased totally due to lack of moisture Seeds of GLP 585 tended to germinate more poorly than the other cultivars from Seprember onwards Percentage plants at harvest was excellent from March to August except in cultivars GLP 1004 GLP 2 and GLP 288 all plants of which were killed in the seedling stages by bean stem maggots (*Ophiomyia* spp)

Table 2 Percentage germination and plants at harvest of four bean cultivars sown on Moi University Farm at monthly intervals (March 1992 February 1993)

	Month of sowing											
Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
% germination (15 days after sowing)												
GLP 1004	0	89	96	94	91	93	77	73	65	14	0	0
GLP 585	0	89	100	99	92	94	68	63	55	8	0	0
GLP 2	0	87	97	93	93	96	89	88	71	11	0	0
GLP 288	0	97	100	97	95	96	89	90	67	17	0	0
% plants at harvest												
GLP 1004	85	90	99	0	0	95	77	73	0	0	0	0
GLP 585	100	100	100	98	96	94	68	64	0	0	0	0
GLP 2	87	92	99	0	0	99	90	88	0	0	0	0
GLP 288	93	98	100	0	0	90	91	90	0	0	0	0

Table 3 Numbers of days to maximum LA and LAI 50% flowering and harvest in four bean cultivars sown monthly (March October 1992) at Moi University Farm

	Month of sowing							
Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
50% flowering								
GLP 1004	59	33	32			33	32	31
GLP 585	59	37	40	39	41	37	35	33
GLP 2	64	45	45			35	33	33
GLP 288	60	40	42			32	30	30
Maximum LAI								
GLP 1004	75	75	90			75	75	45
GLP 585	90	90	105	90	90	75	75	60
GLP 2	120	105	105			105	90	60
GLP 288	120	105	90			105	90	60
Harvest								
GLP 1004	133	118	129			117	96	79
GLP 585	133	118	129	126	113	117	95	79
GLP 2	133	118	129			117	95	79
GLP 288	133	118	129			117	95	79

Phenology

There were large differences in times to 50% flowering maximum leaf area and harvest among cultivars and sowing dates The March sowing flowered later because of the delay in germination Times to flowering and maximum LA were otherwise similar between March and June or July and then fell from August to October GLP 1004 flowered and attained maximum LA earlier than the other cultivars in the earlier sowings but by harvest differences among cultivars had disappeared Times to flowering maximum LA and harvest progressively decreased as sowing became later

Leaf area

Maximum LAs and LAIs progressively increased in March April and May sown crops remained high (in GLP 585) in June and July and then fell rapidly to very low values in the October sowing (Table 4) The LA and LAI of GLP 1004 were much less than those of the other three cultivars in the earlier sowings but the differences among cultivars were much smaller in the later sown crops Maximum leaf areas and LAIs were positively correlated with rainfall and grain yield

Table 4 Maximum LAs (cm^2/plant) and LAIs of four bean cultivars sown monthly (March 1992 February 1993) at Moi University Farm and their correlations with rainfall (RF) and grain yields (GY)

	Month of sowing								r	
Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	RF	GY
Maximum LAs										
GLP 1004	141	193	277			266	234	35	0 51	0 80
GLP 585	275	345	693	671	705	410	213	30	0 88	0 99
GLP 2	252	296	771			205	254	52	0 73	0 40
GLP 288	226	343	939			399	274	44	0 71	0 58
Maximum LAIs										
GLP 1004	0 35	0 48	0 69			0 62	0 59	0 09	0 50	0 77
GLP 585	0 69	0 86	1 73	1 68	1 78	1 02	0 53	0 08	0 86	0 89
GLP 2	0 63	0 74	1 20			0 51	0 64	0 13	0 71	0 48
GLP 288	0 57	0 86	2 3			1 0	0 68	0 11	0 72	0 57

Yield and yield components

Mean pods per plant tended to increase up to the May sowing and declined from August onwards though there was a slight increase in September when GLP 2 and GLP 288 produced their maximum pod numbers GLP 585 produced most pods in the early sowings and GLP 2 in the later ones Numbers of seeds/pod and seed weights were *similar among seasons* except the October sown crop when they were much decreased GLP 1004 produced fewer seeds per pod than the other cultivars except in the September sowing Seeds of GLP 585 were around half the weights of the other three cultivars Seed yields progressively increased from March to May and were poor in October in all cultivars but otherwise behaved rather erratically In the earlier sowings GLP 585 and GLP 288 yielded best and GLP 1004 was the poorest yielder In later sowings the yields of GLP 585 were poorest and GLP 2 and GLP 288 yielded best These two cultivars maintained yields of over 2 t/ha as late as the September sowing

Table 5 Number of pods/plant and seeds/pod weight of 100 seeds (g) and grain yields (kg/ha) of four bean cultivars sown monthly from March 1992 to February 1993 at Moi University Farm and their correlations with grain yield

	Month of sowing								r
Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	GY
Pods/ plant									
GLP 1004	3 0	5 6	6 3			4 4	3 9	3 3	
GLP 585	6 3	7 1	7 0	7 9	8 1	5 3	5 0	2 8	
GLP 2	3 3	4 1	6 5			6 8	7 6	4 3	
GLP 288	5 3	6 0	5 3			4 5	6 7	4 6	
Seeds/pod									
GLP 1004	2 6	2 9	3 2			1 9	5 2	2 0	
GLP 585	6 9	6 8	5 9	6 8	6 7	5 7	3 5	3 9	
GLP 2	4 2	4 9	4 6			5 1	5 3	2 1	
GLP 288	4 8	5 5	6 1			4 8	5 9	4 1	
Weight/100 seeds (g)									
GLP 1004	50 3	51 5	53 9			57 9	50 5	46 6	
GLP 585	24 3	25 0	29 8	23 4	30 8	30 4	23 8	19 8	
GLP 2	53 7	50 7	50 9			52 8	48 4	45 0	
GLP 288	50 6	48 4	55 3			53 7	53 1	47 0	
Grain yields (kg/ha)									
GLP 1004	416	941	1344			575	986	281	0 50
GLP 585	1320	1519	2051	1538	2003	1088	354	184	0 97
GLP 2	809	1168	1883			2267	2187	447	0 14
GLP 288	1496	1955	2236			1305	2389	997	0 32

Soil nitrogen

Soil nitrogen tended to decrease from the initial growth to maximum leaf area stages the decline being significant for GLP 585 and GLP 288 (Table 6) In contrast soil nitrogen increased from initial growth to harvest significant in the cases GLP 1004 and GLP 2

Table 6 Percentages of nitrogen in soil at three stages of growth of four bean cultivars sown monthly at Moi University Farm from March 1992 to October 1993

Cultivars/ growth stages		Month of sowing Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	F values GS	SD	IvII	IvIII
GLP 1004	SI	99	102	104			98	99	99				
	SII	99	99	99			93	96	98	9 0*	6 4*	<1 0	52 7*
	SIII	101	105	107			100	97	99				
GLP 585	SI	99	102	104	104	101	98	99	99				
	SII	99	99	101	100	96	95	98	98	12 9*	4 9*	143 7*	2 3
	SIII	104	108	109	115	102	99	99	100				
GLP 2	SI	99	102	104			98	99	99				
	SII	100	98	99			92	99	99	12 1*	11 7*	6 8	40 0*
	SIII	102	102	106			97	96	98				
GLP 288	SI	99	102	104			98	99	99				
	SII	99	99	100			93	97	99	24 2*	10 5*	140 0*	4 5
	SIII	104	107	108			100	100	101				

SI = initial stage SII = maximum leaf area and SIII = at harvest * F values significant at P<0 05 GS = *growth stages* SD = sowing dates

Plant nitrogen

Nitrogen contents of plant parts at harvest were much greater than at maximum leaf area in every case (Table 7) At maximum leaf area nitogen increased to maxima for May sowings and declined from August onwards Whole plant and vegetative (but not pod) nitrogen were positively correlated with total rainfall in all cultivars The nitrogen contents of all plant parts were positively correlated with grain yields at maximum leaf area

At harvest nitrogen contents were always poorest in the October sowing but were otherwise erratic Maxima occurred in May for GLP 1004 in July for GLP 585 and in September for GLP 2 and GLP 288 The nitrogen content of vegetative parts was positively correlated with rainfall Nitrogen in pod walls and seeds was much better correlated with rainfall in GLP 1004 and GLP 585 than in the other two cultivars Nitrogen in plants at harvest was positively correlated with grain yields in GLP 1004 and GLP 585 but not in the other two cultivars

Table 7 Total nitrogen (kg/ha) in vegetative organs (leaves+shoots+roots) and pods at maximum leaf area (MLA) and harvest and correlations with rainfall and yield

Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	RF	GY
	Month of sowing								r	
Vegetative organs at MLA										
GPL 1004	6 53	9 6	27 9			20 6	9 24	6 15	0 76	0 63
GLP 585	7 13	33 6	46 6	38 2	52 3	28 9	13 9	5 2	0 87	0 85
GLP 2	11 2	20 4	63 9			24 8	17 4	10 2	0 88	0 69
GLP 288	11 86	16 41	59 1			37 0	21 6	11 0	0 79	0 37
Pods at MLA										
GLP 1004	0 34	4 8	8 11			7 84	14 9	0 46	0 1	0 65
GLP 585	2 0	23 4	43 5	14 8	14 2	5 76	9 69	0 16	0 70	0 63
GLP 2	7 94	18 1	14 4			40 4	30 2	7 45	0 1	0 85
GLP 288	24 7	26 5	29 3			44 4	27 1	8 89	0 13	0 79
Whole plant at MLA										
GLP 1004	6 87	14 4	36 1			28 4	24 1	6 61	0 83	0 71
GLP 585	9 13	57 0	90 1	53 1	66 5	34 7	23 5	5 4	0 87	0 72
GLP 2	19 6	38 4	78 2			65 3	47 6	17 7	0 83	0 84
GLP 288	36 6	42 1	88 5			81 5	48 2	19 9	0 63	0 54
Vegetative organs at harvest										
GLP 1004	19 3	48 3	63 0			27 9	39 3	11 4	0 62	0 95
GLP 585	23 3	36 8	58 5	59 0	63 0	35 2	11 0	6 5	0 99	0 99
GLP 2	11 0	37 6	34 1			20 1	44 9	17 8	0 67	0 59
GPL 288	27 9	40 4	32 3			52 0	38 5	17 7	0 66	0 53
Pod walls at harvest										
GLP 1004	2 7	13 6	19 3			8 8	9 1	2 0	0 64	0 94
GLP 585	19 6	20 6	27 1	21 1	29 1	16 0	7 6	3 6	0 95	0 66
GLP 2	7 8	11 2	17 0			21 8	27 3	4 5	0 08	0 99
GLP 288	14 8	18 5	18 6			12 6	24 2	10 2	0 16	0 97
Seeds at harvest										
GLP 1004	18 7	43 2	58 4			16 4	33 8	10 5	0 61	
GLP 585	34 2	39 4	55 0	42 7	57 2	33 9	8 1	3 8	0 95	
GLP 2	24 7	40 4	63 8			65 3	74 8	7 3	0 20	
GLP 288	53 7	53 7	71 4			95 6	138 5	33 4	0 21	

At maximum LA exceptionally large values of ratios of vegetative to pod nitrogen occurred in GLP 1004 sown in March and GLP 585 sown in October and there were no obvious trends (Table 8)

At harvest there were clear diferences among cultivars in the ratios of residual to seed nitrogen In GLP 288 and GLP 2 most of the nitrogen occurred in the seeds (65 75%) followed by GLP 585 (50 60%) with GLP 1004 (50%) having least nitrogen in seeds

Table 8 Ratio of nitrogen content in vegetative parts and reproductive parts at the stage of maximum leaf area and at harvest

	Month of sowing							
Cultivars	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
N veg N pod at maximum LA								
GLP 1004	19 21	2 0	3 4			2 62	0 62	0 95
GLP 585	3 45	1 44	1 07	2 58	3 69	5 01	1 29	32 5
GLP 2	1 46	1 12	4 45			0 61	0 57	1 36
GLP 288	0 48	0 62	2 02			0 83	0 80	1 12
N res N seed at harvest								
GLP 1004	1 03	1 12	1 08			1 1	0 89	0 92
GLP 585	0 4	0 61	0 7	0 9	0 7	0 75	0 7	0 86
GLP 2	0 33	0 38	0 56			0 37	0 35	0 66
GLP 288	0 4	0 46	0 57			0 31	0 25	0 4

N veg = nitrogen contents of vegetative organs N pod = nitrogen contents of pods
N res = nitrogen contents of residues N seed = nitrogen contents of seeds

DISCUSSION

Understanding of the effects of physical and physiological factors on development yield and N assimilation and their relationships with genotype are vital for the improvement of grain yields and nitrogen contribution of beans

Results presented here demonstrate the importance of sowing time on the growth and yields of four bean cultivars in Uasin Gishu District in Eldoret Region in Kenya From meteorological data two separate seasons could not be distinguished as reported previously for Maguga by Chui (1989) and yield was obtained from beans sown throughout the eight months from March to October Sufficient rainfall for growth and yield of beans was recorded from March onwards but germination was delayed in the first sowing and although subsequent moisture was sufficient and final plant stands reasonable the crop was not able to recover from the adverse effects suffered during germination and the yields of the March sowing were very much smaller than those of later sowings

The April and May sowings received better rainfall (517 and 600 mm respectively) and yields improved especially for the May sowing Among cultivars GPL 288 yielded heaviest followed by GLP 585 GLP 1004 produced the poorest yields in these sowings For the June and July sowings rainfall was also sufficient (611 and 592 mm) but potential evapotranspiration was low and night temperatures warm and the resultant humid conditions contributed to increased bean stem maggot infestations which totally destroyed the cultivars GP 1004 GLP 2 and GLP 288 at the seedling stage so no grain was obtained GLP 585 showed remarkable resistance to these pests all germinated plants survived to maturity and produced considerable yields It was evident that climatic conditions during this period were very suitable for growth and yield of beans but also favoured the development of bean stem maggots (Slumpa and Kabungo 1989 Sithanantham 1989)

Yield differences among cultivars were most pronounced in August or September sown beans when rainfall (397 and 196 mm) was low potential evapotranspiration (154 and 179 mm) high and temperatures were cool GLP 2 and GLP 288 produced the heaviest yields GLP 585 produced very little grain at these sowing dates as although it resisted bean stem maggots it suffered from bean rust (*Uromyces phaseoli*) For the October sown crop total rainfall was less (139 mm) and potential evapotranspiration was high (193 mm) and the yields of all cultivars were drastically reduced though GLP 288 produced 997 kg/ha of grain

Leaf area (LA) and leaf area index (LAI) increased with increasing rainfall in all cultivars except GLP 1004 LA and LAI showed positive correlations with yield in all sowings of GLP 1004 and GLP 585 and in the March May sowings of GLP 2 and GLP 288 The nitrogen contents of vegetative parts at maximum leaf area of the same treatments were also positively correlated with rainfall indicating that vegetative growth increased with increasing rainfall associated in these treatments with larger LA and LAI total biomass and grain yields Positive correlations of LA and LAI with yield have been reported in Watson (1958) Ashley *et al* (1965) Eik and Hanway (1966) Iwata and Okubo (1971) and GLP (1983) It is generally believed that LAI is a powerful determinent of canopy photosynthesis and dry matter accumulation (Baker *et al* 1978) Wortmann *et al* (1990) have also related total biomass with grain yield

In August/September sowings GLP 2 and GLP 288 produced heavier yields than the other cultivars despite poorer LAs and LAIs Lower ratios of vegetative to pod nitrogen at maximum LA suggest earlier pod intiation and therefore longer duration of pod filling as an explanation for the better yields of these treatments The relationships of LA and LAI with yield within and between the cultivars are complex (Watson 1952) Adams (1973 1975 1981) emphasized that effective pod filling is important for yield Further Izquierdo (1981) and Izquierdo and Hosfield (1983) related better yields with increased physiological efficiency involving duration of pod filling and partitioning and remobilization of assimilates Paredes (1986) has also demonstrated significant positive correlations between duration of pod fill and yield Further it is important to note that in the Eldoret region frequent occurrence of hail storms complicated the relationships among rainfall vegetative growth and grain yield

The times to 50% flowering of all cultivars were reduced in August and September sowings when grain yields of some cultivars were poorest so early flowering was not important in determining yield Pod numbers were closely associated with grain yields In the case of GLP 585 and GLP 288 more pods per plant and seeds per pod were recorded in May to July sowings accompanied by better vegetative growth and grain yields GLP 2 and GLP 288 produced most pods per plant from August and September sowings when they also produced their best yields

Contribution to soil nitrogen is an important aspect of bean cultivation There was significant seasonal variation in soil nitrogen The variation at sowing may have arisen from incorporation of accumulated weeds during seedbed preparation Subsequent variation could have arisen from differences in vegetative and reproductive growth among cultivars and seasons Declines in soil nitrogen between sowing and maximum leaf area suggested that all four cultivars consumed nitrogen during early growth Beans are poor nitrogen fixers and require an external source of soil nitrogen as reported earlier (Lynch and Piha 1988 Wortmann and Zake 1988) This requirement differs among cultivars

Soil nitrogen was greater at harvest than at sowing or maximum leaf area but the increase may have resulted from the inclusion of dehisced leaves in soil samples

The increased nitrogen contents of plant parts at harvest compared with maximum leaf area suggests that effective nitrogen assimilation occurred during reproductive growth Nitrogen in the plant at maximum leaf area and harvest tended to increase to maxima for sowings between May and August or September and then declined The total nitrogen content of plant parts at maximum leaf area increased with increase in rainfall and was proportional to total biomass Vegetative (but not pod) nitrogen was positively correlated with total rainfall in all the cultivars This indicated that pod development was influenced by other factors

At harvest also the nitrogen content of vegetative organs increased with increases in rainfall especially in GLP 585 Vegetative nitrogen was positively correlated with yield in GLP 1004 and GLP 585 but not in GLP 2 and GLP 288 This observation supports the suggestion that the grain yields of GLP 1004 and GLP 585 are closely associated with vegetative growth and rainfall but those of GLP 2 and GLP 288 are associated with other factors perhaps including duration of pod fill

Considering soil and plant nitrogen contents at maximum leaf area and harvest it is suggested that the bean crop will only contribute to soil nitrogen if residues are returned to the soil The annual nitrogen soil balance will depend on the cultivar pattern of rainfall residue management and seed yield For example since a considerable proportion of plant nitrogen is located in pod walls high yielding cultivars will return less nitrogen to the soil unless pod walls are included in their residues Box and Hammond (1990) also showed the importance of residues and grain yields of other legumes to the soil nitrogen balance

CONCLUSIONS

1 All four cultivars were affected by sowing date and there were considerable differences in yield among cultivars at all sowing dates

2 Grain yield was associated with vegetative growth in GLP 1004 and GLP 585 but dependent on earlier initiation and longer duration of pod filling in GLP 2 and GLP 288

3 Soil nitrogen level was significantly less at maximum leaf area in GLP 585 and GLP 288 and more at harvest time in GLP 1004 and GLP 2

4 Contribution to soil nitrogen by any cultivar is negligible if all plant parts are harvested It is suggested that annual soil nitrogen balance of soil nitrogen under any bean cultivar will depend on rainfall pattern residue management and seed yield

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FARMER PARTICIPATORY RESEARCH IN MATUGGA VILLAGE (UGANDA) AN ALTERNATIVE APPROACH TO TECHNOLOGY DEVELOPMENT AND TRANSFER AND RESEARCH IMPLEMENTATION BY FARMERS

M A Ugen and P K Jjemba

NARO, Kawanda Agricultural Research Institute Kampala Uganda

ABSTRACT

Farmer participatory research (FPR) is being conducted in Matugga village (Uganda) to gain and apply local knowledge of farmers in the formulation of a research programme Various methods have been used to solicit information from farmers including semi structured questionnaires transect walk and observation participatory diagramming and group discussions The different approaches used have been explained and analyzed in this paper

INTRODUCTION

Technology development and transfer have evolved over the years with the role of the farmer becoming of increasing importance (Potts *et al* 1991) Recently it has been realized that farmers creativity skills and knowledge are paramount for successful technology transfer (Lightfoot 1987) A number of researchers have emphasized the importance of proper farmer involvement in research formulation (Ashby 1990 Fujisaka 1989 Lightfoot *et al* 1987 and Tripp and Woolley 1989) and in soil management research specifically All have shown that for a better understanding of farmers production constraints one has to start with farmers being actively involved in research formulation

Through generations of observations trial and error farmers have learnt a great deal about their farming systems They characterize their soils according to features such as colour depth crop performance and existing natural vegetation and understand much about the relevant factors within the systems and environments under which they operate If research is to adequately address farmers needs it has to consider their traditional knowledge Farmers can contribute to problem identification determination of causes evaluation of potential solutions and in the development and implementation of a research plan (Ugen *et al* 1992)

Researchers have used many approaches to understand farmers situations Which is most appropriate depends on the local situation under which one is operating This paper describes the various approaches we used in understanding farming systems and constraints and formulating research in Matugga village (Mpigi District Uganda) The objectives of the research are to conduct farmer participatory research (FPR) at a representative research location in Uganda and to evaluate various techniques and methods used in the FPR process This paper presents an analysis of some of the techniques used to gain and apply local knowledge in the formulation of a participatory research programme

METHODS/APPROACHES USED TO SOLICIT AND APPLY INFORMATION IN FORMULATING A RESEARCH PLAN

The research-extension farmer linkage has long remained wide yet the transmission of technologies and feedbacks has depended on the system It has become important for researchers to develop means of introducing new technologies to farmers and to work hand in hand with farmers to develop suitable technologies for their environments This has prompted researchers to devise means of involving farmers in research formulation and technology development and transfer rather than extending technologies which have already been decided upon by researchers FPR attempts to bridge this gap and bring the three bodies to work together through a number of approaches

1 Interviews using semi structured questionnaires

Our initial visits to the community provided an opportunity to study soil types (according to local classification) and their land uses and management This was approached through semi structured questionnaires Interviews centred mainly around soils and their management but we also noted land tenure systems crop management and adaptation of crops to soil types and collected soil samples Initially we concentrated on soil management which happened to be a crucial problem in the area The results have been reported in Ugen *et al* (1992)

Individual interviews helped to solicit information such as land area and animals owned by individuals which would be sensitive in a group This interview procedure was also useful in obtaining information on soil types crop adaptation to soil types crop rotation and crop management practices It was not very useful in determining the bad and good characteristics of the soil types as perceived by farmers and we think it should be modified to give the farmers view of what researchers need especially with regard to soil characteristics and current management practices But the procedure still remains important for initial introduction to an area and obtaining sensitive information

On the other hand individual interviews are time consuming and if not properly followed up can cause lack of interest in the farming community It is important to inform farmers of the information collected and analyzed if confidence is to be gained in future meetings

2 Transect walk and participant observation

Apart from observing the soil types individually during the interviews a transect walk was organized with a small group of farmers to give more information on soil types and relate the various soil positions along the transect to crop production and other farm activities

Starting from the home of one farmer on a hilltop farmers and researchers walked from the top of the hill to the valley bottom The selection of the transect was at random by the whole group During the transect farmers were asked to note important features and why they were in those particular spots This later helped farmers to diagram a typical catena for the area

The transect walk was particularly important in relating farm activities along the transect to soil types and soil positions It was also useful in identifying the probable locations of problem soils like *lunyu* and *zubugu* However the area covered was not large enough to be representative of the whole community and in future should be increased so that all the different activities can be encountered on the various soil types and positions

3 Participatory diagramming exercises and group discussions

This involved the diagramming of important features in the study area A map was drawn of the research location and information on various features of the area were explored using diagrams Farmers diagrammed labour and rainfall distribution labour distribution according to sex and allocation of land labour and capital to the different crops a typical soil catena and importance of crop changes in importance and reasons for change

The diagramming was done during group meetings where small groups addressed different topics Each group was composed of 6 to 20 farmers depending on attendance during the various days of the meetings Some results are shown in Figures 1 and 2 For others see Ugen *et al* (1992) A small group of farmers drew the rainfall and labour demand distributions (Figure 1) The estimated rainfall coincided well with the actual rainfall data for Kawanda Research Station which is 4 5 km from the study area Labour demand was high during the planting and weeding periods

Diagramming of labour distribution according to sex was useful in determining the sort of activities undertaken by each member of the family This helped in deciding who should be involved in what type of research in that particular area and why certain activities were for one sex and not the other while noting the importance in the change in crops over the last several years indicated why certain crops were now neglected For example coffee used to be an important cash crop but is now neglected because of the high inputs needed and lack of a market Crops like beans and maize have replaced coffee because of the large demand for them Subsequently farmers drew bar graphs with the bar length indicating crop importance Reasons for the changes in relative importance of the crops were elicited through open discussion in the group

A typical soil catena drawn by a small group of farmers included soil information land use and land values They discussed these in relation to three soil positions hill tops hill sides and valleys Soil classification was addressed by a group of farmers knowledgeable about soils They classified and described the soils with regard to colour catena aggregates structure water holding capacity and texture

Allocation of land labour and capital to crops was discussed by a group of 15 farmers They enumerated ten important crops in the area and allocated land labour demand and capital to them The farmers were asked to consider the allocation process as though they were allocating chapati to a number of people with different preferences With this idea in mind farmers found the exercise easy and interesting Diagramming exercises helped discussion and much information was gained within a short time in a relaxed manner They also encouraged participation from every farmer who all had the chance to discuss problems in small groups It became easy to present a large amount of information which could be easily understood by most farmers in a relatively small space At the same time we were not able to prevent the domination of group discussions by the more vocal farmers in some cases In all cases the individual groups presented their findings at the end of each meeting for clarification by the whole group of farmers

4 Problem identification and prioritization by open voting and pairwise comparison methods

Problem identification and prioritization exercises were conducted twice in the study area We used both interviews and brainstorming methods to identify farming problems During interviews problems related to soil fertility management were individually identified and later compiled for group discussion (Ugen *et al* 1992) Interviews identified 14 problems which were discussed during the group meeting and ranked by open voting (Ugen *et al* 1992) (subsequently we felt that in large groups the more vocal farmers influenced the others) Apart from this we restricted ourselves to soil related problems only rather than all the problems affecting crop production We repeated the exercise asking farmers to identify all the problems affecting crop production in the area This involved 80 farmers who identified 23 problems The 23 problems were then separated into four main categories soil related (5 problems) disease related (7 problems) problems related to crop production management (6) and lastly insect pest related (5 problems) The problems covered all crops of importance including beans

Figure 1 Labour demand and rainfall distribution for Matugga (estimated by farmers) and Kawanda monthly rainfall

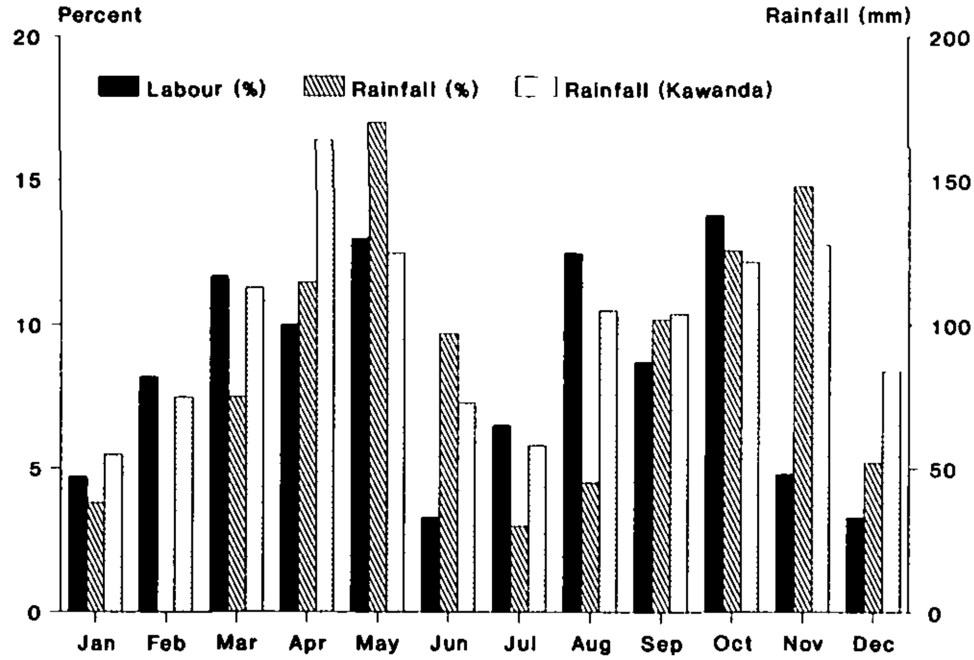
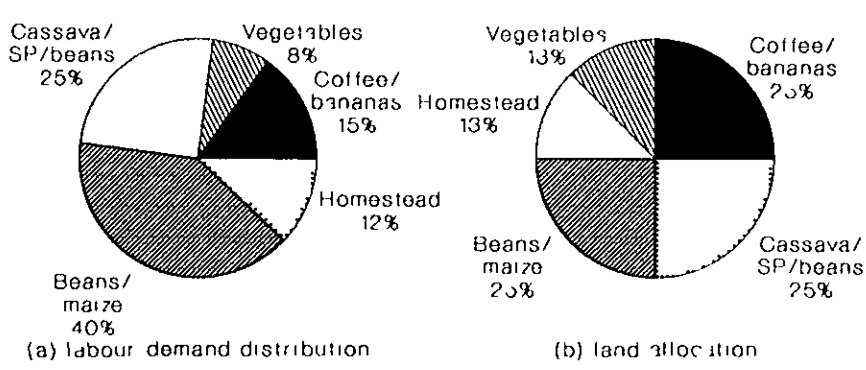


Figure 2 Allocation of labour and land to crops in Matugga Village



SP sweet potatoes

Farmers used the pairwise comparison method to rank the problems by comparing similar problems in each category (Ashby 1990) The two most important problems of each group were considered for diagramming causes and solutions The eight problems that were considered most important were poor soil soil erosion lack of knowledge of farming weeds poor seed quality wilts in vegetables groundnut rosette banana weevils and cassava mosaic Each group was asked to diagram the causes of their two important problems and identify possible solutions After discussion and reporting by the groups to the whole group we selected 12 researchable solutions

The group discussion and diagramming exercises helped to stimulate meetings and motivated all farmers to become involved in the discussions Discussion of many topics was usually accomplished in a short time and had immediate results as the whole group had to compromise on something Complicated features were reduced to understandable forms by the use of diagrams In some of the groups vocal farmers tended to dominate discussion and influence other members in decision making We introduced breaks into long meetings to avoid farmers losing concentration

5 Experimental design and trial implementation by farmers

To stimulate thoughts on experimentation we asked farmers to recount their experiences in their own experiments This was followed by an explanation by researchers of principles of experimentation addressing treatment comparisons plot size site selection replication and randomization Steps in designing trials were highlighted These included title objectives treatments replication plot size site selection trial management and observations to be made

Farmers then worked in groups to design trials They planned seven trials crop rotation involving beans maize and groundnut mulching/weed residue management for vegetables manuring with farmyard manure and household refuse bean variety evaluation cassava mosaic resistance agroforestry involving *Leucaena* and *Calliandra* spp intercropped with maize and banana weevil control

After designing the trials each group presented their findings to the whole group for further discussion and refinement The designs were then posted and farmers volunteered to participate in preferred trials Of the 50 farmers available 23 farmers volunteered to conduct a total of 38 trials Each farmer accepted a minimum of one and maximum of three trials Most farmers have now ploughed their land and are waiting for rains to plant We plan frequent visits with the farmers to build their confidence in the work It should be noted that most of the trial designs were by the farmers themselves with little help from the researchers after the detailed explanation of trial design

SUMMARY

Although the approach is dynamic and a flexible means of integrating farmers experiences and information in technology development in future it may prove very expensive for researchers to maintain It needs constant visits to areas of study requiring funds to operate vehicles pay per diems organize meetings and purchase supplies and materials The choice of a location which researchers can easily reach will reduce costs Also as farmers become more experienced and assume more responsibility in research researcher time may be reduced thereby also reducing costs Compared to the extensive on farm research approach we feel that this will be less costly in future as a small area representative of the whole community is considered at a time

Secondly the involvement of researchers of more disciplines is needed Farmers consider their farming problems as a whole and not in isolation Apart from soil management and bean production problems they include related problems such as insect pests weeds and diseases and socio-economic factors Crops and fields of study should be addressed together in a multidisciplinary approach

In conclusion the FPR approach is promising with a high probability of developing and transferring technologies appropriate to farmers circumstances Its flexibility and dynamism allows the approach to be modified to suit any environment But it remains a learning process for both researchers and farmers The institutionalization of the approach to cover all disciplines will be a worthwhile venture for proper and appropriate technology development

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MANAGEMENT OF ACID SOILS
A DIAGNOSTIC SURVEY IN AMBOHIBARY AND ANTANIFOTSY

B Rabary

Centre National de la Recherche Appliquee au Developpement Rural FOFIFA/DRA, Antananarivo Madagascar

ABSTRACT

A diagnostic survey was conducted in Ambohibary and Antanifotsy in Antsirabe region (Madagascar) to study farming systems farmers management and utilization of acid soils and constraints Individual interviews in the field were combined with crop and field observations plant analysis and soil study The most important constraints are pests and diseases and poor soil fertility Aluminium toxicity is severe and there is deficiency of phosphorus Erosion is noticed everywhere Bad practices of land preparation and the non use of terraces have worsened erosion In general there is a need to review agronomic practices with farmers and establish farmer participatory research

INTRODUCTION

In the highlands of Madagascar beans are the most important leguminous crop and well integrated into cropping systems (Bigot *et al* 1988) The advantage of beans is their adaptability Two crops of beans are possible during the rainy season on *tanety* (upland soil) in the first season beans are sown in September October and in the second season January February Both seasons are equally important Beans can also be cultivated in well drained rice fields during winter in areas with altitudes less than 1200 masl According to the results of a formal survey of bean cropping systems conducted previously in Antsirabe (Rollin and Rabary 1991) the most important constraints to production are pests and diseases followed by poor soil fertility The largest proportion of soils of Madagascar are Ferralsols (sols ferrallitiques) (Oldeman 1990) There is a need to evaluate their soil fertility especially nutrient availability and balance using appropriate methods for assessing these factors (soil tests plant analysis soil survey climatic conditions) (Sanchez 1987) followed by detailed study of the farming systems The objectives of this study were to learn more about farmers management and utilization of acid soils and to identify and evaluate problems caused by acid soils

METHODOLOGY

The method of informal interviewing (Steiner 1990) was adopted Open-ended questions were used to understand farming systems farmer soil fertility management and how farmers perceive their problems Individual interviews in the field were combined with crop and field observations and soil study

Two areas (Ambohibary and Antanifotsy) were chosen in Antsirabe They differ in altitude geology and geomorphology Twenty eight farmers were interviewed fourteen in each area Twenty four soil samples were collected in different toposequences representing the types of soil on which beans are grown Farmers were chosen at random but bean crop locations and type of soils were considered Bean leaf samples (the latest fully developed leaves at flowering) were collected for analysis

Interview teams were composed of an agronomist a soil scientist and a socio economist It took three weeks to complete the survey Background information about the areas was collected from the

Antsirabe CIRVA atlas (Raveromihaja 1992) and from previous formal survey results

GENERAL DESCRIPTION

Ambohibary is located in northern Antsirabe The area surveyed included the villages of Tsarahonenana Antetezamby and Ampetsapetsa Antanifotsy is in the North East and the villages surveyed were Antanambao Tokotanitsara and Fierenana Some characteristics of the areas are summarised in Table 1

Table 1 Some physical and socio-economic characteristics of areas surveyed

Description		Ambohibary	Antanifotsy
Ecology			
altitude (m a s l)		1688 1900	1555 1660
mean annual rainfall (mm)		1545	1310
mean annual temperature (C)		16 3	unknown
latitude		19 37 S	22 06 S
longitude		47°07 E	46°54 E
population density (km^2)		111 8	193 40
Farming system			
flooded rice field/farm (ha)	range	0 1 1 2	0 2 3
	mean	0 34	0 36
available cultivated rice field		1 13	1 17
area/farm in *tanety* (ha)	range	0 15 2	0 18-4
	mean	0 73	0 80
available cultivated *tanety*		1 37	1 44
cattle/person		0 19	0 04
pigs/person		0 055	0 12
chickens and ducks/person		1 18	1 32
number of ploughs/farm		0 063	0 03
number of harrows/farm		0 078	0 09
number of rural farmer associations		53	38

Throughout Madagascar rice is the principal food crop In Antsirabe farmers can raise one to two wetland rice crops per year The rainy season is from mid November to early April During this period mean temperatures are 17°C to 19 C The dry period corresponds to the cold season The coldest months are June July and August with minimum temperatures around 5°C Also Antsirabe is a relatively cold region This region is well suited for temperate zone crops such as wheat barley vegetables and fruits such as apples pears peaches and plums

Family size ranges from two to nineteen with an average of seven persons per family Farms are mainly family operations Land is inherited from parents or owned through traditional systems of usage which causes problems because few farmers have title to their land Very little land is obtained by direct purchase

Traditional farming systems prevail and few new technologies have been adopted except for rice wheat or barley which are promoted by extension agents or training staff from rural development organizations They provide credit or inputs like seeds fertilisers and insecticides and help farmers to market their produce

Often rural development agents and extensionists work only with farmers who are members of village associations Those who are not members have no contact with and criticize them Farmers associations organize credit and saving societies and common granaries to avoid low crop prices during harvest time They work with rural development agencies promoting cattle breeding mainly for milk The presence of farmers organisations helps in diffusing new technologies but efficiency is still low because of the strict bank regulations associated with credit lack of security and because some members do not fulfill their obligations Most farmers beware of new technologies because they fear increased costs

In general farms are characterised by small farmers who lack cash and inputs and whose production costs are larger than their profit Seventy percent of interviewed farmers hire labour for rice production especially for land preparation transplanting and harvesting for *tanety* production especially land preparation and for all forms of transportation (including manure to fields and produce from field to village)

SOIL DESCRIPTION

The soils in the surveyed area are volcanic formed on basal crystalline complex They are moderately organic but acidic and well-drained with medium biological activity Exchangeable Al is very high Aluminium saturation (Kamprath coefficient) (Boyer 1976) shows that Al toxicity is severe and excessive for crops Cation exchange capacity (CEC) is low indicating low base saturation and poor soil fertility (Table 2) The lower horizons (>15 cm) have very low nutrient reserves They are poorer than the top horizons so cultural practices have tended to improve the surface soil

Each farmer has fields on hilltops steep slopes valley bottoms and colluvial soils and has rice fields On steep slopes topsoil is rapidly exhausted and washed away by erosion At the bottom of the hill there are colluvial deposits and the topsoil is deeper These soils are more fertile than those on the slopes

AGRICULTURAL TECHNIQUES AND SOIL MANAGEMENT

The main crops cultivated on *tanety* are maize bean cassava potato soybean sweet potato peas cocoyam and arrow root (especially in Ambohibary) Mixed cropping is common During the main season (October January) beans are always intercropped with maize Sometimes there are two or three associated crops such as cassava maize beans or potato maize beans soybean Pure stands of beans are cultivated during the second season (February May)

One hundred percent of farmers plant beans during the first season During the second season 100% of farmers plant beans in Antanifotsy and 67% in Ambohibary Twelve percent plant beans during winter (July October) in Antanifotsy

Beans are planted throughout the toposequence The most important positions are on slopes and bottoms of the hills Farmers practice complex crop rotations mainly potato or sweet potato followed by beans intercropped with maize or other crops during two or three seasons then fallow or potato again Thirty percent of farmers do not practise rotation Sixty percent of farmers practise fallow for 1 to 2 years with estimated land size ranging from 0 05 ha to 1 5 ha Fallows are practised because land has become increasingly infertile but also because of lack of manure and inputs and cash to hire labour

Table 2 Soil characteristics of Ambohibary and Antanifotsy

Soil characteristics		Ambohibary	Antanifotsy
Geology		complex formation of trachyte andesite with basaltic recovery	migmatites gneiss micaschists substratum
Color (Munsell code)		brown reddish to strong red	brown reddish to red
Topography		hilly and stony	gentle slopes
Cultivated slopes		10 30%	2 10%
Visited		5 and 7 5 years	5 and 7 5 years
Erosion		important	moderate
pH 1 2 5	range	4 5 4 9	4 1 5 2
(soil water)	mean	4 73	4 91
CEC meq/100g	range	2 88 15 14	1 88 24 79
(cobaltihexamin)	mean	6 53	10 09
Exchangeable Al	range	0 57 8 43	0 44 7 71
(meq/100g)	mean	2 86	3 41
Al (Kamprath	range	62 90	58 92
Coefficient %)	mean	79	81
Phosphorus	range	1 8 4 7	1 6 8 4
(Olsen ppm)	mean	3 2	8 3

All farmers applied manure to their fields but the quantity varied according to the amount available When there is a lack of manure maize and bean seeds are sown together in the same hole A few farmers applied inorganic fertilizers (NPK 11 22 16 or urea) but only in small amounts (16 50 kg/ha) Others did not like chemicals because they considered they destroyed soil structure In Ambohibary to increase the quantity of manure farmers burn vegetation and add the ashes to manure mixed with salt In Antanifotsy farmers have a technical skill in processing their farm manure they cover it to improve its quality

Phosphorus uptake by bean crops is inhibited as shown by leaf analysis In general there is P deficiency and a sufficient level of K In Ambohibary there is sufficient Ca and Mg and leaf N is adequate In Antanifotsy several cases of N Ca and Mg deficiencies were found Plant vigour was evaluated at both sites The evaluation ranged between 4 and 8 with an average of 7 Bean growth was very poor depressed by an abnormal drought during December

Most farmers do not terrace slopes except in Tokotanitsara where anti-erosion practices are applied on steep slopes Most farmers practise deep tillage When the topsoils are exhausted they improve the soil fertility by deep digging during land preparation Land preparation is done with spade along the slopes The sowing lines are also made in this way This practice speeds up operations but causes soil erosion Land deterioration is also accelerated by burning

Farmers are fully aware of soil fertility They classify it according to colour and texture They reported that the yields obtained from beans cultivated in valley bottoms and on colluvial soils are twice or three times greater than yields from beans cultivated on the slopes Farmers grow land races Menakely is the common cultivated variety on *tanety* because it is well adapted to marginal soils and is relatively resistant to pests and diseases Menakely has small dark red seeds and a high yield but commands the lowest price on the market The most preferred varieties have large white green or pale-coloured seeds They are preferred for their taste and command a high price But they are very susceptible to pests and diseases and yield poorly on *tanety* being better suited to fertile soils

The assessment of bean yields in farm conditions is very difficult because farmers begin to harvest beans as soon as possible and continue up to the dry pod stage Yield estimates lie in general between 300 and 800 kg/ha with a mean of 400 kg/ha (Bigot *et al* 1988) Farmers consider the poor yields to be due to pests and diseases which cause losses of 10 75% with an average of 50% Poor soil fertility is also considered a major cause of poor yields The most widespread insects are *Apoderus humeralis* and *Pyrameis* spp which attack leaves The most important soil insects are cutworms which occur every season The only important disease recorded during the survey was common bacterial blight

Force field analysis to improve bean yields

Driving forces	Restraining forces
awareness of soil infertility	aluminium toxicity and low P soil
awareness of the low yield	poor land preparation and absence of terracing
importance of bean crops for food and income	pests and diseases
willingness to try new techniques	
	lack of improved or certified seeds
wish to get new varieties	
	lack of implements
wish to work with research	
	chemicals unavailable or too expensive
land availability	
skill in farm manure processing	crop rotation according to needs
use of ash	insufficient cattle for transport or manure
several cropping seasons	
multiple cropping systems	
presence of farmers associations	
categorize beans according to soil fertility	

RESEARCH NEEDS

An important aspect of this diagnostic survey is to study the possibility of involving farmers in participatory research There is a need to carry out experiments under farmers conditions and management and to use farmers criteria of evaluation of results (Tripp and Woolley 1989)

Control of pests and diseases is the main priority A bean pests and diseases survey should be conducted to obtain accurate data on these problems A study of biological control strategies will be very relevant Existing farmer organizations should try to obtain credit and purchase chemicals and other inputs (for example spray pump seeds fertilisers)

Attention should be paid to soil conservation and management which requires close collaboration between extension research and farmers There is a need to establish land preparation measures (tillage anti-erosion bands) to avoid erosion on slopes New varieties should be tested for tolerance to low P and high Al compared to landraces More efficient crop rotations should be identified and tested Techniques of processing compost and manure should be strengthened Agronomic practices in general should be reviewed with farmers

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HARICOT BEAN DOUBLE CROPPING WITH MAIZE, WHEAT, TEF AND IRISH POTATO UNDER RAINFED CONDITIONS IN THE SOUTHERN RIFT VALLEY OF ETHIOPIA

Tenaw Workayehu and Waga Mazengia

Institute of Agricultural Research, Awassa Ethiopia

ABSTRACT

Double cropping is commonly practised within the southern rift valley of Ethiopia farmers grow haricot bean after harvesting medium to late maturing crops such as maize grown for its green cobs We investigated the system to seek better crop combinations and conduct an economic evaluation The yields of double cropped haricot bean varied among years due to changes in moisture regimes and sowing dates which were governed by the time of harvest of the preceding crop The best yields were obtained from haricot bean grown after Irish potato wheat or tef Higher gross income was obtained from double cropped than from monocropped haricot bean

INTRODUCTION

Population growth has resulted in a shortage of farm land particularly in the southern rift valley of Ethiopia (CIMMYT 1990 CIMMYT 1992) which has affected crop production Double-cropping (growing and harvesting two crops from the same field in the same year) offers a means of increasing yield per unit area so as to feed the larger population According to surveys (Getahun Degu *et al* 1991 Tenaw Workayehu 1990) growing haricot bean as a precursor or successor to maize tef wheat and Irish potato is common practice in Arsi Negelle Shashemene Sidamo and Wolayita districts Farmers crop varieties in particular maize are medium to late maturing For the purpose of double cropping farmers harvest maize as green cobs to prepare the land for the next crop

A number of studies have demonstrated the value of double cropping (Crabtree *et al* 1990 Daniels and Scott 1991 LeMahieu and Brinkman 1990) The preceding crop can remove soil moisture and nutrients especially if it is high yielding Daniels and Scott (1991) observed that the depletion of soil water by wheat and variation in rainfall affected the yield of the following soybean crop but despite the reduced yield of double-cropped soybean better economic returns were achieved from wheat/soybean double cropping than from either crop grown alone Crabtree *et al* (1990) reported a yield reduction of 22% from double cropped soybean because of inadequate and unevenly distributed rainfall LeMahieu and Brinkaman (1990) reported yields ranging from 60 to 105% of soybean alone from double-cropped soybean following barley wheat and rye while soybean grown after oat yielded 38 to 57% of soybean alone due to late sowing of the soybean crop

No information is available on the double cropping of haricot bean after harvesting cereal crops for their grain yield in Ethiopia The objectives of this study were to

1 measure the yields of haricot bean double-cropped after maize tef wheat and Irish potato grown for their grain/tubers

2 seek better yielding crop combinations and

3 determine the economic benefits of the system

MATERIALS AND METHODS

The study was conducted for three consecutive years (1986 1988) at two research sites (Awassa and Arsi Negelle) in the southern rift valley of Ethiopia The soils are sandy loam at Awassa and clay loam at Arsi Negelle The cultivars used were Katumani Composite (early maturity) and A511 (medium) maize Dz 01 354 (medium) tef local (medium) Irish potato Dashen (medium) wheat and B 935 (medium) haricot bean Each variety was grown as precursor or successor to haricot bean The sowing time for the first crops was the first week of April (Table 1) Haricot bean was sown as a monocrop for comparison at the optimum sowing times which were within the first 20 days of June at Awassa and the whole of June at Arsi Negelle All crops were harvested for their grain/tuber yields The recommended fertilizer rates (41 kg/ha N for maize and 18 kg/ha N for other crops and 46 kg/ha P_2O_5) were applied DAP was broadcast and incorporated at planting while urea was side-dressed to maize at knee height Recommended seed rates were used Rainfall for Awassa and harvest dates and grain and tuber yields were recorded The experimental design was a randomized complete block with three replicates Individual year and combined analyses of variance were conducted Economic analysis was carried out using the mean market price of each crop for each of the three seasons

Table 1 Sowing and harvesting dates in double cropping trials at Awassa and Arsi Negelle 1986 88

		Awassa				Arsi Negelle			
		Preceding crop		Haricot bean		Preceding crop		Haricot bean	
Years	Crops	Sown	Harv	Sown	Harv	Sown	Harv	Sown	Harv
1986	Maize[1]	9/4	20/8	25/8	30/12				
	Maize[2]	9/4	8/8	18/8	30/11				
	Wheat					14/4	20/7	9/8	20/11
	Tef	9/4	18/7	30/7	6/11	14/4	4/8		
	Irish potato	9/4	15/7	30/7	1/11	14/4	10/7	23/7	20/11
	Haricot bean			10/6	10/10			21/7	20/10
1987	Maize[1]	1/4	31/7	18/8	20/12				
	Maize[2]	1/4	16/7	3/8	10/11	27/3	20/7	27/7	10/11
	Wheat					27/3	25/7	7/8	10/11
	Tef	1/4	7/7	17/7	1/11	27/3	12/7	21/7	20/10
	Irish potato	1/4	5/7	17/7	29/10	27/3	16/7	20/7	19/10
	Haricot bean			13/6	11/10			27/6	19/9
1987	Maize[1]	9/4	15/9	20/9	26/12				
	Maize[2]	9/4	20/8	1/9	8/12	13/4	19/7	8/8	12/11
	Wheat					13/4	25/8	30/9	
	Tef	9/4	18/7	29/7	4/11	13/4	26/8	8/9	20/11
	Irish potato	9/4	29/7	2/8	4/11	13/4	25/7	6/8	20/11
	Haricot bean			14/6	5/10			20/6	6/10

[1] A511 [2] Katumani Composite

RESULTS AND DISCUSSION

In 1986 rainfall at Awassa was good in April June and September but poor in October December Total rainfall was 21% more than the long term mean (Table 2) In 1987 rainfall was good in May but poor in June September and total rainfall was 6% less than the long term mean In 1988 better rainfall occurred in April and June October but total rainfall was 10% less than the long term mean

Table 2 Awassa mean monthly rainfall 1986 1988 and long term means 1972 1991

Months	1986	1987	1988	Means
March	44 4	125 9	16 4	71 5
April	115 3	87 1	102 8	110 5
May	257 9	246 4	93 4	144 1
June	152 6	59 1	106 9	105 2
July	195 7	104 5	121 3	138 8
August	167 0	105 5	129 4	139 8
September	160 2	75 7	215 5	140 5
October	46 1	95 3	71 0	77 8
November	20 1	0 0	2 4	29 4
December	32 2	2 3	6 0	21 2
Total	1159 3	899 5	859 1	957 6

The yields of second-cropped haricot bean over the three years ranged from 0 3 to 2 2 t/ha at Awassa (Table 3) and 0 2 8 t/ha at Arsi Negelle (Table 4) The lightest yield at both sites was from haricot bean after maize Better growth and yield were obtained from haricot bean after Katumani Composite maize than after A511 The heaviest yields (2 0 t/ha at Awassa and 1 8 t/ha at Arsi Negelle) were obtained from haricot bean after Irish potato The variation in haricot bean yields among years resulted from variation in sowing date due to the preceding crop Depletion of soil water by high yielding crops such as maize also affected bean performance and yield

Table 3 Mean yields in double cropping trials at Awassa in 1986 88

Cropping system	Other crops 1986	Other crops 1987	Other crops 1988	Other crops Mean	Haricot bean 1986	Haricot bean 1987	Haricot bean 1988	Haricot bean Mean
Bean/wheat	1 9	2 4	2 1	2 1	2 5	2 5	0 8	1 9
Bean/maize[2]	1 8	2 7	2 2	2 2	2 5	1 7	1 4	1 9
Bean/tef	0 6	0 6	0 7	0 6	2 8	2 2	0 5	1 9
Bean/potato	6 8	6 6	0 0	4 5	2 7	2 1	1 3	2 0
Maize[1]/bean	5 9	6 5	5 0	5 8	0 3	0 3	0 5	0 4
Maize[2]/bean	4 9	5 3	3 2	4 5	1 4	1 3	0 8	1 2
Tef/bean	1 2	0 5	0 6	0 7	1 5	2 1	2 1	1 9
Potato/bean	7 9	6 4	10 1	8 1	1 9	2 2	1 9	2 0
Bean alone					2 5	1 4	2 8	2 2
CV (%)					17 3	38 6	22 6	
SE±					0 3	0 6	0 2	

[1] A511 [2] Katumani Composite

Table 3 Mean yields in double cropping trials at Arsi Negelle in 1986 88

Cropping system	Other crops				Haricot bean			
	1986	1987	1988	Mean	1986	1987	1988	Mean
Bean/wheat	2 1	2 0	1 1	1 7	3 7	3 6	0 8	2 7
Bean/maize[2]	1 3	2 1	0 7	1 4	2 8	3 5	0 7	2 3
Bean/tef	1 5	1 4	0 9	1 3	3 8	4 1	0 8	2 9
Bean/potato	3 7	3 5	0 08	2 4	3 7	3 7	0 7	2 7
Maize[1]/bean	2 5	2 4	0 08	1 7	0 9	1 1	1 4	1 1
Maize[2]/bean		3 6	1 8	2 7		0 8	0	0 4
Tef/bean		1 5	0 9	1 2	0 6	1 9	0 4	0 9
Potato/bean	13 9	7 8	11 9	11 2	1 9	2 8	0 7	1 8
Bean alone					2 1	2 9	2 7	2 6
CV%					25 9	20 2	51 6	
SE(±)					0 5	0 5	0 4	

Haricot bean produced better yields after the harvest of Irish potato wheat and tef when planted early According to Daniels and Scott (1991) high yielding crops extract large quantities of soil water from anthesis to physiological maturity which coupled with seasonal variation in rainfall can deplete the moisture available for the following crop (in their case soybean)

The yield losses at the two sites varied with amount and distribution of rainfall and the time of harvest of the preceding crop The average yield loss of double-cropped haricot bean ranged between 9 and 82% at Awassa and 31 and 65% at Arsi Negelle This result agrees with that of Daniels and Scott (1991) who reported pronounced effects of the preceding crop and rainfall on double-cropped soybean Crabtree *et al* (1990) and LeMahieu and Brinkman (1990) reported similar findings It is observed that haricot bean planted as a preceding crop in *belg* had a comparable yield with the monocrop haricot bean

Over years the heaviest grain yield was obtained from haricot bean after tef and Irish potato at Awassa and haricot bean after Irish potato at Arsi Negelle (Table 5)

ECONOMIC ANALYSIS

Double cropping can be viewed as a means of boosting crop production efficiency thereby increasing returns This study has shown the feasibility of producing haricot bean after the harvest of crops in particular maize for their grain Despite the poor bean yields economic returns procured from double cropping are better than those from monocrop haricot bean (Table 5) 141% at Awassa and 48% at Arsi Negelle This result agrees with those of LeMahieu and Brinkman (1990) who reported benefits from double cropping

Table 5 Mean yields (t/ha) of haricot bean at Awassa and Arsi Negelle 1986 1988

	Cropping system	1986	1987	1988	Mean	% of check
Awassa	Maize[1]/ bean	0 3	0 3	0 5	0 4	18 2
	Maize[2]/bean	1 4	1 3	0 8	1 2	54 5
	Tef /bean	1 5	2 1	2 1	1 9	86 4
	Potato/ bean	1 9	2 2	1 9	2 0	90 9
	Bean (mono-crop)	2 5	1 4	2 8	2 2	
	LSD(p<0 05)		NS		0 5	
	Mean	1 5	1 5	1 6		
	LSD(p<0 05)		NS			
	CV%		27 6			
Arsi Negelle	Wheat/bean	0 9	1 1	1 4	1 1	42 3
	Tef/bean	0 6	1 9	0 4	0 9	34 6
	Potato/bean	1 9	2 8	0 7	1 8	69 2
	Bean	2 1	2 9	2 7	2 6	
	LSD(p<0 05)		0 2		0 08	
	Mean	1 4	2 2	1 3		
	LSD(p<0 05)		NS			

[1] A511 [2] Katumani Composite

Table 6 Returns (birr/ha) from double cropping trials and average market prices (birr/kg) of grains and tubers at Awassa and Arsi Negelle

Companion crop	Returns (birr/ha) Preceding crop		Returns (birr/ha) Succeeding crop		Average market price	
	Awassa	A N	Awassa	A N	Awassa	A N
Maize[1]	1849		2138		0 32	0 28
Maize[2]	1862	1822	2120	1127	0 32	0 28
Wheat		2507		1653		0 57
Tef	1702	2627	1782	1767	0 88	0 58
Potato	2524	2320	4378	3510	0 37	0 25
Bean alone	951		1462		0 73	0 55

[1] A511 [2] Katumani Composite A N = Arsi Negelle

CONCLUSIONS

The amount and distribution of rainfall greatly affected and contributed to the reduced yield of double cropped haricot bean In addition a pronounced effect of the preceding crop on haricot bean yield was observed The results from the two sites show that high yielding crops like maize and wheat seem to deplete soil moisture causing yield losses of beans grown after maize and wheat of 64 and 58% respectively Double cropping usually resulted in greater total grain yield due to better use of weather and land than monocropped haricot bean Better gross income was obtained from double cropping haricot bean and other crops These results accord with the results of double cropping trials in the U S A Further investigation is needed on double cropping in relation to tillage stubble management cultivar selection weed control fertilizer and soil type

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HIGHLIGHTS OF AGRONOMIC RESEARCH IN SUPPORT OF THE REGIONAL BEAN NETWORK

Charles S Wortmann

CIAT, Kawanda Agricultural Research Institute, Kampala, Uganda

ABSTRACT

Bean agronomy research conducted in support of the regional bean network has addressed crop and soil management screening for tolerance to edaphic stresses extrapolation of soil fertility results and farmer participation in research A more productive maize bean intercropping system involving climbing beans for mid altitude areas (1150 1400 masl) was tested and found to be generally acceptable to farmers but adoption has been minimal due to dissatisfaction with available adapted climbing varieties Bean yield in banana bean intercropping was found to be most affected by shading competition for K and possibly toxic Mn levels in beans Bananas are more competitive than beans while a LER of 1 6 was measured Bean cultivar performance under bananas was found to be highly correlated to sole crop performance suggesting that sole crop evaluations will identify good non climbing bean varieties for the banana bean system In a study of weed suppression bean varieties varied in their ability to suppress weeds and 73% of this variation was accounted for by variation in leaf area index and leaf size Revised critical nutrient levels in beans for N P and K were determined and norms for the Diagnosis and Recommendation Integrated System (DRIS) of interpreting foliar analysis were determined and validated *Crotalaria ochroleuca* can be produced as a green manure by intercropping with either maize or beans with a dramatic effect on yields of subsequent crops increasing maize yield by 60 80% Preliminary results from on farm research indicates that *Crotalaria* will be well adopted Lines promising for tolerance to specific edaphic stresses including low soil N and P and Al and Mn toxicity have been identified and are undergoing multilocation confirmation testing An intensive approach to farmer participation in research is being evaluated at two locations in Uganda Efforts to improve extrapolation of bean research results include work on the FCC land classification system and the BeanGro model

INTRODUCTION

Strategic bean agronomy research conducted to support the regional bean network in Eastern Africa has addressed research on production systems and diagnostic tools soil fertility management screening for tolerance to edaphic stresses farmer participation in research and extrapolation of research results Ugen (1995) has reported on the farmer participatory research in this workshop and this work does not receive further elaboration here

MAIZE BEAN INTERCROPPING

The intercropping of maize with climbing beans in the medium altitude areas (1200 masl) of central Uganda was studied to determine the potential of using growing maize plants to support climbing beans while achieving similar bean yields to a bean sole crop A series of experiments was conducted over three seasons at Kawanda Research Station to determine how to manage the maize climbing bean association so that maize supports the beans with minimal suppression of bean yield (Wortmann and Ugen 1990) The most productive system was a modification of the traditional system by planting climbing beans near the maize plants i e the most productive system contained maize bush beans and climbing beans

During farmer evaluation of the intercropping system in on farm trials concern was expressed about the extended maturity periods of the climbing beans Farmers faulted the climbing bean variety used in the OFTs but concluded that if an acceptable variety were available they would grow climbing beans with maize if the bean yields were increased by 50% over their bush bean systems As the current emphasis for these environments is on breeding bush bean varieties an acceptable climbing variety has not been identified for this system

BANANA BEAN INTERCROPPING RESEARCH

Beans and bananas are commonly intercropped in eastern Africa Little published information is available about how the intercropping of these two species influences the yields of the component crops and land use efficiency

Beans and bananas were grown in sole-crop and intercrop near Kampala Uganda for three seasons in 1989 and 1990 The objective of the study was to determine the effects of cropping systems on diseases insects and land use efficiency and the roles of certain bean plant physiological traits on bean yield in the two systems A second objective was to determine if selection of bean cultivars in monoculture can result in genetic progress for the banana bean association

Bean yield in the banana bean system averaged 0 629 t ha^{-1} and was 52% of the sole crop yield (Wortmann *et al* 1992) Shading reduced bean yield but stem starch levels chlorophyll content and the chlorophyll a/b ratio were unrelated to seed yield in both systems Leaf area index was linearly related to bean yield in the banana bean association suggesting that a higher bean plant density may result in higher yields Nutrient concentrations in foliar tissue of beans indicate that low potassium and high manganese availability constrained intercrop bean yield Manganese levels in the foliar tissue were found to be high and possibly toxic in beans grown under bananas Competition for other nutrients did not appear to affect bean yield Apparently interspecies competition for soil moisture reduced bean yields little as moisture levels did not differ with cropping systems Disease and insect pest levels were similar for the two bean production systems with the exception that flower thrips were fewer per flower in beans under bananas

Bananas appear to be more competitive than non-climbing beans in this system with mean competitive ratios of 1 39 and 0 85 respectively The land equivalent ratio of the banana bean intercropping system over three seasons was 1 6

Cultivar x cropping system interactions were not significant for bean seed yield and the components of yield (Wortmann and Sengooba, 1993) Rank correlation coefficients of bean cultivar seasonal mean yields in monoculture with the overall cultivar mean yields in association were high and significant ranging from 0 50 to 0 84 This was consistent with the lack of cultivar x cropping system interaction Numbers of pods and seeds per plant were more closely associated with intercrop bean yield than sole crop yield The results of this research have shown that evaluation of non-climbing bean genotypes for seed yield in monoculture provides sufficient information to efficiently select cultivars for the banana bean intercropping system (Table 1)

Table 1 Yields (t ha⁻¹) of bean varieties intercropped over three seasons selected at an intensity of 0 25 in different selection environments

System of selection	Season of selection 1989a	1989b	1990a	Mean
Sole crop	0 748	0 782	0 744	0 758
Intercrop	0 771	0 759	0 761	0 764

(from Wortmann and Sengooba 1993)

BEAN PLANT MORPHOLOGY AND WEED SUPPRESSION

Weed control has a large labour requirement in small scale bean production systems in eastern Africa and productivity of these systems is often constrained by labour availability at weeding times A study was conducted to determine which morphological characteristics of bean contribute to weed suppression and to assess the feasibility of breeding genotypes for improved ability to suppress weeds (Wortmann 1993a) Morphological characteristics grain yield and weed biomass weight at harvest were measured for 16 20 genotypes over three seasons

Table 2 Bean plant traits contribution to suppression of weed growth three seasons at Kawanda Research Station

Bean plant trait	Contribution to total variation in weed biomass (R^2)
Leaf size (LS)	0 21
Stem length (SL)	0 00
Primary branches (PB)	0 10
Plant weight (PW)	0 60
Stem weight (SW)	0 31
Leaf weight (LW)	0 57
Leaf area index (LAI)	0 62
LAI + LS	0 73
LAI + SL	0 64
LAI + PB	0 63
LAI + PW	0 77
LAI + SW	0 79
LAI + LW	0 64
LAI + LS + SW	0 80
All traits	0 85

(from Wortmann 1993a)

Mean weed biomass at time of bean harvest ranged from 55 to 120 g m^{2} The ability to suppress weeds was found to be independent of bean growth habit but was related to leaf size leaf area index and plant growth rate Leaf size and leaf area index accounted for 73% of the variation among genotypes for weed biomass at the time of bean harvest (Table 2) These traits were related positively to bean seed yield Inclusion of large leaf size and high leaf area index as criteria to select high yielding genotypes with improved ability to suppress weeds should be feasible

FOLIAR TESTING AS A DIAGNOSTIC TOOL

Interpretation of foliar tissue analyses has traditionally been based on the comparison of analytical results relative to standard values such as critical nutrient levels (CNLs) Such approaches are easily applied but each nutrient is considered independently of the other nutrients As nutrient concentrations vary with plant age and with stress conditions consideration of nutrient balances can improve the interpretation The Diagnosis and Recommendation Integrated System (DRIS) of interpreting results of foliar analysis is an alternative to the CNL approach DRIS uses indices of ratios of nutrient concentrations and has been found to be more accurate in predicting nutrient needs for numerous crops than the CNL system

Table 3 Summary of predictions for bean yield responses to applied nitrogen phosphorus and potassium

	Response to applied nutrient occurred		Overall prediction accuracy	
	Correct	Incorrect	Correct	Incorrect
			Nitrogen	
DRIS	32	20	67	45
CNL (3 0%N)	1	51	61	51
CNL (4 7%N)	27	25	54	58
			Phosphorus	
DRIS	43	23	68	44
CNL (0 25%P)	13	53	51	61
CNL (0 32%P)	39	27	63	49
			Potassium	
DRIS	43	16	80	32
CNL (1 0% K)	18	41	69	43
CNL (1 4% K)	37	22	79	39

(adapted from Wortmann *et al* 1992)

DRIS norms for beans were determined from a broad based data set and the norms for N P and K were validated using results of trials conducted in Uganda and Tanzania (Wortmann *et al* 1992) The previously recommended foliar CNLs of 3 0% N 0 25% P and 1 0% K were found too low to be useful in predicting responses to applied fertilizers Prediction based on levels of 4 7% N 0 32% P and 1 4% K was more accurate than with the lower CNL values (Table 3) DRIS was more accurate than either set of CNL values in predicting responses to applied N P and K The use of DRIS for beans is being promoted through the distribution of a set of relevant materials (Wortmann 1993b)

GREEN MANURING WITH *Crotalaria ochroleuca*

On station research was conducted in 1991 and 1992 to evaluate *Crotalaria ochroleuca* as a green manure crop in farming systems of central Uganda The objectives of the research were to determine if *Crotalaria* could be produced in association with a food crop such as maize or beans without substantial loss of grain yield and the green manure s effects on the performance of subsequent crops

Maize and bean yields were not significantly reduced by intercropping with *Crotalaria* while *Crotalaria* yields were substantially reduced In the 1991b season maize following *Crotalaria* yielded 60% higher than maize following either maize or beans in rotation In the 1992a season maize following *Crotalaria* yielded 82% higher than maize following the grain crops In the second season following *Crotalaria* bean yield in plots which initially produced sole crop *Crotalaria* was 44% more than in plots sown to either maize or beans in the first season

Additional labour is needed to sow and weed *Crotalaria* at what are generally busy times of the year However following OFTs farmers assessment of the technology has been favourable and despite the additional labour requirement probability for adoption appears to be high

SCREENING FOR TOLERANCE TO EDAPHIC STRESSES

The Africa Network for Screening for Edaphic Stresses (ANSES) was recommended in a regional workshop (Anon 1988) and further developed in a working group meeting (Anon 1990) The ANSES is a pan Africa effort to screen for tolerance to specific stresses Evaluation is in two stages Preliminary evaluation is carried out for two seasons at one location and secondary evaluations of the most promising entries are at multiple sites to confirm the tolerance The ANSES is addressing four stresses low soil N and P and Al and Mn toxicities with seven national programmes participating

The first cycle of the ANSES evaluated 280 entries contributed by national and regional breeding programmes The best 33 entries for each stress are undergoing multilocation confirmation testing Approximately 400 entries are being multiplied for the second cycle of the ANSES

EXTRAPOLATION OF RESEARCH RESULTS

Efforts to better utilize information on beans are directed at improvement of the bases for extrapolation Validation of the Fertility Capability Classification System and of simulation models including BeanGro and WEPP (for soil erosion) is receiving limited attention

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DISCUSSION SESSION VI INTEGRATED CROP AND SOIL MANAGEMENT

Chair Mitiku Haile Rapporteur P K Jjemba

Paper by D O Michieka, A M Ndegwa and G W Mbugua

Fischler Why did you apply fertilizer to the systems investigated and not use farmers practice? It makes it impossible to attribute yield gain due to additional water or fertilizer application

Michieka Farmers in the area apply fertilizer to maize but not to beans Fertilizer application to maize was uniform in all treatments Fertilizer was applied to beans in the water harvesting systems where the research recommendation for the zone was followed We will modify this factor in subsequent seasons in order to validly evaluate the effect of water harvesting systems

Sperling You have shown significantly increased yields but you have not mentioned all the factors which may be contributing to these yields Certainly the technique described is one variable but you also have differential fertilizer use and very different labour requirements In evaluating the technology you probably should look for heavy farmer involvement as well as consider the full range of factors which are being changed by use of the technology (e g labour risk levels)

Michieka The comment is noted and suggestions will be included in subsequent seasons However in practice farmers usually apply fertilizer to maize and this was uniformly done in all the treatments We therefore probably need to readdress the issue of fertilizer application to beans in the water harvesting treatments Labour requirements for the various systems were noted with the aim of conducting an economic analysis at the end of the second season A point to note is that the pit catchment system was actually adopted from farmers Farmers have been very actively involved in the trial

Wortmann First of all the comparison of farmers practice to alternatives is impossible as differences may be due to planting fertilizer and/or water management practices Non-experimental variables should be the same for all treatments Secondly much research has been done on water management in eastern Africa since the 1960 s Therefore I am glad that you took this research straight to farmers fields Adoption of such practices has often been poor despite promising research results Therefore please have farmers fully involved in selection of treatments and their evaluation

Michieka Both comments are noted In regard to the first in the water harvesting systems beans were planted according to research recommendations This will be adjusted in subsequent seasons

Tenaw Workayehu Pit catchment gave you the heaviest yield but don t you think that this is labour intensive time-consuming and costly?

Michieka Complete economic analysis of the various water harvesting systems has not been done During this first season of the trial it was noted that the pit catchment system was labour intensive during construction of pits However the pits remained intact and less labour was required during land preparation in the subsequent season unlike tie ridges which required rebuilding

Paper by R T Jasdanwala and A G Chege

Wortmann How can this information be used to improve bean yields? There are models for example the Beangro model to which the information can be useful The presenter is advised to contact the CIAT plant physiologist (Colombia) for data inclusion into the growth model

Paper by N Govinden, B Gaurea and F Ismael

Gridley In use of fractional replication care must be taken in deciding which are fixed and random effects for correct use of the error term in determining the significance of main and interaction effects

Govinden Certainly a fractional design is appropriate to on farm testing of agronomic treatments

Paper by M A Ugen and P K Jjemba

Sperling You mentioned that you arranged your experiments according to farmers designs Could you give examples with say variety and crop rotation trials how farmers designs might differ from researchers designs?

Ugen In case of bean varieties farmers designs did not differ from our design considering that we are doing the same variety evaluation in other districts The only difference is that here the farmers asked for 3-4 varieties from us plus the inclusion of one of their own (farmer s choice) In other places where we are conducting researcher designed on farm trials we give farmers 5 7 varieties The crop rotation trial was slightly different in that it involved beans maize and groundnut In one season groundnut follows beans which counters the aim of rotation as they are both legumes To avoid this farmers proposed a fallow break between these two crops to produce a more acceptable rotation Therefore four plots are considered rather than three

Mitiku Haile How homogenous is your farmer group? Does it include the young middle aged and old?

Ugen The group is quite heterogenous across age groups and sexes Even the sub groups (cooking groups) were quite heterogenous What we are interested in is to see if any person regardless of age or gender can participate After meeting with the farmers for a number of times you find that individuals and not necessarily particular categories tend to leave by themselves We feel that the mixture is satisfactory More emphasis should however be placed on women who do most of the physical work rather than men But no stratification of any sort is placed on the farmers during the meetings

Paper by B Rabary

Sperling It is interesting to note that farmers choose beans according to soil types What characteristics do they use? For example in the Great Lakes Region farmers generally believe that small seeded beans do well on poor soils Do your farmers use the same criterion?

Rabary Farmers categorize beans according to soil types using yield and adaptability criteria Farmers did not mention this criterion although they may know it They know which varieties are suited for poor or fertile soils from their own experience

Mitiku Haile Do farmers use a particular variety to improve soil fertility? For example in Ethiopia they usually use Black Dessie to regenerate soil fertility

Rabary In choosing varieties according to soil fertility farmers just consider variety performance They have few varieties and know exactly which are suited to marginal soils and which are suited to fertile soils according to their yields

Mtcbieka You indicate that farmers sometimes use urea to improve soil fertility Don t you think this increases soil acidity?

Rabary Yes this may increase soil acidity but few farmers use urea and even then in very small quantities They obtain it from extension agents or buy it

Paper by Tenaw Workayehu and Waga Mazengia

Mitiku Haile What are the labour requirements for all these rotations? Are you considering them?

Tenaw Workayehu Farmers use their own labour Because of this we did not include labour in our gross revenue analysis

Govinden Is there any reason why you did not have beans following beans?

Tenaw Workayehu Since farmers do not practice double cropping of haricot beans following haricot beans we did not include it Instead farmers grow haricot beans either prior to or following other crops

Paper by C S Wortmann

Mitiku Haile What other benefit except ameliorating soil fertility does *Crotalaria* have? Can it be used as a livestock feed?

Wortmann While the species is reportedly used as a fodder crop in parts of Tanzania it is not a very ideal (palatable) forage species While there is need for cut and-carry fodder crops it is not likely that these will contribute to improved soil fertility and may enhance depletion Nutrients returned in FYM are a small percentage of the total harvested and fed However *Crotalaria* s greatest role may be in more distant fields which normally do not receive FYM

Tenaw Workayehu We know that leguminous trees are multi purpose Research also recommends their beneficial use Where there is shortage of land farmers may not grow trees in association with food crops Rather they intercrop food crops only What would be the fate of a research recommendation in such areas of land shortage?

Wortmann *Crotalaria* is not a tree but the point is relevant We cannot predict the fate of the technology However considering that it can be produced with a food crop and results in 60 80% increase of yield in the following season I believe the technology has good potential

Opio First of all what is the farmer s response on farm with *Crotalaria*? Secondly why was the yield of maize following maize plus *Crotalaria* greater than the yield of maize following *Crotalaria* alone?

Wortmann Firstly the farmers response has been favourable and some are experimenting to test alternative ways of utilizing *Crotalaria* However the number of farmers involved until now has been small and so the feedback is not conclusive To the second question the difference between the two treatments was not significant It is probable that *Crotalaria* grown with maize supplied adequate nutrition so that yield became limited by other factors possible low moisture stress

General discussion

Minimum tillage

Comment There is failure to understand the relevance of research on minimum tillage rather than doing research on why this technique which is already known to work has not been widely adopted so far

Response This is an important question but it is necessary to point out that very little research on this practice has been done under farmer management Most research on minimum tillage has been on station In our case this was farmer participatory to help farmers choose whether to adopt the technology by involving them outright This kind of approach also brought out the fact that much as use of Basagram is recommended by researchers farmers reject it under their conditions as it damages their crops So the work considering the approach was quite necessary

Supplement It is also interesting to note that farmers also have a minimum tillage practice Maybe there is a way of improving this practice through further research

Acid soil management in Madagascar

Question One of the problems found during this survey was a high common bacterial blight (CBB) incidence Is anything being done to combat this disease?

Answer Nothing at the moment

Suggestions There is a sub project on this disease within the region Your coordinator can contact the Ugandan coordinator to incorporate resistance through breeding Also there is a regional nursery which could be sent to you if requested for evaluation

Chairman The two coordinators are advised to get together during the week and work out a feasible arrangement

***Crotalaria* as an intercrop**

Question There may be problems in the adoption of *Crotalaria* as an intercrop due to management of the crop in association with the *Crotalaria* weed What about growing *Crotalaria* between seasons?

Response The advantage of producing *Crotalaria* in association with a food crop is that farmers can continue using the land for food production We cannot predict how farmers might best fit *Crotalaria* into their systems We encourage and sometimes work with them to try alternatives We are using *Crotalaria* intercrop as well as sole crop systems to introduce the technology to farmers Once they have seen that it may have a place in their farming systems then they may fit it in accordingly

Question/comment *Crotalaria* is used especially on sugar estates to ameliorate soil compaction due to use of heavy machinery Are you finding differences in soil porosity after this crop?

Response We thought that because of the long tap root this crop would open the soil However we find that its rooting does not go through the argillic horizon

Question I am wondering whether *Crotalaria* could be an alternative host for BSM as has been indicated by some reports in Tanzania An earlier presentation also indicated it as an alternative host for BCMV

Response For BCMV *Crotalaria* is only one of many alternate hosts

General comment When we are talking about other scientific issues we get the fine details e g so much dosage of a particular chemical/fertilizer used However when it comes to on farm or participatory research we tend to get the general information that farmers prefer and specifics are often lacking What sort of farmers like it what is the actual response? There should be technical observations

Response There is a need for good monitoring and self-evaluation during such work This also involves availability of funding and could be dwelt on further in working groups

COMPARATIVE PROFITABILITY OF HARICOT BEAN PRODUCTION IN ETHIOPIA

Senait Regassa

Institute of Agricultural Research, Nazreth, Ethiopia

ABSTRACT

Although the predominant objective of small farmers is to ensure adequate food supply for their families they also consider profitability as a criterion Crop profitability study helps to justify allocation of research resources among crops and regions This study was initiated to determine the competitive position of haricot bean compared to other major crops The crops included in this study are haricot bean tef maize potato and sorghum This paper deals with financial and economic profitability The area is *sub-divided into two zones* (wet and dry) because of differences in moisture stress crop mix soil type and importance of livestock enterprises In the wet zone using the input and output prices in 1990 and 1991 in terms of financial profitability haricot bean ranks fourth next to tef potato and maize In the dry zone financial analysis indicates that haricot bean is the third crop next to tef and maize In 1992 the price of haricot bean was increased by 145% When financial profitability is calculated using the new price haricot bean is more profitable than all other crops in both wet and dry zones Haricot bean is an important crop not only from the point of view of individual farmers but also the nation Therefore particular attention of researchers and other concerned officials is needed to solve problems encountered by haricot bean growers

INTRODUCTION

It is known that research is the base for development But there is limitation of resource to carry out research on each and every problem This emphasizes the importance of ranking so that the most pressing problems of farmers can be solved earlier than others Crop profitability study helps to justify allocation of research resources among crops and regions (Beyrlee and Longmire 1986) Moreover although the dominant objective of small farmers is to ensure an adequate food supply for their families they also consider economic return in order to satisfy their cash requirements This study was initiated to determine the competitive position of haricot bean as compared to other major crops The objectives of the study were to

1 identify the major inputs and outputs of haricot bean tef maize sorghum and potato
2 determine the major costs and benefits of these crops and
3 compare the profits obtained from haricot bean with those from other major crops to provide information for policy makers

SURVEY METHODS

Because of differences in the degree of moisture stress crop mix soil type and importance of livestock enterprise the survey area is divided into two target groups the wet and dry zones The wet zone where maize tef and haricot bean are the major crops is mostly clay loam The dry zone in the eastern part of the survey area where maize tef and sorghum are the major crops is mostly sandy loam In this zone farmers practise transhumance *godantu* i e during the wet season they take their animals to the eastern part of the region where there is ample grazing (Aleligne Kefyalew *et al* 1992)

Secondary data from previous studies was the main source of information However available secondary data was not sufficient and in some cases it was found to be exaggerated This initiated the need for supplementing and verifying already existing data Therefore a questionnaire was designed and a total of about 90 farmers was interviewed The method of sampling was two stage random sampling The data were collected for three consecutive years starting in 1990 Since the price of haricot bean paid to farmers was raised by 145% in 1992 the resulting change in the profitability rank assumed by haricot bean is given due emphasis One researcher and two technical assistants were involved in interviewing farmers Labour data was collected at the time the respective activities were being performed One problem encountered during the survey was that farmers were suspicious and sensitive to income issues They tended to overestimate costs and underestimate returns Hence extreme values were omitted

Profitability can be viewed from three aspects financial economic and social A major objective of financial analysis is to estimate gross receipts and expenditures including the costs associated with production and the credit repayments farm families must make to determine what remains to compensate the family for its labour management skills and capital The economic aspects of project preparation and analysis require determination of the likelihood that a proposed project will contribute significantly to the development of the total economy and that its contribution will be great enough to justify using the scarce resource it will need The point of view taken in the economic analysis is that of the society as a whole In the social aspect analyses are expected to examine carefully the broader social implications of proposed investments such as income distribution and its responsiveness to national objectives (Gittinger 1982)

This survey deals with the financial and economic profitability of the major crop enterprises There are three very important distinctions between the two that must be kept in mind First in economic analysis taxes and subsidies are treated as transfer payments These taxes which are part of the total project benefit are transferred to the government which acts on behalf of society as a whole and are not treated as a cost to society since the subsidy is an expenditure of resources that the economy incurs to operate the project In financial analysis taxes are usually treated as a cost and subsidies as a return

Second in financial analysis market prices are normally used These take into account taxes and subsidies In economic analysis some market prices may be changed so they more accurately reflect social or economic values

Third in economic analysis interest on capital is never separated and deducted from the gross return because it is part of the total return to the capital available to society as a whole and because it is that total return including interest that economic analysis is designed to estimate In financial analysis interest paid to external suppliers is deducted from gross benefit (Gittinger 1982)

The parameters used in this analysis are given below

1 Net returns to land labour and management costs of land labour and management are not deducted from the gross return This value is given in terms of birr/hectare (br/ha) and birr/workday (br/wd)

2 Net returns to land and management labour is valued in cash and included in the cost of production It is given in br/ha

ENTERPRISE PATTERN

In the survey area the average farm size is about 2 ha Farmers produce a wide range of crops among which maize haricot bean and tef are most important in the wet zone Minor crops are sorghum wheat and barley Maize is grown by almost all farmers and is the staple cereal of the farming community Tef and haricot bean are grown by 89% of the sample farmers in the wet zone These two crops are cash crops produced for the market The other cash crop in the wet zone is potato Tef and haricot bean are equally important in terms of proportion of farmers growing the crops in the wet zone In the dry zone tef is grown by 81% of farmers whereas haricot bean is grown by 65% Like farmers in the wet zone almost all farmers in the dry zone grow maize Sorghum is more important in the dry than the wet zone

The average number of cattle per family is 4 1 in the wet zone and 4 9 in the dry zone Some 31% of farmers in the wet zone do not have a pair of oxen compared to 23% in the dry zone Farmers with no oxen either use *mekenajo* (partnership) or a labour service system (three days of work on the oxen owners field in return for two days of work on his field) Other strategies of farmers without oxen are share cropping borrowing and using cows as draft animals (Alemayehu Kefyalew *et al* 1991)

PROFITABILITY OF HARICOT BEAN VERSUS OTHER MAJOR CROPS FARMERS PERSPECTIVES

Returns earned and costs incurred in producing haricot bean maize tef sorghum and potato were identified and used to calculate the profitability of these crops to farmers The local market price of inputs was recorded to calculate costs of production There is a big gap between the prices of haricot bean in 1990/1991 and 1992 The prices in the first two years were approximately the same averaging 55 br/100 kg but in 1992 the price was increased to 135 br/100 kg This has resulted in a change in the position of haricot bean in the profitability rank In the first analysis it was assumed that the farm family is the only source of labour Hence labour was not valued in cash Instead costs other than labour were deducted from the gross benefit to determine the net returns to land labour and management This parameter is given in br/ha and br/wd

The number of workdays spent ploughing haricot bean fields are 125% fewer than for tef The preparation of tef fields takes longer because the frequency of ploughing is greater Haricot bean requires the fewest days for land preparation Among the four crops in the wet zone potato has the highest fertilizer cost followed by tef and haricot bean In comparing other variable costs of the crops in the wet zone potato has the highest followed by tef haricot bean and maize The cost of oxen constitutes the main proportion of the variable costs in maize

Potato production requires greater labour input than other crops particularly during planting cultivation and harvesting Similarly tef weeding and harvesting are labour intensive activities On the other hand very little attention is paid to haricot bean field management Labour requirements for potato are 3 5 times higher than for haricot bean and maize consumes three times the amount absorbed by haricot bean

Using input and output prices in 1990 and 1991 the net return to land labour and management shows that haricot bean is the least profitable crop (251 br/ha and 5 7 br/wd) in the wet zone Similarly when labour is valued in cash haricot bean generates 3 br/ha indicating that the gross benefit is only slightly larger than the total cost In the dry zone haricot bean has the smallest net return except when labour is valued in cash when it generates a greater return than sorghum

Using 1992 prices the net returns to land labour and management expressed in br/ha show that tef is more profitable than all other crops in the wet zone (Table 1) The profit earned from tef is larger than the next most profitable crop potato by about 6% Haricot bean is the third crop in terms of br/ha but when the net return per workday is taken as a measure of profitability it ranks first with a return of 21 br/wd followed by maize (10 35 br/wd) tef (8 4 br/wd) and potato (7 2 br/wd)

Table 1 Costs and returns analysis of haricot bean and other major crops among smallholders (labour not valued in cash)

	Haricot bean		Tef		Maize		Pot ato	Sorg hum
Items	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Yield (kg/ha)	1040	963	1041	962	1473	1324	9880	1213
Gross benefits (br/ha)	1404	1300	1770	1635	1134	1020	2964	691
Labour (wd/ha)	48	48	150	139	82	82	166	78
Other variable costs (br/ha)	337	175	456	229	243	190	1667	114
Fixed costs (br/ha)	22	22	24	24	22	24	22	24
Cost of capital (br/ha)	12	7	24	13	18	14	85	9
Total cost (br/ha)	371	207	504	266	285	228	1774	147
Net returns (br/ha)	1033	1093	1266	1369	849	792	1190	547
(br/wd)	21 5	23	8 4	9 8	10 4	9 7	7 2	7

Notes

Gross benefit is calculated based on farm gate price of output at harvest ploughing four times for tef three times for maize potato and sorghum and twice for beans the new price announced by government (1 95 br/kg) is used for fertilizer applied on haricot bean one workday is equivalent to 8 working hours tef is weeded twice maize and sorghum once haricot bean is not weeded at all potato is cultivated twice the first cultivation lasts 40 wd/ha and the second 39 wd/ha transporting refers to the number of workdays required to transport the harvested crop to the threshing field ox hours are converted to cash at a rate of 0 75 br/hr seed cost is calculated based on farm gate price at planting fertilizer price is calculated based on farm gate price cost of ploughing is shared among the crops based on area coverage and frequency of ploughing cost of tools (waggle sickle and sack) is calculated using capital service method

$$c = \frac{r*v}{1\ (1+r)}$$

c= annual service cost r= interest rate (10%)
v= acquisition cost
n= number years of service

every farmer pays 20 br/annum land tax irrespective of the farm size he owns cost of capital stands for opportunity cost of the money in the process of production it is calculated using an interest rate of 10/ per year (8 months for maize 6 months for tef and potato and 4 months for haricot bean

$$\text{rate of capital turnover} = \frac{\text{Gross benefit}}{\text{Total cost}} * 100$$

As in the wet zone labour consumed by haricot bean in the dry zone is less than by all other crops The profitability of crops in the dry zone was analysed using local market prices of inputs and outputs The same output price was used for both wet and dry zones Tef is the most profitable crop (1369 br/ha) followed by haricot bean (1093 br/ha) and maize (792 br/ha) Net return of tef to land labour and management is greater than haricot bean by about 25% The least profitable crop is sorghum (544 br/ha) As in the wet zone haricot bean is the most profitable crop in terms of the net return per workday (23 br/wd) Tef and maize have approximately equal returns (9 8 and 9 7 br/wd)

In calculating the profitabilities of major crops to individual farmers it was considered necessary to value labour in terms of cash since labour is considered a constraint in the survey area Taking net returns to land and management as a parameter to measure profitability haricot bean generates the highest net return in both wet and dry zones (Table 2) Rate of capital turnover is calculated for all crops and indicates that haricot bean is the most efficient crop in utilizing capital

Table 2 Costs and returns analysis of haricot bean and other major crops among smallholders (labour valued in cash)

	Haricot bean		Tef		Maize		Potato	Sorghum
Items	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Yield (kg/ha)	1040	963	1041	962	1473	1324	9880	1213
Gross benefits (br/ha)	1404	1300	1770	1635	1134	1020	2964	691
Labour costs (br/ha)	241	220	805	748	389	361	775	345
Other variable costs (br/ha)	384	175	456	229	243	190	1667	114
Fixed costs (br/ha)	22	22	24	24	24	24	22	24
Costs of capital (br/ha)	22	14	64	50	44	38	44	32
Total costs (br/ha)	669	431	1352	1051	700	613	700	515
Net returns (br/ha)	735	869	488	548	453	407	434	176
Rate of capital turnover (%)	210	302	131	156	131	166	162	134

SOCIETY'S PERSPECTIVES

Profitability to farmers of cereal production often reflects the effect of policy *interventions* such as low producer prices to protect consumers or subsidies on specific inputs as an incentive to producers (Beyrlee and Longmire 1986) In the previous section profitability of crops from the point of view of farmers is calculated using local market prices Since local market prices are distorted by government policies the profitability of crops to individual farmers does not show the true economic return to the nation Shadow prices are intended to reflect the true economic value of goods and services in the absence of taxes subsidies import tariffs quotas price controls and other government policies In this analysis the local market prices of non tradeable inputs like labour and ox power are assumed to reflect the real value of the inputs

The starting point for calculating the shadow price of haricot bean in the survey area is its FOB price at Asseb This price includes costs of transport processing handling insurance and other miscellaneous expenses In order to arrive at the shadow price of haricot bean in the survey area the FOB price at Asseb should be adjusted by deducting all above mentioned costs (Table 3) Table 3 also shows that shadow price of haricot bean at Nazret is about 1416 br/t This price is used to calculate the profitability of haricot bean from the national point of view In the wet zone the gross economic benefit of haricot bean is 1473 br/ha and the economic profitability analysis shows a net return to land labour and management of 1126 br/ha or 23 4 br/wd (Table 5) This table also shows that the net return to land and management is 887 br/ha In the dry zone the net return to land labour and management is 1182 br/ha or 24 6 br/wd When labour is valued in cash and included in the cost of production the net return to land and management becomes 962 br/ha (Table 5)

Table 3 Calculation of shadow price of haricot bean in the survey area

Items	USD/t	br/t
Haricot bean FOB Asseb	490	2448
Loading unloading inland insurance and transport bags and twines		127
Processing costs		285
Export Expenses		326
Miscellaneous expenses		295
Total cost of haricot bean export		1032
Shadow price of haricot bean in survey area (Nazret)		1416

Ethiopia neither exports nor imports maize and sorghum However since these two crops are internationally traded their shadow prices were calculated by taking FOB prices at US gulf and adding transport and insurance costs to obtain the CIF price at Asseb Handling storage port charges and inland transport costs are added to the CIF price at Asseb to arrive at the shadow price of maize and sorghum at Nazret (Table 4)

Table 4 Calculation of shadow price of maize and sorghum in the survey area

	Maize		Sorghum	
Items	USD/t	br/t	USD/t	br/t
Maize price Gulf ports USA	131		120	
Transportation & other costs to move grain to Asseb	45		45	
CIF price Asseb	176	880	165	825
Port charges		53		53
Storage and handling		6		6
Cost to transport maize from Asseb to Nazret		109		109
Shadow price of maize at Nazret		1048		993

From The profitability of coffee and maize among smallholders a case study of Lieu Awraja

In the survey area the shadow price of maize is 1048 br/t (Table 4) For the remaining inputs market prices were assumed to reflect true economic values For maize in the wet zone the net economic return to land labour and management is 1341 br/ha or 16 br/wd (Table 5) Maize has net returns to land and management of 948 br/ha The return is slightly lower in the dry zone The calculated shadow price of sorghum is 993 br/t (Table 4) The net return to land labour and management of sorghum in the dry zone is 1083 br/ha or 14 br/wd When labour is valued in cash and added to the cost items the profitability of sorghum expressed in net returns to land and management becomes 738 br/ha

Table 5 Economic profitability of haricot bean and other major crops in the survey area

Items		Haricot bean		Maize		Tef		Sorghum
		Wet	Dry	Wet	Dry	Wet	Dry	Dry
Yield (kg/ha)		1040	963	1473	1324	1041	962	1213
Gross benefits	(br/ha)	1473	1364	1547	1390	1997	1847	1203
Labour costs	(wd/ha)	48	48	83	82	150	139	78
	(br/ha)	241	220	393	361	808	748	345
Other variable inputs (br/ha)		345	180	202	166	639	222	116
Fixed costs	(br/ha)	2	2	4	4	4	4	4
Net returns	(br/ha)	1126	1182	1341	1220	1354	1621	1083
	(br/wd)	23 4	24 6	16	15	9	12	14
Net returns	(br/ha)	887	962	948	859	546	873	738

Although tef is widely grown in Ethiopia it is not traded internationally so does not have a direct world market price It is normally argued that the values of goods of this type can be estimated by the value of the expenditure diverted from these items to other consumption goods In other words if more of these goods are purchased by some consumers and they are in fixed supply other consumers will have to switch their expenditure to other items The value of every br of expenditure switched will be given by the world price of the new commodities purchased by the diverted expenditure (Project Planning Center 1987) In the survey area maize is an important substitute for tef therefore the world price of tef is calculated based on the world market value of maize that can be bought by cash switched from tef Tef generates 546 br/ha net return to land and management in the wet zone and 873 br/ha in the dry zone (Table 5) From the national point of view maize is more profitable than haricot bean and tef in the wet zone In the dry zone haricot bean generates a net return of 962 br/ha which is greater than the returns for tef maize and sorghum

CONCLUSIONS

According to farmers the main reason for growing haricot bean is as a source of cash This is so even when the price is unattractive because its field management is simpler than for other crops and it matures early when farmers are in urgent need of cash The incremental change in haricot bean price has considerably improved the profit earned from haricot bean production thereby making haricot bean a very important enterprise in the system Moreover this study verifies that haricot bean is an efficient user of scarce resources such as labour and capital Therefore particular attention of researchers and other concerned officials are required to solve problems of haricot bean production

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HARICOT BEAN MARKETING IN ETHIOPIA SOME POLICY IMPLICATIONS

Alemigne Kefyalew

Institute of Agricultural Research Nazreth Ethiopia

ABSTRACT

A haricot bean marketing study was conducted in the Nazret and Ziway areas ETOPLC had a market share of 70 75% of Ethiopia s export of pulses Since ETOPLC is a government institution its overhead expenses allowances for impurities and transport costs are more than those of private exporters The major marketing constraints are shortage of cash supply instability poor infrastructure government monopoly of output market and mixtures of pea bean with other varieties Providing credit improving the road network trade privatization establishing marketing cooperatives strengthening agricultural research and extension and subsidising exporters during lean years are suggested for improvement But the role of the government in stabilizing prices by holding stocks should not be neglected

INTRODUCTION

Prior to and during the 3-4 year revolution smallholders demonstrated a rapidly increasing capacity to use improved seeds fertilizer and credit Unfortunately the policies adopted to enhance state control have led to substantial inefficiencies dampened incentives to increase production and made it difficult for smallholders to afford yield enhancing inputs and services (Cohen and Nils Ivar 1988)

Very little information is available with regard to market performance as the government had little interest in the private sector The objectives of this paper are (1) to shed light on the conduct structure and performance of the marketing system in Ethiopia with special emphasis on haricot bean one of the major crops and (2) to draw implications from the analysis for improving the performance of the agricultural marketing system

A haricot bean marketing study was conducted in the Nazret and Ziway areas Secondary information was collected from relevant sources and a market participant survey was conducted to understand marketing organizations channels and problems from the perspective of different market participants In this paper the importance of haricot bean in the system the marketing organizations and facilities are described Next major marketing constraints and some policy implications are presented

OVERVIEW OF THE STUDY AREA

The study area is the major pea bean producing region of Ethiopia The principal constraints to production include moisture stress (39% of the farmers) and shortage of land (28%) seed (28%) oxen (28%) and fertilizer (20%) On average farmers in the study area have a farm size of 2 9 ha a family size of 7 3 persons and a pair of oxen

Maize tef and haricot bean are the three most important crops grown in the study area Haricot bean is grown by 83% of sample farmers and covers about 20% of the total area It is produced mainly for market and is the first cash crop for 21% of farmers and the second for 28% of farmers About 75% of the haricot bean produced (equivalent to 329 kg) is marketed Unlike maize and sorghum tef and haricot bean are usually marketed in bulk by the husband since the cash is required to settle fertilizer debts and tax payments and buy clothing About 67% of the haricot bean produced is marketed in bulk sale

MARKETING ORGANIZATIONS

There are several organizations and traders actively involved in the marketing of agricultural products These include the Agricultural Marketing Corporation (AMC) service cooperatives private traders and the Ethiopian Oilseeds and Pulses Export Corporation (ETOPEC)

Agricultural Marketing Corporation (AMC)

The history of government intervention in grain marketing dates back to the 1950s with the establishment of the Ethiopian Grain Board (EGB) EGB had a mandate to regulate domestic and export prices license grain export and control quality In 1960 the Ethiopian Grain Corporation (EGC) was established to stabilize domestic prices by holding stocks (which was the main failure of the EGB) and promote grain production for export Strong government intervention took place in 1976 with the establishment of the Agricultural Marketing Corporation (AMC) under the Ministry of Domestic Trade Farm gate prices were fixed regardless of seasonal and regional variations In order to ensure the delivery of grain a rigorously enforced quota system was imposed on producers The AMC s operation was effected through service cooperatives and farmers were forced to deliver 100 300 kg of grain per family

AMC was supplying ETOPEC with its export requirements from 1986 to 1989 because it was felt prudent (Debela Gutema 1988) to utilize already existing and expanding AMC network personnel fleet storage and other assets During that period export crops were treated similarly to food crops and their quality was poor because there was no quality inspection at purchasing points In 1990 ETOPEC was allowed to purchase its major crops Haricot bean accounted for 3% of the total grain procured by AMC from domestic sources an average of 11 000 t of haricot bean being procured by AMC annually from 1986/87 to 1990/91 The main supplier of haricot bean is Shoa The study area supplied 18% 52% (average 45%) of the total haricot bean purchased by AMC from 1987/88 to 1989/90

After January 1988 the government relaxed its policy and permitted private traders to move grain among regions provided they delivered 50% of their purchases to AMC at official prices Crop quotas and trade restrictions were abolished in March 1990 Since then AMC purchases at free market prices and purchasing prices have risen dramatically AMC has scaled down its operation since the quota system was abolished

Service Cooperatives (SCs)

Until 1981 cooperative grain marketing was almost non-existent Since then however cooperatives have emerged and developed to play a major role in grain trade As of 1987 there were about 4 052 SCs of which 1 670 were involved in grain collection as agents of AMC More than 90% of AMC s annual purchase from the peasant sector is collected by SCs In 1982 their share was only 38% (Debela Gutema 1988)

The SCs contributed much to the achievement of AMC s objectives They assembled grain from farmers at a fixed price Usually the service cooperatives received a margin of 4 5 birr/100 kg bean purchased This was 8 11% of the AMC s purchase price from Service Cooperatives The main source of finance for purchasing grain was the Commercial Bank of Ethiopia

Private traders

There are different classes of private traders including assemblers wholesalers processors and exporters The number of private traders has increased since March 1990 following liberalization of the market Prior to market reform grain trade was a very risky business since AMC took any quantity of grain found in store more than 500 kg This was broadly and strictly enforced

Assemblers Assemblers buy mainly from rural markets and sell to wholesalers in urban centers They mostly receive cash from wholesalers and earn commission based on the total quantity purchased None of the assemblers has a license or his own grain shops

Brokers Brokers mainly bring sellers (producers) to *assemblers* or wholesalers Their payment depends on the relationship between the partners Their function is considered important on market days after harvest In some cases they also act as a bridge between two traders

Wholesalers Wholesalers receive grain from producers and assemblers They have their own grain shops Most wholesalers have started up very recently and most do not have trading licenses As of December 1991 *the number* of wholesalers in the study area having licenses reached 119 However it is estimated that more than 200 grain wholesalers operate without license

Processors The main function of processors is to clean and separate mixtures to the accepted export level They charge a processing fee of 100 Birr/t They are mainly concentrated in Nazret

Haricot bean is graded by grain colour size and shape Since the export market favours small white pea beans (4 8 mm length) these types are most preferred Large white beans are also exported to a limited extent Coloured beans are used mainly for home consumption but Red Wolaita is also exported to Cuba

Private exporters The share of private exporters in bean export has not exceeded 30% But this trend is changing after the new economic policy of free market Private exporters may function as wholesaler processor and exporter They are the *major sources* of finance for assemblers and wholesalers Exporters are few in number and have offices in Addis Ababa Nazret and Dire Dawa Most of them have their own cleaning machines and others use the services of processors These exporters have their own stores or rent them

Ethiopian Oilseeds and Pulses Export Corporation (ETOPEC)

The Ethiopian Oilseeds and Pulses Export Corporation (ETOPEC) was established in 1975/76 under the Ministry of Foreign Trade It is the leading oilseeds and pulses export trading organization in the country ETOPEC grew from a small enterprise to a large state trading corporation with a market share of about 80% of the national export of oilseeds and pulses

The main objectives of the corporation are to (1) enhance the export of high quality agricultural products to international markets and thereby contribute to foreign exchange earnings (2) assist farmers to obtain a fair price for their exportable agricultural commodities and (3) contribute to the export diversification scheme of Ethiopia

The major export type of haricot bean is pea beans (A) (4 8 mm) Other exportable varieties are (1) Small (A and B) (2) Medium B and (3) Red beans (small A and B and Medium B) Red beans from Wolaita are exported to Cuba *Cubans prefer* black to red beans but black beans are not widely grown in Ethiopia ETOPEC has exported 3 512 10 534 t haricot bean worth 3 9 10 9 million Birr per annum Europe is the main market for Ethiopian haricot beans

ETOPEC purchases from one or more traders or service cooperatives provided they assemble a full truck The main financial source for ETOPEC is credit from the Commercial Bank of Ethiopia at an interest rate of 9% until September 1992 and 14% thereafter The corporation has its own trucks but they are not sufficient especially during purchasing periods Thus it has to rely on the Ethiopian Freight Transport Corporation (EFTC) The corporation s central warehouse has a capacity of 35-40 thousand t The corporation has its own cleaning and grading machines They usually hand pick to separate mixtures Packing is in 69/70 kg (69 kg net/70 kg gross) or 49/50 kg (49 kg net/50 kg gross) new single strong jute bags at the buyer s option

The major difficulties of ETOPEC are (1) mixtures of beans of different sizes and shapes (2) shortage of transport facilities particularly at peak purchasing periods (3) fixed exchange rate which limits its profitability and (4) inability to enforce contracts frequently overseas clients default on their promises to buy after costs for packing and labelling have been incurred

MARKET INFRASTRUCTURE

Transportation facilities

One problem of agricultural development in Ethiopia (Debebe Agonafir 1974) is the absence of simple animal drawn carts which could reduce current high transport costs Slow and inexpensive pack animals are widely used to transport agricultural products on farm and to the nearest village markets

Ethiopian Freight Transport Corporation (EFTC) is a government corporation It had the mandate of coordinating all ground freight transport in the country In the new economic policy the transport sector is open for free competition Small truck transporters are limited by fuel unavailability ageing trucks and shortage of spare parts high taxation and a poorly developed and maintained road network

Storage facilities

Haricot bean is usually sold within a short period after harvest However it can be stored for nine months before it is attacked by bruchids Since there is a shortage of sacks at harvest haricot bean may be left on the ground in the market until the next trader in the channel buys it

Financial services

Credit is most important at harvesting (November February) Wholesalers have the right to credit from financial institutions provided that they have a license and assets for collateral The collateral may be a house or a truck Compared to the informal market the interest rate charged by financial institutions is very low (9 14% per annum) However very few traders receive credit from these institutions because they are unable to fulfil loan requirements

Some wholesalers and exporters may lend money for purchasing haricot bean The total amount of such a loan may reach 20 30 thousand birr Such credit attracts a very high commission the most common commission is 10 birr/t bean purchased equivalent to 2% per month

EFFECTS OF POLICY CHANGES ON PEA BEAN MARKETING

The major changes in the new economic policy can be summarized as follows (1) devaluation of local currency (from 2 07 to 5 00 birr per US$) (2) setting a minimum guaranteed producer price of haricot bean (from 450 600 birr/t to 1350 birr/t) (3) increasing interest rate for institutional credit (from 9% to 14%) (4) raising export (transaction) tax (which was 2% of the exported value) (5) subsidizing transport costs (6) opening the transport sector for free competition and (7) removing the subsidy for ETOPEC

The effects of these policy changes are felt immediately in pea bean marketing (Table 1) The changes were made as a package and therefore it is difficult to isolate the effect of one policy change from the others Assuming a long term (1973 1993) average selling price FOB at Assab (489 66 US$/t) both producers and exporters may have reaped the benefit However the 1993 FOB price is exceptionally low (on average 445 US$/t) and reduced the profit of private exporters and scaled down ETOPEC s bean purchases Since ETOPEC is a government institution its overhead expenses allowances for impurities and transport costs are more than those of private exporters Private exporters can easily negotiate transport costs A major factor in marketing the increased Ethiopian exports is the high cost of moving crops from point of production to port (Debebe Agonafir 1974)

Based on the long term average world bean price at Assab ETOPEC was operating at a loss of 99 62 birr/t However this was mainly due to the fixed exchange rate (2 07 birr = 1 US$) which was very low to give incentives for both exporters and producers As the exchange rate is raised to Birr 5 per 1 US $ part of the increased benefit is passed to the producers as an incentive for quality produce and to reduce cleaning and handling costs

Since purchasing prices have been very low farmers have not given attention to the purity of their produce Instead they add foreign materials to increase the weight Mixtures are a major cause of increased processing costs The marketing system is not able to distinguish quality and hence reward merchants and producers on that basis (Debebe Agonafir 1974) Other factors leading to poor quality produce are the use of indeterminate bean varieties and delay in harvesting The question of improved quality in pea beans resides in Ethiopia s ability to use the determinate varieties and machine handling methods of Western agriculture (Deran Markarian 1979)

Table 1 Cost sheet for pea bean export on FOB basis for ETOPEC and private exporters before and after policy changes (br/t)

Type of costs	ETOPEC Before policy change	ETOPEC After policy change	Private exporters Before policy change	Private exporters After policy change
Purchasing costs				
Long term average purchasing price (1978/79 1990/91)	556 00	1400 00	600 00	1500 00
Loading and unloading cost	10 00	44 30	10 00	10 00
Inland insurance (average)	1 50	1 60	0 00	0 00
Inland transport ( )	48 80	68 00	0 00	0 00
Bags and twines	10 50	13 30	20 00	25 00
Sub total	626 80	1527 20	630 00	1535 00
Processing costs				
Stock insurance (average)	1 90	1 90	0 00	0 00
Fumigation at store	0 80	3 90	3 00	3 00
Cleaning and handling labor costs	69 00	69 00	50 00	50 00
Allowance for foreign materials spillage and weight loss	27 80	70 00	12 00	30 00
Allowance for mixtures	55 60	140 00	36 00	90 00
Sub total	155 10	284 80	101 00	173 00
Export expenses				
Export bags and twines	30 50	43 10	40 50	53 10
Transport to Assab port (average)	108 50	217 50	98 00	167 00
Transit insurance (average)	2 90	2 90	2 90	2 90
Fumigation at port	2 80	3 30	2 80	3 30
Weight and quality inspection	3 00	3 20	3 00	3 20
MTSC handling charges	43 60	43 90	43 60	43 90
Ethiopian standards	2 80	3 30	2 80	3 30
Declaration	5 60	5 60	5 60	5 60
Transaction tax	11 12	0 00	12 00	0 00
Quarantine costs (average)	0 50	0 50	0 50	0 50
Storage at port and Other charges	0 30	2 20	0 30	2 20
Sub total	213 62	325 50	212 00	285 00
Miscellaneous expenses				
Bank interest (for 4 months)	29 80	99 75	28 29	93 00
Overhead expense	100 40	194 00	35 41	35 41
Sub total	130 20	293 75	63 70	128 41
Total cost of pea bean export	1123 72	2431 25	1006 70	2121 41
Long term average selling price FOB Assab 1973 1993	1013 60	2448 30	1013 60	2448 30
Plus sale of rejected beans	10 50	21 00	21 00	42 00
Total revenue from bean export	1024 10	2469 30	1034 60	2490 30
Net profit/loss	99 62	38 05	27 90	368 89

Source Costs related to ETOPEC are obtained from ETOPEC headquarters

MAJOR MARKETING CONSTRAINTS AND SOME POLICY IMPLICATIONS

Major marketing constraints

The marketing system is hindered by many interrelated factors among which shortage of cash poor transportation facilities and infrastructure and supply instability are worth mentioning

1 **Shortage of cash** Grain movement and storage length are limited by cash shortage causing more rapid capital turnover and thus greater seasonal price variations Service cooperatives are also hampered from participating in the grain trade by shortage of cash

2 **Poor transportation facilities** Most farmers use pack animals or head loads to take their produce to market Traders are limited by poor transportation facilities the cost of which is high even if they are available Scarcity of spare parts for ageing trucks is also a problem

3 **Poor infrastructure** Although the road network is good relative to other parts of the country roads do not reach most service cooperatives Roads are in poor condition and cause frequent truck repair

4 **Supply instability** The supply of haricot bean is seasonal it reaches its maximum immediately after harvest and sharply declines before the next harvest In July/August haricot bean trade freezes The root causes of this instability are the vagaries of weather lack of agricultural technology to increase and stabilize production and policy constraints The study area frequently faces crop failure due to the late onset or early cessation of rainfall The agricultural research system has not developed sufficient technology to cope with moisture stress

5 **Government monopoly of output market** About 70% 75% of haricot bean export is handled by government ETOPEC operates at a loss or with minimum margins due to high overhead costs transport expenses and allowances for impurities

6 **Mixtures of pea bean with different coloured and size beans** Most exporters and processors were worried about mixtures of pea beans with other varieties In Meki and Ziway areas the percentage of mixtures is as high as 12%

Some policy implications

Government action in the following areas would greatly enhance the efficiency of the marketing system

1 **Credit** Loans should be extended to service cooperatives traders and transporters to facilitate long term storage increased scale of operation and movement of grains The AID Bank should reconsider the assets required as collateral

2 **Improving the road network** The road network should be improved to reach rural areas This would facilitate transporters and traders visits to rural areas and could be achieved by strengthening the collaboration between relief agencies service cooperatives and the Ethiopian Road Transport Authority through food for work programmes

3 **Trade privatization** The government should withdraw itself from exporting bean and encourage private exporters as the overhead expenses of government institutions are much higher than those of private exporters Private exporters are more efficient in terms of handling costs and searching for

better markets However a quality control mechanism must be devised as the state disappears from marketing to avoid damaging prices on international markets Trade liberalization does not mean *laissez faire* The role of government in stabilizing prices by holding stocks should not be neglected Government should play an important role in supporting strategic grain stocks and establishing a floor price It should also support rural transport

4 **Marketing cooperatives** Reducing the number of middle men by operating through service cooperatives will increase the share of the farmer from the grain market Profits from grain sales could be used to repay credit and maintain existing facilities and a portion could be redistributed among members This could be implemented by signing a contract in advance Private exporters government agencies and consumers could be the customers of the service cooperatives but structural reorganization and regulation of the service cooperatives must be implemented to ensure efficiency and avoid theft

5 **Strengthening agricultural research and extension** The development of high yielding haricot bean varieties is crucial to attain increased and stable production An integrated approach for distribution of clean seed must be devised by researchers extensionists seed companies and exporters

6 **Subsidy for exporters during lean years** With the introduction of a guaranteed minimum producer price a trigger mechanism should be introduced by which cash would be syphoned off and kept in special accounts during windfall periods thus creating fall back funds for lean years The Customs and Excise Administration could take and deposit the money thus generated in the special accounts Whenever prices fall below the total cost of export the government should subsidize exporters based on exported quantity with certain percentage allowances for off types

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EXPERIENCES IN ON FARM RESEARCH WITH BEAN (Phaseolus vulgaris) CULTIVARS

Isaac Mulagoli

Laikipia Rural Development Programme Nanyuki, Kenya

ABSTRACT

On farm trials of three bean cultivars (Rose Coco Kat B1 and Kat MM) were conducted in the cool dry climate of Laikipia District in the Rift Valley Province of Kenya The trials sought to verify the performance economic viability and social acceptability of the cultivars under farmers circumstances and field management They were conducted for seven consecutive seasons (second season 1988 to second season 1991) in nine localities that have bimodal rainfall and two growing seasons per year One hundred farmers were actively involved in carrying out all field operations with eight of them recording important climatic data Agricultural extension assistants residing in their respective working units were responsible for data collection and assisting farmers in completing evaluation questionnaires Cultivar Kat MM was superior and most consistent in performance across localities and seasons with an overall yield advantage of 26% over Rose Coco Kat MM afforded 26% more monetary returns to farmers than Rose Coco at local market prices and 13% at gazetted prices Kat B1 was highly susceptible to diseases and was least productive but it had the most acceptable taste in all localities with over 90% of the farmers opting to retain it for preparing local dishes Rose Coco remained the farmers choice in seed size colour and market value In summary this paper recommend that Kat MM beans be released for extension services in target areas of the district Kat B1 beans be returned to the research station for further research on disease control and management and Rose Coco should continue as the farmers choice to be grown alongside Kat MM when weather conditions are favourable

INTRODUCTION

The Laikipia Rural Development Programme (LRDP) has adopted on farm research (OFR) as a method for attaining high crop yields for guaranteed food security and farm income for small farmers The yield potential of three bean cultivars and their socio-economic applicability were assessed in OFTs in Laikipia for seven consecutive growing seasons The trials were conducted with the objective of introducing improved bean cultivars that are ecologically adapted economically viable and socio culturally acceptable to settled and settling small farmers of Laikipia District

This paper describes the continuation of the trials in the Laikipia case study highlighted by Mulagoli (1990) It outlines the contribution of OFR in the generation and transfer of appropriate knowledge of bean cultivars for utilization by resource poor small farmers An attempt is made to evaluate the research findings from the perspective of collaborating farmers The entire coverage of the paper underscores the need for this research approach in the area especially when it is appreciably recognized that all those involved in the trials are new in the district with limited knowledge of dryland farming techniques in cold dry environments They are thus not well equipped with proper agricultural interventions for increased and sustainable crop production (Mulagoli 1990)

The discussion in subsequent sections is a synthesis of information drawn from data collected simple questionnaires field days and personal interactions between the author and collaborating farmers in OFR It also considers the contribution of the following specialists who worked in partnership with farmers throughout the OFR process

plant breeders pathologists and entomologists from Kenya Agricultural Research Institute (KARI) Katumani and Thika

socio-economists from Laikipia Research Programme (LRP)

community development specialists from LRDP and Ministry of Culture and Social Services Laikipia and

agricultural extension agents from the Ministry of Agriculture Livestock Development and Marketing Laikipia

Besides promoting and improving research activity in the district for the welfare of small farmers the paper may provide a more practical interaction between research scientists and extensionists with small farmers serving as lynch pins in the system (Abbas 1989) OFR on beans which is the focus of this presentation continued in Matanya and seven additional localities of similar agro-ecological conditions for two more years (four growing seasons) 1990 1991 involving one hundred farmers

OBJECTIVES OF OFR IN LAIKIPIA

to involve farmers in the selection of adapted bean cultivars through verification of the performance economy viability and social acceptance of Kat B1 Kat MM and Rose Coco (control) in Laikipia (cold dry) under farmers circumstances and field management

to recommend the adapted bean cultivars for dissemination to farmers through extension services in the target areas and

to provide feedback to the research station on cases that require further research on bean crop improvement

METHODOLOGY

These were farmer managed and farmer-executed verification trials They were thus conducted according to farmers methods of growing beans For details refer to Mulagoli (1990) The observations reactions and comments of farmers and extension agents were compared to help in presenting a balance assessment in the final report The following steps were undertaken in succession and sometimes in an overlapping manner during the trial period

Choice of cultivars

There was no change in treatments for the entire trial period (1988 1991) However screening of varieties at Matanya station continued whereby three more bean cultivars namely Kat 69 3330 and 3334 were recommended for OFR effective from 1992

Choice of localities and farmers

The trials were extended from Matanya to seven more recommendation domains namely Kihato Muhonia Sweetwater Witharc Kangu ini Nyambogichi and Wiuminrie With the help of predetermined criteria (Mulagoli 1990) ten farmers were selected from each target area A total of 100 farmers were selected and enlightened on purpose of the trials and their role during meetings convened in their respective villages

Planning and design

The procedure followed in the preparation of the trial programme remained the same A randomized complete block design (RCBD) of three treatments (Kat B1 Kat MM and Rose Coco) was maintained with a single replication per farm Instruction and data collection sheets were prepared and supplied to the agricultural assistants deployed in localities of OFR (Rohumoser Eschborn 1985)

Weather review

The review of weather is based on climatic data (temperature and rainfall) recorded within the target areas of OFTs The stations were located in farmers fields and records taken by farmers themselves Full instructions on the use rain gauges and reading of maximum minimum thermometers were given on frequent supervisory visits

Field operations

All field operations from land preparation to harvesting were undertaken by farmers themselves but key operations like planting and harvesting were witnessed by the agricultural assistants of their respective localities This methodology afforded farmers the opportunity for full and active participation in the OFTs The produce was left with the farmers to cook separately and also compare the cooking time taste preference and storability (of both cooked and dry grains)

Land preparation and sowing were by hand Traces of manure could be spotted in farms where maize was also grown but no farmer applied fertilizers to the OFTs Weeding was also by hand using mainly family labour The family labour involved mostly women and children whereas hired labour included young men and women who were mostly school leavers Weeding was practised twice on average but caused much damage in wet seasons

Pests observed in the field included bean stem maggots cutworms bean aphids and pod borers The effect of pests varied with seasons but was similar in all localities No farmers attempted chemical control of pests

There was high disease incidence in all localities and seasons especially towards crop maturity Commonly observed diseases on beans included common bacterial blight (*Xanthomonas campestris*) halo blight (*Pseudomonas syringae*) anthracnose (*Colletotrichum lindemuthianum*) and angular leaf spot (*Phaeoisariopsis griseola*) and there were traces of ascochyta blight (*Phoma exigua*) Kat B1 was most affected with many farms showing severe necrosis of bean plant parts Diseases may have contributed to loss of plants especially for Kat B1 Farmers generally requested control measures since they did not wish to abandon the variety due to its other important traits of early maturity and consumer taste preference All farmers interviewed concurred that the poor yield of Kat B1 may be due to its susceptibility to diseases Kat MM and Rose Coco were less affected in the vegetative phase but anthracnose and angular leaf spot occurred near maturity affecting seed development and reducing yields Rose Coco also suffered from leaf rust especially during wet seasons No farmers sprayed against diseases

The full harvesting operation was witnessed by agricultural assistants who recorded date of harvesting grain yield and percentage grain moisture content (% MC) The grains were left with farmers to cook and comment on the sweetest variety storability cooking time and grain colour and size

RESULTS AND DISCUSSION

The good weather conditions experienced in the two year period (1990 91) were punctuated by dry spells from May to July (Tables 1 and 2) coinciding with the flowering and pod filling stages of beans

Table 1 Monthly rainfall (mm) at Matanya for four years 1988 91

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1988	39 2	70 4	169 2	138 0	27 1	86 3	122 6	99 6	58 2	85 5	58 2	66 2	1020 8
1989	48 6	26 7	78 9	73 5	30 7	8 9	116 1	37 3	34 6	110 4	104 3	102 1	772 1
1990	39 6	35 9	102 1	136 3	67 3	6 2	10 1	9 8	8 0	9 1	128 5	69 6	622 5
1991	29 4	13 5	78 4	100 4	43 0	84 7	10 1	64 6	2 8	93 2	132 3	60 0	712 4

Table 2 Monthly mean minimum and maximum temperatures and rainfall (mm) and number of days of rainfall for farm of Jane Watanya 1990 91

	1990					1991				
	Temperatures (oC)			Precipitation		Temperatures (oC)			Precipitation	
	Mean	Min	Max	Total mm	No of days	Mean	Min	Max	Total mm	No of days
Jan	20 3	7 0	33 0	39 6	10	20 8	7 0	39 0	29 4	4
Feb	21 1	10 0	33 0	38 9	12	22 2	10 0	35 0	13 5	3
Mar	21 6	12 0	32 0	102 1	11	22 1	10 0	36 0	78 4	5
Apr	21 3	11 0	32 0	136 3	10	21 0	10 0	32 0	100 4	10
May	20 4	11 0	30 0	67 3	3	23 0	12 0	38 0	43 0	4
Jun	19 3	11 0	29 0	6 2	5	21 6	11 0	38 0	84 7	10
Jul	18 9	11 0	29 0	10 1	2	18 5	10 0	30 0	10 1	4
Aug	19 4	10 0	32 0	9 8	2	20 5	10 0	34 0	64 6	8
Sep	20 8	10 0	32 0	8 0	1	22 1	10 0	37 0	2 8	2
Oct	20 3	10 5	32 0	9 1	13	23 3	10 0	37 5	93 2	16
Nov	19 8	10 0	29 0	128 5	19	22 3	10 0	36 0	132 3	16
Dec	20 9	11 0	32 0	69 6	9	22 4	10 0	36 0	60 0	9

The evaluation of OFT results consisted of yield response socio-cultural acceptability and economic returns In the analysis of variance of grain yields the test farms in a locality were considered replications so that the variation among them was reflected in management x treatment interactions The variation among localities reflected environment x treatment interactions There were no farm x treatment interactions due to absence of within farm replications Data were obtained from 55 farms in 1990 and 54 in 1991 from a possible 100 farms in seven villages

Kat B1 and Kat MM reached physiological maturity at the same time and six days earlier than Rose Coco (Table 3) The dry spell experienced during the reproductive phase may have disturbed observations of physiological maturity but Kat MM registered the heaviest yield per day of growth while no significant difference was noted between Kat B1 and Rose Coco (Table 5)

Table 3 Mean number of days from planting to physiological maturity 1988 1991

	Season							
Varieties	2nd 88	1st 89	2nd 89	1st 90	2nd 90	1st 91	2nd 91	Mean
Rose Coco	133 0	83 0	98 0	87 0	94 0	89 0	90 0	93 4
Kat B1	102 0	80 0	91 0	88 0	88 0	83 0	83 0	87 9
Kat MM	102 0	80 0	91 0	88 0	88 0	83 0	83 0	87 9
Mean	105 7	81 0	93 3	87 7	90 0	85 0	85 3	89 7
STD	5 2	1 4	3 3	0 5	2 8	2 8	3 3	2 6
CV (%)	4 9	1 7	3 5	0 5	3 1	3 3	3 9	2 9

Grain yields ranged from 77 (Rose Coco in Wiumirrie in 1990) to 2843 kg/ha (Kat B1 in Kihato in 1990) The average yield for the three cultivars was 790 kg/ha over four seasons (1990 91) The separate averages were 942 725 and 703 for Kat MM Rose Coco and Kat B1 respectively over the same period Kat MM thus recorded average yields above 800 kg/ha (national average for bean) with a yield advantage of 30% over Rose Coco Kat MM was superior and most consistent in performance across localities and seasons registering an overall 26% yield advantage over Rose Coco over the seven seasons (Table 4)

Table 4 Mean grain yields (kg/ha) of varieties in OFTs over seven seasons 1988 1991

	Season							
Varieties	2nd 88	1st 89	2nd 89	1st 90	2nd 90	1st 91	2nd 91	Mean
Rose Coco	569	352	177	534	755	989	620	571
Kat B1	432	383	154	600	776	757	680	540
Kat MM	626	407	236	879	891	994	1005	719
Mean	542	381	189	671	807	913	768	610
SD	81 4	22 5	34 5	149 5	59 8	110 6	169 1	78 4
CV (%)	15 0	5 9	18 3	22 3	7 4	12 1	22 0	12 8

Table 5 Mean grain yields (kg/ha/day) of three varieties in OFTs over seven seasons 1988 1991

	Season							
Varieties	2nd 88	1st 89	2nd 89	1st 90	2nd 90	1st 91	2nd 91	Mean
Rose Coco	5 0	4 2	1 8	6 1	8 0	11 1	6 9	6 2
Kat B1	4 2	4 8	1 7	6 8	8 8	9 1	8 2	6 2
Kat MM	6 1	5 1	2 6	10 1	10 1	12 0	12 1	8 3
Mean	5 1	4 7	2 0	7 6	9 0	10 7	9 1	6 9
SD	0 8	0 4	0 4	1 7	0 9	1 2	2 2	1 0
CV (%)	15 2	7 4	19 7	21 9	9 6	11 1	24 5	14 2

The village by village average yield distribution (Figure 1) generally indicates that Kat MM out yielded the rest while Kat B1 yielded poorest in all but one locality The frequency distribution of farms in yield classes (Figure 2) indicates the appearance of Kat B1 in extremes making it a risky alternative for the area In fact the majority of farmers registered yields below 600 kg/ha for Kat B1 Kat MM was found mainly among the heavier yielding classes with maximum distribution between 800 and 1400 kg/ha The farmer who produced 77 kg/ha was found to have poor fencing and his trial was grazed by livestock while those with yields above 1500 kg/ha were found to take better care of the trials The consistent performance of Kat MM across individual farms and its spread in yield classes above the average make it a more suitable choice for extension services

Disease incidence had a direct impact on the decline in bean performance There was apprehension among farmers on the suitability of Kat B1 due to its high susceptibility to common bacterial blight and halo blight which greatly reduced plant number and decreased yields Other diseases of economic importance were anthracnose angular leaf spot and ascochyta These appeared during the later stages of the crop

Other factors affecting performance were pests and lodging Major pest problems had a latent effect on bean performance especially bean stem maggots and aphids Lodging was notable during wet periods mostly at podding stage but on a large scale There were weed problems during wet conditions necessitating the hire of additional labour for weeding

Socio-economic assessment

The aim of OFTs was not only to increase and stabilize yields but also to improve economic returns and consumer qualities This necessitated the evaluation of social and economic aspects from inception to post harvest period of the trials in order to gauge farmers perceptions of OFR The bottlenecks in existing production systems would be identified to help formulate research priorities in the target areas Conducted informally and through a questionnaire information was collected on major farm enterprises income levels wealth status social status sensory taste marital status income levels market prices credit facilities storability and household economy in general (Keter 1989) Monitoring of these aspects was structured to allow dialogue with farmers through frequent and regular visits

The farmers regarded Kat MM as the earliest maturing and most vigorous in performance Its taste and grain size were appreciated but grain colour betrayed it to be GLP 1004 (Mwezi Moja) which is regarded as less palatable It has good keeping quality both as *githeri* and dry grain and the majority

Figure 1 Frequency of farms in yield class categories

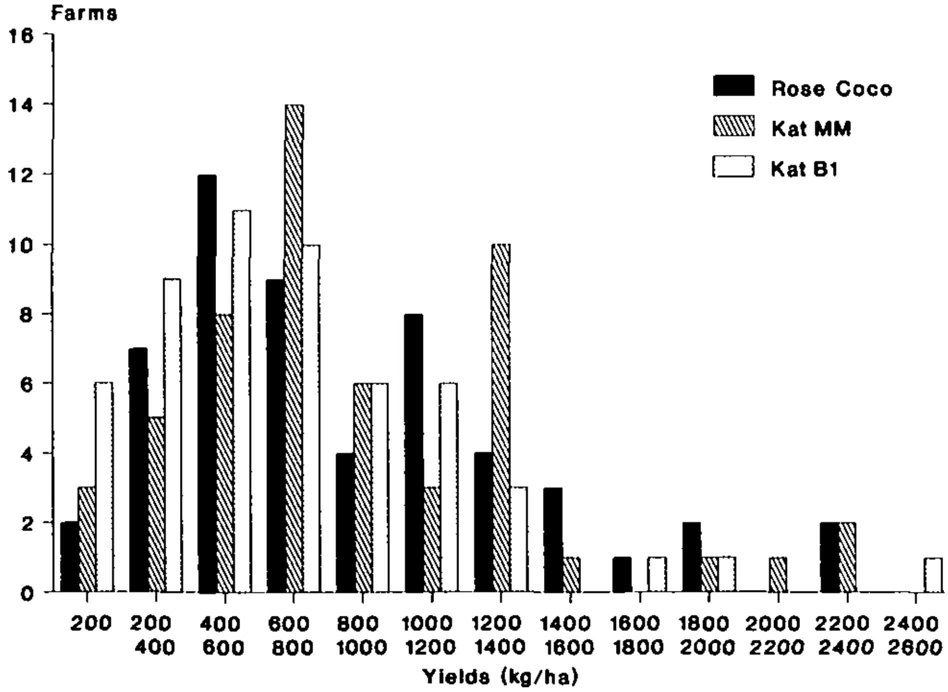
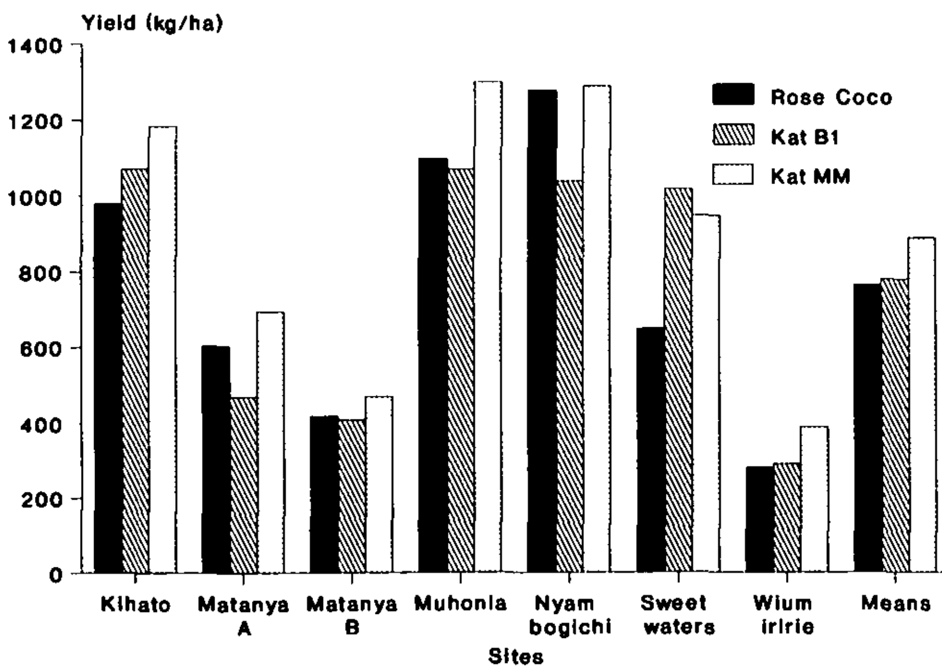


Figure 2 Mean yields (kg/ha) of Rose Coco Kat B1 and Kat MM at seven sites in 2nd season 1990



of farmers were interested in having the variety judging by the numerous applications for inclusion in OFTs Kat B1 showed poor physical performance but was early maturing and tasted best Farmers wished to retain the variety but with specific recommendations on disease management and poor storability after cooking and in store (heavy pest attack) Rose Coco remained the most attractive in grain colour and size but was least appreciated in for taste This assessment of the qualities of beans by farmers was conducted during individual farm visits and through exercises during field days The results of two such field days held in two of the localities in the same week involving preparation of *githeri* are shown in Table 7 Note that the dish was prepared at the same time by the same person and tasting was conducted before farmers had a meal or drink after the field day

Table 7 Numbers and percentages of farmers preferring the tastes of Kat B1 Kat MM and Rose Coco during two field days

Locality	Total	Rose Coco	Kat MM	Kat B1
Matanya	89	3 (3 3%)	45 (50 7%)	41 (46 0%)
Muhonia	41	0 (0%)	19 (46 3%)	22 (53 7%)
Total	130	3 (2 2%)	64 (49 2%)	63 (48 6%)

The market price was the same at local market centres (LMC) whereas institutional pricing policy favoured Rose Coco by 8% over other varieties However none of the OFT farmers sold their produce to the National Cereals and Produce Board (NC&PB) since local demand outstripped supply The table below shows the market value of the three bean varieties traded at two different prices levels in 1991

Table 8 Market value of beans at institutional (NC&PB) and local market centre (LMC) prices

		Price/90 kg bag		Market value (Ksh)	
Variety	(kg/ha)	NC&PB	LMC	NC&PB	LMC
Rose Coco	570 8	520	1200	3297 95	7610 65
Kat B1	540 3	480	1200	2881 60	7204 00
Kat MM	719 8	480	1200	3838 95	9597 30

The table shows 13% and 26% increases in market value in favour of Kat MM over Rose Coco at NC&PB and LMC prices respectively Production costs were the same for all cultivars The introduction of Kat MM involved no extra cost as no changes in inputs and practices were contemplated Hence it is profitable to adopt Kat MM since the increase in yield is sufficient to compensate for the lower prices offered by the NC&PB

Extension of Kat MM Beans

The ultimate goal of OFR in Laikipia was to develop well adapted extension recommendations within a limited period of time In this way OFTs have helped in the recommendation of Kat MM an adapted bean variety appropriate for the cold dry conditions of Laikipia LRDP involved LRP KARI and extension agents of the MoA right from the diagnostic stage of OFR in the district Extension agents were assigned with specific functions during trials as part of their responsibilities in developing the variety for effective transfer to farmers

The transfer of the Kat MM bean package was achieved through various extension methods that included crop demonstrations field days individual farm visits Agricultural Society of Kenya (A S K) Nanyuki shows field tours training workshops and seminars Following the recommendations of Kat MM for extension services on farm demonstrations were established in which large plots of the variety were grown beside local ones Each locality was represented by two demonstration plots The farmers hosting the demonstrations had revealing experience on vigour of growth time of flowering rust resistance and assured yields of the variety boosting chances of its adoption Field days were organized on these plots during which OFT farmers were given the opportunity to act as resource persons in explaining to others the attributes of Kat MM beans Separate field days were held for each locality at a frequency of one field day per locality per season The field days were attended by LRP experts in ecology and socio-economic studies community development specialists from the Ministry of Culture and Social Services local administrators and public health personnel in the host areas Each of these groups had an opportunity to communicate to farmers on the essence of adoption of the practice The attendance of the field days rose from 35 in 1988 to over 300 farmers in 1992 at the same period (December) of the year in the same locality (Matanya) (LRDP reports on field days)

Individual farm visits were also conducted with more positive results as over 3 000 farmers had had access to the variety since its release Field extension agents conducted the farm visits During the A S K Nanyuki shows held annually some OFT farmers attended as stewards at the demonstration site in the show ground This approach attracted large numbers of show goers most of whom enquired about selection to be an OFT farmer The most emphasized variety attributes during the extension sessions included early maturity vigour of growth stable yield and palatability as opposed to the unpopular GLP 1004 (Mwezi Moja) that has the same colour Training workshops and seminars were held for extension agents to familiarize all staff in the district with the Kat MM package for effective and efficient dissemination to farmers The package was also incorporated in the train and visit (T&V) system that was in operation (LRDP reports on training workshops 1992) Field tours of farmers and staff to target areas were organized for all to witness the superiority of Kat MM

Farmers were willing to adopt the variety but some husbandry practices especially fertilizer and pesticide application may not be readily accepted due to the costs involved Since the adoption of the entire package would be negligible a step by step recommendation (Steiner 1987) was suggested for the variety Apart from the costly inputs there are not many agronomic changes in the package except spacing (40 x 15 cm) and pest/disease control measures Farmers assessment of the variety was the major basis of its dissemination in the target areas making diffusion amongst farmers themselves another important extension method that was not only noted for Kat MM but also Kat B1 These OFT varieties were being grown by farmers outside the target areas even before the recommendations The demand for the variety (Kat MM) is so high that a seed multiplication programme will be necessary on a commercial basis

MAIN CONSTRAINTS OF OFR IN LAIKIPIA

Inadequate number of extension personnel in the district reducing the number of localities to be included in the OFTs

Lack of specialists in Farming Systems Research (FSR) coupled with inadequate training of those involved in the trials

High risks of crop failure due to erratic climatic conditions

High costs of labour for weeding and land preparation

High incidences of bean diseases

Lack of institutionalized collaboration between the district and KARI

There is no specific budget for the OFTs in the ministry allocations Hence withdrawal of LRDP can be a big blow to the project

RECOMMENDATIONS

Kat MM beans should be released to farmers in Laikipia through extension services A seed multiplication programme should be established to provide seed at reasonable costs

Kat B1 should be returned to the research station for further research on disease control and management It should be returned to farmers for its positive attributes

Rose Coco should be grown alongside Kat MM during favourable conditions

The OFTs should continue with new bean varieties namely Kat 69 3330 and 3334

Training should be intensified to instil confidence in staff and farmers alike The training should also lead to specialization and awards of certificates diplomas degrees etc

More specialists should be involved in OFR especially soil scientists socio-economists ecologists pathologists entomologists and community development specialists

CONCLUSIONS

The release of Kat MM beans was due to its high yield economic benefits and farmers assessment The variety is early maturing with wide adaptation and yield stability The high yields realized without costly changes in cultural practices may raise the economic status of the rural poor Laikipia farmers depending on market forces and prices With farmers rating all quality attributes but colour to be positive the bean is sure to raise the nutritional status of the local community for a healthy society The adoption of Kat MM has already been facilitated by targeting both extension agents and farmers Farmers have personally witnessed the superiority of the variety and should disseminate the package with confidence Socio interactions amongst OFT farmers with neighbours relatives and friends should enable diffusion of the package Hence the variety has guaranteed chances of widespread adoption in the district and beyond

As a feedback mechanism inherent in OFR further research on disease management has been recommended for Kat B1 beans In order to strengthen collaboration with farmers the variety should be returned to the latter as soon as encouraging results are obtained The variety has proved highly suitable for the preparation of local dishes It is also early maturing but its yield fluctuates due to disease and pest problems

OFR in Laikipia has proved to be an effective and efficient approach to research *extension* and training in the generation and dissemination of site specific technical packages to target groups of farmers The consideration of the production income and taste of the variety in the OFR process was a sound recognition of the inseparable connection between the farming business and a healthy society The bean package was developed with very low external inputs which created no visible changes in the existing production system except insurance in crop yield (a positive attribute) OFTs on beans thus achieved the objective of ensuring sustainable resource management for increased crop production and subsequent food security for subsistence farmers

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RETAIL MARKET SURVEY OF DRY BEAN CULTIVARS SOLD IN KENYA

Susan M W Munene

Kenya Agricultural Research Institute
National Horticultural Research Centre, Thika, Kenya

ABSTRACT

An informal survey of 21 retail markets most of them located in bean growing districts was conducted between January and April 1992 Information was collected on dry bean cultivars offered for sale at each market including local names price/kg quantity offered and production source Information on prices of competitive and complementary food items was also collected The cultivar Muhiki (GLP 2) a Rose Coco type was found in all markets visited Other common cultivars were Mwitemania (GLP x92) Wairimu (GLP 585) and Canadian Wonder (GLP 24)

INTRODUCTION

Beans are the most important pulse in Kenya and second only to maize in importance as a food crop (Njuguna *et al* 1981) They provide an essential source of protein for human consumption with relatively high amounts of lysine tryptophane and methionine With a rapidly growing population and rising meat prices the demand for beans has increased

The Grain Legume Project (GLP) was established at the National Horticultural Research Centre Thika in the early 70s to cater for bean research and development In 1979 the project offered three cultivars to the Kenya Seed Company These were the Rose Coco type (GLP 2) suited to wet parts of Kenya a Canadian Wonder type (GLP 24) for medium rainfall areas and Mwezi Moja (GLP 1004) for dry marginal areas Later a Mwitemania bean (GLP x92) was identified adapted to various environments A further two cultivars New Mwezi Moja (GLP x1127a) and Red Haricot (GLP 585) were released later to make a total of 6 varieties

Beans are marketed through two separate channels local outdoor markets where most beans for home consumption are sold and the National Cereals and Produce Board (NCPB) (Njuguna *et al* 1981) In Bosongo (Kisii) Murang a and Meru farmers prefer selling beans to local vendors where they report better prices than in NCPB but when local markets are in glut prices are low and most farmers sell to NCPB In local markets prices vary among cultivars (Muthamia *et al* 1990) At the time of the survey beans were a scheduled crop covered by the Produce Marketing Act which restricts produce movement and imposes price controls for purchases by the NCPB The sale of surpluses to the NCPB is compulsory (Njuguna *et al* 1981)

Many Kenyans prefer beans to other pulses (Kenya Farmer 1983) In Kisii and Murang a Rose Coco was most preferred due to fast cooking and having good gravy In Meru Gakumu and Rose Coco were preferred for similar reasons (Muthamia *et al* 1990) Little is known about the popularity of the Grain Legume Project s released cultivars among consumers and their marketing across the different agro-ecological zones within the country Information on the extent of distribution of these cultivars their acceptability and relative popularity in a wide range of retail markets throughout the country will provide useful feedback to the research development of any future cultivars

The objectives of the survey were to determine

1 the distribution and quantity of bean cultivars sold in consumer retail markets across the country paying particular attention to those released by GLP

2 major sources of production of beans sold in consumer retail markets and

3 relative consumer preferences among bean cultivars and the relative competitive position between beans and the basic food items complementary and competitive in consumption

DATA SOURCES AND RESEARCH METHODS

Bean growing districts in Kenya were identified by Gitu *et al* (1989) and 21 consumer retail markets located in major trading centres were selected to be visited once during January to April 1992 The markets were Embu Meru Nanyuki Murang a Kirinyaga (Kutus) Machakos Wundanyi Mombasa Loitokitok Karatina Nyeri Kiambu (Limuru) Nairobi Thika Nakuru Eldoret Busia Bungoma Kakamega Kapenguria and Kitale

Dry bean retailers were asked the local names the price/kg the quantity offered for sale and the production source of each cultivar Researchers also estimated the quantities of each bean cultivar at each market Information on the prices of competitive and complementary food items was obtained from the retailers dealing with them at each market

Bean samples (250 g) of each cultivar were purchased for later identification by name grain size and colour and supplied to the breeder at NHRC/Thika for further characterization The data were analysed using descriptive methods (SPSS) and presented in tabular form

RESULTS AND DISCUSSION

The bean cultivars and their quantities price/kg and production sources are shown in Appendix 1 The cultivar Muhiki (GLP 2) a Rose Coco type was found in all 21 markets surveyed Muhiki Mwitemania Canadian Wonder and Wairimu were offered for sale in quantities in that order in Nairobi Kirinyaga (Kutus) Thika Nyeri Kiambu (Limuru) and Nakuru In Eldoret Kakamega Karatina Machakos and Embu there was more Wairimu than Canadian Wonder whereas in Murang a there was more Canadian Wonder than Mwitemania Mwitemania was absent from Busia Bungoma Kakamega Kapenguria (West Pokot) and Kitale (Trans Nzoia) and Wairimu was absent from Nakuru Busia Mombasa Nanyuki and Meru

Similar findings are reported (Muthamia *et al* 1990) from three districts (Meru Kisii and Murang a) where Rose Coco (GLP 2) was the most common variety followed by Canadian Wonder Mwitemania and Red Haricot but Red Haricot was said to be almost phased out in Meru

Table 1(a) Numbers of bean vendors numbers of bean cultivars bean supplies and prices of beans maize rice and beef at selected retail markets in Kenya January April 1992

Markets	No of vendors	No of cultivars	Bean supply (kg)	Prices (Ksh) Beans	Maize	Rice	Beef
Embu	47	9	1914	6 50	4 50	20 00	35 00
Meru	55	5	3157	6 20	5 00	n f	35 00
Nanyuki	75	8	2105	8 80	5 00	16 00	25 00
Murang a	57	7	2201	7 90	5 50	14 00	35 00
Kutus	43	5	1729	7 80	5 50	10 00	35 00
Machakos	45	14	1542	9 90	5 00	17 00	40 00
Wundanyi	30	7	356	14 00	6 00	18 00	34 00
Mombasa	28	3	6492	10 30	7 00	20 50	45 00
Loitokitok	5	3	11250	5 00	5 00	15 00	15 00
Karatina	150	9	7659	9 70	5 00	18 50	35 00
Nyeri	80	6	6399	9 70	5 00	n f	20 00
Limuru	60	7	1437	10 30	5 00	20 00	40 00
Nairobi	75	8	24566	11 10	6 00	11 00	40 00
Thika	60	9	84105	8 20	5 50	18 00	40 00
Nakuru	67	8	1548	12 10	5 00	18 00	40 00
Eldoret	243	8	38395	12 40	4 50	24 00	35 00
Busia	76	3	1511	13 30	7 00	24 00	40 00
Bungoma	72	4	3215	10 50	6 00	20 00	40 00
Kakamega	94	8	5013	12 10	5 50	20 00	40 00
Kapenguria	36	5	1152	10 00	5 00	20 00	35 00
Kitale	79	4	8926	10 00	5 00	20 00	40 00
Mean	70	6 7		5 30	18 10		35 40

n f = not found

The number of cultivars at each market varied from 3 (Mombasa Busia and Loitokitok) to 14 (Machakos) (Table 1a) Quantities by market varied from 84 1 t (Thika) to 356 kg (Wundanyi) Bean grain prices were lowest in Loitokitok (Ksh 5/kg) and highest in Wundanyi (Ksh 14/kg) except for a few cultivars at a few markets that sold for Ksh 15 20/kg

Of the complementary food items (maize rice) whole maize kernels were on sale in all 21 markets and rice in all but two The mean price of rice was three times that of maize The mean prices of other legumes (competitive food items) ranged from Ksh 17 10 to 23 30 (Table 1b) and the mean price of common cuts of beef with bones was Ksh 35 40

Table 1(b) Prices of beans and other legumes at selected retail markets in Kenya January April 1992

Market	Beans	Cow peas	Ground nuts	Garden peas	Pigeon peas	Dol ichos	Green gram
Embu	6 50	10 00	n f	n f	12 50	14 00	17 50
Meru	6 20	12 00	n f	15 00	11 00	14 00	15 00
Nanyuki	8 80	20 00	25 00	15 00	19 00	20 00	20 00
Murang a	7 90	15 00	n f	n f	15 00	17 50	17 50
Kutus	7 80	10 00	n f	17 50	15 00	17 50	14 00
Machakos	9 90	20 00	n f	20 00	12 50	n f	20 00
Wundanyi	14 00	20 00	26 00	n f	14 00	n f	24 00
Mombasa	10 30	16 00	28 00	n f	14 00	20 00	n f
Loitokitok	5 00	n f	n f	n f	n f	n f	n f
Karatina	9 70	12 50	n f	20 00	15 00	20 00	15 00
Nyeri	9 70	20 00	19 00	20 00	20 00	20 00	20 00
Limuru	10 30	20 00	25 00	30 00	20 00	20 00	20 00
Nairobi	11 10	20 00	20 00	20 00	17 50	17 50	24 00
Thika	8 20	15 00	n f	14 00	14 25	20 00	18 00
Nakuru	12 10	27 50	20 00	30 00	20 00	30 00	20 00
Eldoret	12 40	20 00	24 00	30 00	30 00	30 00	25 00
Busia	13 30	30 00	24 00	n f	n f	n f	30 00
Bungoma	10 50	20 00	20 00	16 00	20 00	20 00	16 00
Kakamega	12 10	30 00	25 00	40 00	n f	n f	25 00
Kapenguria	10 00	40 00	23 00	20 00	n f	n f	20 00
Kitale	10 00	40 00	24 00	25 00	20 00	25 00	20 00
Mean		20 90	23 30	22 20	17 10	20 40	20 10

n f = not found

The numbers of vendors selling beans ranged from 243 (Eldoret) to 28 (Kongowea market Mombasa) but there were five in Loitokitok (Entarara market) who were buying any quantities that were offered by the farming community of that area These were found bagging and selling beans to other traders These bean vendors reported that the season was bad for all crops in the area and that not all farmers had finished harvesting their beans The survey team found farmers shelling beans (Mwitemania) in several places as they travelled towards Taita Taveta

Table 2 Bean supplies grain characteristics and prices at selected retail markets in Kenya January April 1992

Cultivar	Frequency[1]	Supply (kg/market)	Size[2]	Grain colour	Grain pattern	Price/kg[3]
Muhiki	21	6381	M	Red	Mottled	10 10
Canadian Wonder	18	945	M	Red	Solid	10 10
Mwitemania	16	1968	S	White	Spotted	8 40
Wairimu	15	1509	S	Red	Solid	9 70
Gathiga Ndune	13	253	S	Pink	Stripes	10 30
Kirinyaga	7	377	M	Pink	Stripes	10 90
Gathiga	6	166	S	White	Stripes	8 80
Mwezi Moja	5	138	M	Purple	Spotted	10 90
Gikara	4	293	M	White	Stripes	10 30
Githiga	3	12	M	White	Stripes	6 70
Kariuki	3	14	S	Pink	Stripes	10 00
Mbumbu	3	4	L	White	Solid	16 70
Itulenge	3	13	M	White	Stripes	11 30
Katiringi (1)	2	262				
Yellow Beans	2	24	S	Yellow	Solid	13 50
Alulu	2	95	M	Cream	Stripes	12 80
Gatumu	1	100	S	White	Spotted	10 00
Rosebell	1	40	S	Purple	Mottled	15 00
Mwitemania wa Nyamwathi	1	20	S	White	Stripes	8 50
Mitariki	1	13				
Rose Coco (2)	1	10	M	Purple	Mottled	10 00
Rose Coco (1)	1	10	L	Pink	Stripes	7 50
Gathika	1	6	S	Green	Solid	10 00
Ngoco	1	5	M	White	Stripes	10 00
Kaboro	1	5	S	White	Solid	15 00
Kiraruca	1	4	L	White	Stripes	10 00
Mweri Umwe	1	4	M	White	Stripes	15 00
Loan ya Ngiringaca	1	4	L	Purple	Solid	7 00
Rose Coco (3)	1	1	S	Maroon	Solid	10 00

number of markets in which the cultivar is found [b] S M and L indicates small medium and large grain size respectively weighted average price (Ksh /kg) across markets (Ksh 30 00 = 1 US$)

Bean grain sizes were predominantly small and medium (Table 2) but there were observations that the weather could have reduced the grain sizes of most cultivars Only four cultivars had large grains but their frequency of occurrence (once or thrice) and supply (4 10 kg) were small The most prevalent grain colour was white (11 cultivars) followed by pink and purple (4 cultivars each) red (3 cultivars) green maroon yellow and cream (one cultivar each) The most prevalent pattern was striped (13 cultivars) followed by solid (8 cultivars) and mottled and spotted (3 cultivars each) The most common colour pattern combination was white stripes (8 cultivars) followed by pink stripes (4 cultivars) white spotted (2 cultivars) purple mottled (2 cultivars) red mottled purple spotted and cream stripes one cultivar each)

Table 3 Production sources of bean cultivars found at selected retail markets in Kenya January April 1992

Provinces	Districts	Cultivars
Eastern	Embu	Muhiki Mwitemania Gathiga Ndune Canadian Wonder Wairimu Loan ya Ngirigaca Githiga Gathiga Kirinyaga & Mwitemania wa Nyamwathi
	Meru	Muhiki Mwitemania Gathiga Ndune Canadian Wonder Githiga Gathiga Kariuki Mwezi Moja & Mbumbu
	Machakos	Muhiki Mwitemania Gathiga Ndune Canadian Wonder Wairimu Mwezi Moja, Gatumu Katiringi (1) Mitariki Gikara Gathika Ngoco & Itulenge
Central	Murang a	Muhiki Mwitemania Canadian Wonder Wairimu Githiga & Rose coco (1)
	Kirinyaga	Muhiki Mwitemania Gathiga Ndune Canadian Wonder & Wairimu
	Nyeri	Muhiki Canadian Wonder Wairimu Gathiga Kirinyaga Kariuki & Mweri Umwe
	Nyandarua	Kariuki & Mbumbu
	Kiambu	Mwitemania & Kiraruca
Rift Valley	Nakuru	Muhiki Mwitemania Canadian Wonder Wairimu & Kaboro
	Trans Nzoia	Muhiki Canadian Wonder Wairimu Kirinyaga & Rosebell
	Nandi	Gathiga Kirinyaga & Mwezi Moja
	Kajiado	Muhiki and Mwitemania
	Laikipia	Rose Coco (2)
	Elgeyo Marakwet	Canadian Wonder
Western	Kakamega	Muhiki Wairimu Kirinyaga Gikara Yellow Beans & Alulu
	Bungoma	Muhiki Wairimu Kirinyaga & Itulenge
	Busia	Canadian Wonder
Nyanza	Kisumu	Yellow Beans
Non Kenyan	Tanzania	Muhiki Mwitemania Gathiga Ndune Wairimu Mwezi Moja & Rose Coco (3)
	Uganda	Muhiki Canadian Wonder & Gathiga Ndune

Most bean cultivars were produced in the Eastern Province followed by Central Rift Valley Western and Nyanza Provinces (Table 3) The beans found at Wundanyi market were said to be bought at Taveta market which is a border town between Kenya and Tanzania The bean vendors at Wundanyi said that Taita Taveta District produces beans but because of the bad season most of the beans had come from Tanzania Busia, another border town (between Kenya and Uganda) had beans the vendors said had come from Uganda

CONCLUSIONS

The most widely distributed cultivars were Muhiki (21 markets) Canadian Wonder (18) Mwitemania (16) Wairimu (15) and Gathiga Ndune (13) Muhiki (average of 6 4 t/market) Mwitemania (1 9 t) Wairimu (1 5 t) and Canadian Wonder (0 9 t) were most frequently on sale These cultivars were released by the GLP in the late seventies

The major sources of production of beans were districts in Eastern Central Rift Valley Western and Nyanza provinces in that order Rose Coco types were the most preferred

Beans were present in all the markets surveyed while some competitive legumes were missing from some markets Maize a complementary food item to beans was also present at all the markets surveyed Dry beans are widely accepted by consumers of different communities of Kenya as evidenced by their presence in every market surveyed

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Appendıx 1 Bean cultıvars and pnces and productıon sources of beans ın selected retaıl markets ın Kenya January Apnl 1992

Market	Cultıvar	Supply (kg)	Cost/kg (Ksh)	Productıon sources
Embu	Muhıkı (GLP 2)	1295	7	Gachoka (Embu)
	Mwıtemanıa	450	5	Gachoka
	Waınmu	55	6	Mbetı
	Gathıga Ndune	30	7	Gachoka
	Gathıga	30	6	Gachoka
	Canadıan Wonder	30	7	Mbetı
	Gıthıga	10	6	Gachoka
	Kırınyaga (GLP 764)	10	6	Gachoka
	Loan ya Ngıngaca	4	7	Runyenjes
Meru	Mwıtemanıa	1760	5	Munıthu (Meru)
	Muhıkı	1260	7	Gaıtıthura
	Gathıga Ndune	105	6	Munıthu
	Gathıga	25	7	Gaıtıthura
	Gıthıga	7	6	Ruırı
Nanyukı	Muhıkı	1475	10	Gaıtıthura (Meru)
	Mwıtemanıa	345	10	Munıthu
	Gathıga Ndune	210	10	Munıthu
	Canadıan Wonder	35	10	Gaıtıthura
	Mwezı Moja	15	15	Gaıtıthura
	Kanukı	13	10	Nyahururu (Laıkıpıa/Nyandarua)
	Rose Coco 2	10	10	Mukıma (Laıkıpıa)
	Mbumbu (Noe)	2	20	Gaıtuthura (Meru)
Murang a	Muhıkı	1049	8	Kıgumo (Murang a)
	Canadıan Wonder	910	9	Kıgumo
	Mwıtemanıa	426	7	Kıgumo
	Waınmu	166	8	Kıgumo
	Gıthıga	20	7	Kıgumo
	Rose Coco (1)	10	7	Kıgumo
Kutus	Muhıkı	1084	8	Mwea (Kırınyaga)
	Mwıtemanıa	310	7	Kutus
	Canadıan Wonder	200	8	Gıchugu
	Waınmu	85	8	Ndıa
	Gathıga Ndune	50	8	Mwea

Appendix 1 (continued)

Market	Cultivar	Supply (kg)	Cost/kg (Ksh)	Production sources
Machakos	Muhiki	750	10	Mua hills (Machakos)
	Mwitemania	510	9	
	Gatumu	100	10	
	Gathiga Ndune	55	10	Masii (Machakos)
	Katiringi (1)	54	10	
	Gikara	25	10	Mua hills
	Mitariki (2)	13	10	Mua hills
	Wairimu	10	10	Iveti (Machakos)
	Mwezi Moja	10	10	Iveti
	Gathika	6	10	Masii
	Ngoco	5	10	Mua hills
	Itulenge	2	10	Iveti
	Canadian Wonder	1	10	Mua hills
	Rose Coco (3)	1	10	Tanzania & Wundanyi
Wundanyi	Muhiki	190	14	Tanzania
	Canadian Wonder	100	14	
	Mwitemania	30	14	
	Wairimu	15	14	
	Mwezi Moja	13	14	
	Gathiga Ndune	8	14	
Mombasa	Muhiki	3895	11	Kitale Nakuru Gaitithura & Entarara
	Mwitemania	1907	9	Entarara Gaitithura & Tanzania
	Gathiga Ndune	690	11	Meru
Loitokitok	Mwitemania	5400	5	Entarara
	Muhiki	5400	5	
	Mwezi Moja	450	4	
Karatina	Muhiki	4230	10	Mwea Mathira and Ndia
	Mwitemania	1620	8	
	Wairimu	1110	10	Mwea Mathira Ndia & Nyahururu
	Canadian Wonder	405	10	Mwea Mathira & Ndia
	Gathiga Ndune	200	10	Ndia
	Kirinyaga	50	15	Mathira & Ndia
	Kariuki	20	10	Nyahururu
	Mwitemania wa Nyamathi	20	8 50	Mbeti
	Mweri Umwe	4	15	Mathira
Nyeri	Muhiki	4035	10	Endarasha (Nyeri) & Meru
	Mwitemania	1449	8	Meru
	Gathiga Ndune	605	10	
	Canadian Wonder	280	10	Endarasha
	Wairimu	20	10	Tetu (Nyeri)
	Kariuki	10	10	Mathira

Appendix 1 (continued)

Market	Cultivar	Supply (kg)	Cost/kg (Ksh)	Production sources
Limuru	Muhiki	798	11	Nakuru Ndeiya (Kiambu)
	Mwitemania	524	10	Ndeiya Kigumo & Gaitithura
	Gathiga	90	11	Mathira
	Canadian Wonder	15	10	Nakuru
	Mbumbu	4	10	Olkalou
	Kiraruca	4	10	Ndeiya
	Wairimu	2	10	Mua hills
Nairobi	Muhiki	14101	12	Gachoka
	Mwitemania	5580	9	Kigumo
	Canadian Wonder	2475	12	Gaitithura
	Wairimu	1260	12	Gachoka
	Gathiga Ndune	510	12	Gaitithura
	Gathiga	300	9	Munithu
	Mwezi Moja	200	11	Mua hills
	Gikara	140	11	Mua hills & Nakuru
Thika	Muhiki	64890	9	Mua hills & Gaitithura
	Mwitemania	10755	7	
	Canadian Wonder	3250	9	Nakuru Mua hills & Uasin Gishu
	Wairimu	3520	6	Nakuru & Kitale
	Gikara	1000	10	Mua hills Kiambu
	Gathiga Ndune	700	10	Gaitithura
	Katiringi (1)	470	7	Gachoka & Kigumo
	Gathiga	270	8	Gaitithura
	Mwezi Moja	250	7	Mua hills
Nakuru	Muhiki	1113	10	Nakuru
	Mwitemania	402	10	
	Gathiga Ndune	9	12	Mua hills
	Gathika	7	10	Kakamega
	Mbumbu	7	20	Olkalou
	Canadian Wonder	5	10	Nakuru
	Kaboro	5	15	Nakuru
Eldoret	Wairimu	14735	11	Kakamega Kitale & Uasin Gishu
	Muhiki	13569	11	Kakamega
	Canadian Wonder	8160	11	Elgeyo Marakwet
	Kirinyaga	1582	15	
	Gathiga	283	11	Elgeyo Marakwet Trans Nzoia
	Alulu	30	13	Kakamega
	Mwitemania	18	11	Gaitithura
	Yellow Beans	18	12	Kisumu
Busia	Muhiki	1313	14	Kitale & Uganda
	Gathiga Ndune	120	13	Uganda
	Canadian Wonder	78	13	Uganda

Appendix 1 (continued)

Market	Cultivar	Supply (kg)	Cost/kg (Ksh)	Production sources
Bungoma	Muhiki	2230	9	Bungoma & Chwelle hills
	Wairimu	575	10	
	Kirinyaga	380	9	
	Itulenge	30	14	Bungoma
Kakamega	Muhiki	2775	10	Kakamega & Kitale
	Wairimu	1393	10	
	Canadian Wonder	364	11	Mt Elgon
	Kirinyaga	251	11	Kakamega
	Alulu	160	12	
	Rosebell	40	15	Kitale & Kakamega
	Yellow Beans	30	15	Kakamega
Kapenguria	Muhiki	586	10	Trans Nzoia & West Pokot
	Canadian Wonder	386	10	
	Kirinyaga	99	10	West Pokot
	Wairimu	75	10	
	Itulenge	7	10	
Kitale	Muhiki	7964	15	Trans Nzoia & Bungoma
	Wairimu	622	10	
	Kirinyaga	266	10	Kitale
	Canadian Wonder	74	10	

DISSEMINATION STRATEGIES FOR IMPROVED BEAN CULTIVARS AND MANAGEMENT PRACTICES IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

Aberra Deressa

Institute of Agricultural Research, Nazreth, Ethiopia

ABSTRACT

The central Rift Valley of Ethiopia is characterized by erratic rainfall heavy weed infestation poor soil fertility and soil erosion Common bean (*Phaseolus vulgaris*) has long been an important food and cash crop for millions of small farmers in this area The crop is grown in traditional agricultural production systems and usually produces poor grain yields (5 7 q/ha) while improved varieties and good management practices produce over 20 q grain/ha Currently improved haricot bean cultivars and their management practices are available at research centres but these technologies are not widely used by farmers partly due to inadequate publicity and demonstration activities and lack of training of extension staff To overcome such poor adoption of technologies and to enhance food production a National and Zonal Research and Extension Liaison Committee (RELC) was set up and a Research and Extension Coordination Division and an Extension Task Force have been formed by the Institute of Agricultural Research (IAR) In addition demonstration trials involving IAR Ministry of Agriculture (MOA) and farmers were conducted on farmers fields in the central Rift Valley of Ethiopia Since 1986 several improved haricot bean varieties have been demonstrated at 71 locations The results of demonstration trials indicate that improved varieties and management practices are superior to traditional management practices Over 40% yield increase was obtained by the improved management system Extension staff the vehicles for technology transfer have also been trained Such programmes promote interaction between researchers and extension staff and facilitate technology transfer

INTRODUCTION

Most areas of the central Rift Valley of Ethiopia receive bimodal rainfall and are drought prone Mean annual rainfall and temperature for Melkassa for 1992 and 15 year (1977 1992) averages are summarised in Table 1 The FAO/UNESCO soil map of the world (1973) shows that entisols and inseptisols are the dominant soil types Texturally the soils are either clay loam loam or sandy loam and in some areas clay Both water and wind erosion are major problems of the area

Common bean (*Phaseolus vulgaris*) has long been an important food and cash crop for millions of small farmers in the region The national area under haricot bean production is currently estimated to be over 300 thousand hectares In the central Rift Valley the area under haricot bean production in the 1990/1991 and 1991/1992 cropping seasons accounted for 14 214 and 16 579 ha, respectively (MOA Office Eastern Shoa)

Farmers grow the crop in traditional agricultural production systems and usually obtain low grain yields (5 7 q/ha) Currently improved haricot bean cultivars and management practices are available at research centres and produce over 20 q/ha of grain A wide gap therefore exists between what researchers have achieved on experiment stations and average farmers yields This wide gap exists partly due to the lack of strong linkages among researchers extension staff and farmers thereby delaying the adoption of improved technology

Table 1 Rainfall and maximum and minimum temperatures for Melkassa (longitude 39°33 E latitude 8°24'N altitude 1550 masl) in 1992 and 15 years from 1977 to 1991

	Rainfall (mm)		Temperatures (C) Minimum		Maximum	
Month	1992	1977 1991	1992	1977 1991	1992	1977 1991
January	5 5	14 3	12 7	12 1	27 4	27 6
February	11 0	34 9	14 7	14 1	28 3	28 5
March	0 0	47 3	18 0	15 5	31 4	29 9
April	42 3	48 8	16 2	15 7	31 4	29 8
May	10 5	59 6	15 4	15 8	31 9	30 7
June	95 8	61 4	16 1	16 3	29 8	30 0
July	143 8	169 4	17 3	15 3	34 3	26 5
August	238 1	182 7	13 2	15 6	28 1	26 1
September	96 8	86 4	12 7	14 6	28 1	27 3
October	47 2	34 9	11 9	11 8	29 3	28 6
November	2 6	9 1	13 2	11 0	29 6	28 3
December	57 6	7 8	13 1	11 1	27 4	27 3
Total	751 2	756 6				
Mean			14 5	14 1	29 8	28 4

To overcome the poor adoption of improved technology and to enhance food production national and a centre based Research and Extension Liaison Committee (RELC) and Research and Extension Coordination Division have been established and Extension Task Forces have been formed at major research centres of the Institute of Agricultural Research (IAR) Demonstration trials involving IAR MOA staff and farmers have been conducted on farmer fields in the central Rift Valley A 20-40% yield increase over farmers practice has been achieved by improved varieties with good management practices

CURRENT RESEARCH RECOMMENDATIONS

Three haricot bean cultivars are currently recommended Mexican 142 and Awash 1 both white pea beans and Roba 1 Recommended management practices are to sow in late June at a seed rate of 100 kg/ha and weed 2 3 weeks after emergence With these practices yields of 20 22 q/ha may be obtained

PROBLEMS IN ADOPTION OF TECHNOLOGIES

It is essential for production inputs and better cultural practices to reach the farmer if productivity is to increase In spite of the availability of new production technologies at research centres a wide gap exists between research yields and yields obtained by farmers indicating poor adoption of available technology This is due to many reasons including

inadequate publicity and demonstration of available technology to users
lack of training of extension staff
inappropriate recommendations
unavailability of inputs to farmers when needed
absence of strong linkages among researchers extension staff and farmers and
poor feedback of results and problems to research units

CURRENT STRATEGIES FOR SOLVING POOR ADOPTION

Some steps have been taken to overcome the poor adoption and enhance food self sufficiency including

Formation of Research and Extension Linkage Committee

The absence of an adequate working relationship between research and extension has been recognized and remains an issue of great concern In the past unsuccessful attempts have been made to link research and extension Recently a national research centre based Research and Extension Liaison Committee (RELC) has been established in Eastern Shoa Administrative Region The committee composed of senior IAR and MOA staff meets 3-4 times/year to review annual extension recommendations and zonal research programmes identify zonal priority problems for researchers and determine MOA staff training needs

Research and Extension Coordination Division

A Research and Extension Coordination Division was introduced at Nazret Research Center in April 1986 The division is expected to provide efficient and fast diffusion of information through popularization and demonstration of improved crop production technologies in conjunction with extension staff of MOA to organize training for extension staff through field days in collaboration with MOA staff at Awraja or Wereda level and to prepare production guidelines for users

Extension Task Force

An extension task force was formed at Nazret Research Center to encourage researchers to spend at least 25% of their time on extension related activities including training of extension staff visiting farmers fields giving advice and preparing production guidelines

CURRENT ACHIEVEMENTS

Demonstration of improved haricot bean production technologies on farmers' fields

Demonstration of improved haricot bean cultivars and packages of production practices were undertaken in the central Rift Valley Improved management practices (sowing in rows and correct seed rate and time of sowing and weeding) were compared with farmers practices (broadcasting high or low seed rate and late or no weeding)

The improved management plots were laid out by both research and extension staff with farmers participation and the farmers plots were planted by farmers Seeds and technical advice were provided from Melkasa Field days were organized at different growth stages including harvest to demonstrate the differences between the two management practices Development staff researchers and administrative officials also participated in the field days

Demonstrations of the response of the traditional haricot bean cultivar (Mexican 142) to improved management were conducted at 33 locations from 1987 to 1989 Improved management produced better yields than traditional management Mean grain yields across locations were 12 7 14 3 and 14 q/ha in each of the three years under improved management and 7 9 9 and 10 q/ha under farmers practices (Table 2) The mean yield increases from improved management across locations in 1987 1988 and 1989 were 81 44 and 40%

Mexican 142 is widely grown by farmers in the Central Rift Valley The variety was released many years ago and seed quality is deteriorating because of its susceptibility to leaf diseases The disease resistant and good quality haricot bean cultivar Ex Rico 23 (Awash 1) has been identified at Nazret Research Center Demonstrations of the effects of improved management on Awash 1 were conducted at 30 sites in the central Rift Valley from 1990 to 1992 Mean grain yields across locations under improved practices were 14 2 9 5 and 12 3 q/ha during 1990 1991 and 1992 respectively and 11 2 7 and 10 q/ha under farmers management (Table 3) giving increases in yield from improved management of 27 36 and 23% for each of the three years

Table 2 Grain yields (q/ha) of Mexican 142 under farmers and improved practices in demonstration plots in the Central Rift Valley of Ethiopia from 1987 to 1989

Year	Location	Management practice Improved	Farmers	% increment
1987	Dekadi	12	6	98
	Wonji	18	12	52
	Marmarsa	6	4	60
	Boffa	9	7	32
	Dengore	14	8	81
	Jarawayu	22	10	115
	Malimo	16	6	116
	Mekedela	10	6	62
	Bekeli & Grissa	9	5	70
	Mean	12 7	7	81
1988	Yaya & Gmibich	14	9	56
	Keechachule	24	15	60
	Dengore	17	12	42
	Tedecha Hadecha	15	11	37
	Arorecha	18	14	29
	Rado	8	5	60
	Dado	16	12	34
	Mekedela	8	5	60
	Keraro & Shubi	18	13	39
	Wacho & Grissa	8	6	34
	Weyo Gebrael	11	7	58
	Mean	14 3	9 9	44 3
1989	Rado	14	10	40
	Ombole	14	10	40
	Berta	13	9	44
	Awash Melkassa	13	8	62
	Boffa	11	8	38
	Arorecha	14	9	55
	Mukiye	15	10	50
	Afeyela	19	12	58
	Wacho & Grissa	13	8	62
	Gerado fela	10	8	25
	Abossa	22	17	29
	Bulbula	16	9	77
	Hizbawi Bettele	11	7	57
	Mean	14	10	40

Table 3 Grain yields (q/ha) of Awash 1 under farmers and improved practices in demonstration plots in the Central Rift Valley of Ethiopia from 1990 to 1992

Year	Location	Management practice Improved	Farmers	% increment
1990	Boffa 1	15 5	13 0	19
	2	15 0	12 5	20
	Welenchiti	22 0	14 0	57
	Rado	13 8	10 0	38
	Dodo	11 0	6 0	83
	Aneno	15 5	9 5	63
	Weyo Gebrael	13 8	11 3	22
	Abossa	10 0	8 8	14
	Daro	12 5	17 5	
	Gado bicho	20 0	13 0	54
	Honba	17 5	13 8	27
	Debudera	4 4	5 6	
	Mean	14 2	11 2	27
1991	Harget	5 0	50	
	Fechiso	6 0	4 0	50
	Badusa kore	6 4	6 4	0
	Wake tiyo	15 0	7 5	100
	Hati offi	13	8 0	62
	Dibibisa	11 3	8 5	32
	Arorecha	4 5	4 5	0
	Wake tiyo	12 3	9 0	37
	Mean	9 5	7 0	36
1992	Aerba gosa	14	8	75
	Fechiso 1	14	16	
	Fechiso 2	10	11	
	Lodihada	6	8	
	Adulala	12	6	100
	Wake mia	11	8	38
	Dabi	10	15	
	Wachulata	18	9	100
	Odalanga wanga	15	12	25
	Welenchiti	13	15	
	Mean	12 3	10	23

In the Central Rift Valley haricot bean competes with tef for labour for weeding and in the past has received less priority because of its smaller market price (50 60 birr/q) relative to tef (180 200 birr/q) Since haricot beans are an export crop government has recently increased the bean market price to

135 birr/q in an attempt to encourage increased bean production

Training

Extension staff need training and their knowledge updating to provide the essential link in technology transfer Based on the timing of farmers activities four training programmes are being organized at three month intervals each year for district extension subject matter specialists and extension supervisors of the Central Agricultural Development Zone of MOAT (Table 4) The training has brought researchers and extension staff together for discussion and exchange of views It also helped researchers to inform extension staff about available research results and obtain feedback on farmers problems The training has created a linkage between researchers and extension agents for fast dissemination of new findings and initiated a two way exchange of views

Table 4 Training courses conducted since 1986

Year	No of training courses	No of participants
1986	4	108
1987	4	200
1988	3	180
1989	2	150
1990	2	60
1991	2	45
1992	1	45
Totals	18	688

Provision of improved seed

Since 1986 about 100 q of haricot bean cultivars have been provided to farmers around Nazret Research Center either freely or by sale in order to popularize bean production and disseminate improved seeds

CONCLUSIONS

Participation of research center based IAR/MOA Senior Staff in the RELC the joint conduct of demonstrations by researchers extension staff and farmers the regular in service training of extension staff and organization of farmers field days have been very important for the dissemination of improved haricot bean cultivars and management practices and rapid feedback of problems faced by farmers and extension staff

Constraints that need immediate attention are

1 There is no ox-drawn row planter suitable for haricot bean and farmers are slow to adopt row planting

2 Planting haricot bean by ox plough at recommended spacing is labour intensive and difficult

3 Farmers have been unwilling to weed haricot bean because of poor returns

4 Farmers have input and labour problems

Future outlook

1 Continue demonstration of improved management practices at new sites

2 Continue in service training for extension staff

3 Study methods of seed dissemination

4 Prepare production guidelines for newly released varieties

5 Study technology adoption in collaboration with agricultural economists

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TECHNOLOGY TRANSFER HARICOT BEAN EXPERIENCE IN THE SOUTHERN ZONE OF ETHIOPIA

Getachew Kassaye

Institute of Agricultural Research, Awassa Ethiopia

ABSTRACT

Haricot bean variety demonstrations have been conducted on farmers fields in different locations within the Southern Zone for the past six years Farmers have readily accepted improved varieties and management practices In 1989 and 1990 a dissemination program was launched at specific demonstration sites to increase the seeds of haricot bean and examine the adaptability of new technology

INTRODUCTION

Most farmers in the Southern Zone of Ethiopia practise subsistence farming with average agricultural land per household of 0 7 ha (Getahun Degu and Yeshi Chiche 1989) Bean is produced on small farms often in association with maize coffee enset and fruit trees The total area under pulses is estimated to be 27 528 ha of which haricot bean covers 7 560 ha (27 5%) (MOA 1984) At present the production of haricot bean is concentrated in Shebedino Dale Aleta Wondo and Bensa Districts in Sidamo Region and Wolaita Gofa Arba Minch Zuria and Boreda Districts in North Omo Region

Beans are produced both for home consumption and generation of income The major cultivar grown is the local land race (Red Wolaita) with an average grain yield of 600 kg/ha (Getachew Kassaye 1990) In haricot bean variety verification trials conducted in Awassa Ex Rico 23 A 176 15R-42 and B 933 yielded better than the local cultivar (IAR 1986 1989 Getahun Degu and Yeshi Chiche 1989) These cultivars were also demonstrated under improved and traditional farming methods and the results indicated that farmers acceptance of the improved technology (population method of planting and weeding) has been high

Along with technology popularization each research centre provides breeder seeds to the Ethiopian Seed Corporation (ESC) for multiplication and dissemination to user agencies including MOA and MCTD/SF but supply of improved seeds to farmers has not satisfied peak demands Research centres have devised mechanisms under the Farming System and Research Extension Divisions to alleviate this problem This paper will highlight the mechanism of technology transfer and study of adoption rates

MECHANISMS OF TECHNOLOGY TRANSFER

On farm research

IAR outreach programs started in 1984/85 with the aim of demonstrating recommendations from research stations to the farming community On farm verification is critical to ensure that new varieties and technologies are acceptable to farmers before they are recommended and distributed The OFR Program at Awassa has made important contributions to agricultural research and development in the Southern Zone Results of on farm trials for haricot bean are as follows

On farm verification trial for haricot bean varieties This trial was initiated in 1986/87 at five sites in the Sidamo farming system zone The main objective of the trials was to compare the performances of four improved varieties and a local check under farmers management (Table 1)

Table 1 Yields (kg/ha) of haricot bean varieties in Woinadega and Kola in 1986/87 and 1987/88

		1986/87		1987/88	
Varieties	Seed colour	Woinadega (3 sites)	Kola (2 sites)	Woinadega (4 sites)	Kola (1 site)
Red Wolaita	Red	1306	1460	2402	1179
B 933	White	1277	1448	2679	2079
15R-42	Brown/yellow	1602	1270	3124	2684
Mexican 142	White	nt	nt	2493	2236
6R 395 08	White	nt	nt	2287	1333
FF 00016 FS	White	1085	1199	nt	nt
15R 52	Black	1122	1256	nt	nt

nt = not tested source Getahun Dege and Yeshi Chiche (1989)

Among the white seeded varieties Mexican 142 is preferred for consumption and marketing because of its bright white colour and short cooking time The improved white variety B 933 was also accepted by farmers for consumption because of its suitability for *nefro* (cooked beans) and its yield (Table 2)

Table 2 Ranking of varieties for some factors determining farmers varietal preferences

	Varieties				
Factors	Local	B 933	15 R 42	Mex 142	6R 395 08
Taste/appearance	2	3	4	1	5
Price	4	2	5	1	2
Yield	5	2	1	3	4
Cooking Time	1	3	4	5	2

Factors are ranked on a scale of 1 5 where 1 = very good and 5 = poor source Getahun Dege and Yeshi Chiche (1989)

In on farm trials at three locations in 1989 the improved cultivars Ex Rico 23 and A 176 out yielded the local check (Table 3) and were released to farmers by the dissemination program

Table 3 Yields (kg/ha) of haricot bean varieties in verification trials at three locations in 1989

	Locations			
Varieties	Areka	Busa	Taramesa	Means
BAT 338 1C	917	883	1189	996
Ex Rico 23	1130	2025	1644	1600
A 176	1154	1465	1557	1392
Diacol Calima	591	995	1078	888
Local	566	1040	1441	1016
Means	872	1282	1382	1179

Source IAR (1989)

Research/extension activities

A number of approaches have been taken to strengthen the link between research and extension such as formation of a Research Extension Linkage Committee (RELC) and Research Task Forces (ETF) These approaches have helped users and researchers by providing immediate solutions and feedback

Demonstration of improved technologies to farmers Improved varieties of haricot bean were demonstrated under traditional and improved crop management at several locations in the Southern Zone in 1986 1987 1988 and 1992 15R-42 Brown Speckled and Ex Rico 23 were superior under improved management and Mexican 142 and 15R 42 produced the best yields under traditional management (Table 4) The consistent superior performance of 15R-42 under both managements would be advantageous to farmers The yields of B 933 were less than the local check due to damage by wild animals and other factors Farmers acceptance of the improved technology has been very high

Table 4 Yields (kg/ha) of improved and local haricot bean varieties under traditional and improved management (means of three years 1986 88 except Ex Rico 23 and A 176 1992 only)

	Management		% increase from improved
Varieties	Improved	Traditional	management
Brown Speckled	1670	500	234
B 933	970	420	137
15R 42	1710	1140	50
Mexican 142	1350	1110	22
Ex Rico 23	1560	870	79
A 176	1380	980	41
Local (Red Wolaita)	1050	810	30
Mean	1384	833	66 2

Source Getachew Kassaye (1990)

Disseminating seeds of improved varieties in extension The distribution of packages of services to enable farmers to take advantage of new technologies is one of the activities of extension This approach helps to assess the impact of research results and will be vital to future research planning as well as in justifying further investment in research The dissemination programme was launched in 1989/90 but it was not possible to carry out the programme in 1991 due to political instability The programme was modified and reinitiated in 1991/92 with the following objectives

to accelerate the dissemination rate and popularize research activities
to help farmers obtain sufficient seeds for sowing in subsequent years
to determine farmers acceptance of Ex Rico 23 (Awash 1) and A 176 (Roba 1)
to determine the adoption rates of Ex Rico 23 and A 176
to determine the adoption rates of different villages and
to determine the diffusion of Ex Rico 23 and A 176 three years after seed distribution

The dissemination process involves three aspects amount of seed distributed number of farmers per village type of cultivars distributed In one dissemination scheme in Sidamo and North Omo Regions farmers obtained yields of 1200 1600 kg/ha from Ex Rico 23 and A 176 (Table 5) confirming the yield advantages of the new varieties over local materials

Table 5 Yields (kg/ha) of improved varieties under farmers management in Sidamo and North Omo in 1992

		Varieties		
Regions	District	Ex Rico 23	A 176	Means
Sidamo	Shebedino	1630	1330	1480
	Dale	1462	1479	1471
	Aleta Wondo	1392	1213	1303
	Bensa	1420	1500	1460
North Omo	Damot Gale	1406	1523	1465
	Boloso	1417	1368	1393
	Kutcha	1225	1289	1257
	Boreda	1420	1490	1455
Means		1422	1399	1411

Average of 10 or 15 farmers/location total of 120 farmers/variety

FUTURE OUTLOOK

The results of demonstrations and dissemination of new technologies must be assessed by a study of adoption rates through extension workers and farmers

Methods for estimating the adoption rate of beans at disseminating sites

One of the recommendations passed at the national workshop held in Addis Ababa from 1 3 October 1990 was to identify research strategies for technology transfer and in particular to assess the impact of research results on bean production It was also suggested that haricot bean researchers have a *responsibility for making* extension more effective and responsive to the needs of the farmers

The following methods will be used to estimate the acceptability of new technologies to farmers in the dissemination sites

a) Questionnaires will be developed and *distributed at each dissemination site* This approach can help researchers to discuss the results of dissemination with farmers in order to obtain their opinions of new technologies

b) The diffusion/adoption process will be studied on an annual basis to present it in terms of the cumulative percentage of farmers making adoption decisions over time *resulting in a characteristic* S shaped curve (Fliegel 1984)

c) Through an acceptability index derived from data on the rate of acceptance of new technologies introduced into an area calculated from farmers participating in the farmer managed bean production and from farmers participating in record keeping The index is the product of the percentage of farmers who adopt the new technology and the percentage of the crop on their farms divided by 100 According to W W Shaner ICTA considers an index of 25 enough to justify the recommendation of a technology (Shaner *et al* 1982)

CONCLUSIONS

It is obviously known that the results of verification have given the necessary feedback to release recommendations for dissemination The recommended packages also have to be popularized to users through *demonstration and brochures* If the packages are accepted then further dissemination or distribution should take place Based on the procedures to achieve such goals adoption studies should be made with the involvement of researchers extension workers and farmers Finally researchers have to participate more in the dissemination of new technologies Their input is of paramount importance in monitoring and evaluating the system of technology transfer

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PRODUCTION AND DISTRIBUTION OF SNAP BEAN SEED IN KENYA

Mercy W Wanjiru

KARI National Horticultural Research Centre, Thika Kenya

ABSTRACT

Although snap beans have become a major foreign exchange earner of the Kenyan agricultural sector farmers are still realizing low yields Studies of snap beans have shown the use of poor quality seed to be one of the major constraints to snap bean production This paper describes the production use and distribution of snap bean seed in Kenya It also tries to identify the constraints that inhibit the use of good quality seed Five registered companies were found to be producing certified snap bean seed there were also individual farmers supplying seed although this was on a smaller scale Seeds of 35 varieties of snap bean are being produced in Kenya but we encountered only five varieties with farmers The total acreage under snap bean seed in 1990/91 was 4 585 acres 60% of which were destined for export Those found involved in distributing seed included snap bean exporting agents retailers parastatals agents of snap bean canning factories and snap bean farmers The price of good quality seed was 30 40% greater than that sold by farmers Some constraints inhibiting the use of good quality seed were high prices unavailability in local kiosks and uncertainty of the quality of certified seed

INTRODUCTION

Seed quality can be a decisive factor in the profit or loss of growers enterprises A farmer sowing poor quality non-certified seed may lose not only the cost of seed but also the whole value of the expected crop due to seed borne diseases and pests poor vigour and plant stand Low quality seed and poor availability have been identified as the principal constraints to the rapid diffusion of new varieties and improvement of crop production in the developing world High quality seeds give high germination rates rapid emergence and vigorous plants

Although snap beans have become a major foreign exchange earner Kenyan farmers are still achieving smaller yields than farmers in other snap bean producing areas in the world Various studies have shown poor quality seed to be one of the major constraints to snap bean production in Kenya An increase in snap bean yields by Kenyan farmers can only be achieved if good quality certified seeds are made available to growers at the right time and place and at reasonable prices The aim of this study is to identify the constraints limiting the use of certified seed and to suggest possible solutions The study is exploratory and preliminary data are gathered in order to shed light on the real nature of the problem

METHODOLOGY

Nine districts have been identified as important snap bean growing areas they include Meru Embu Machakos Muranga Nyeri Kiambu Kirinyaga Kakamega and Bungoma The registered seed companies which produce snap bean seed have also been identified Production distribution and consumption stages of the seed are being studied An informal survey is being conducted to collect the required information At the consumption level snap bean growers in various districts are to be visited and information on the seed type variety source and constraints in seed acquisition is to be sought through interviews and discussions At the production stage information is being sought from registered seed companies and contracted seed growers Information on seed distribution from point of production to consumption level is being sought from traders and other bodies involved in seed distribution Five of the major snap bean seed growing areas and two of the main registered seed companies have already been visited

RESULTS AND DISCUSSION

The following section gives a general indication of the data that has been collected so far

Sources of seed

Sources of seed varied among regions and among farmers within the same region Farmers who were producing snap beans on contract for a particular exporting company were provided with the seed by the company through their buying agents This practice was mainly found in western Kenya and to a lesser extent in central Kenya Farmers who were producing snap beans without a contract arrangement obtained seed from any source depending on preference and availability of seed This was the most common practice in central Kenya

Registered seed companies were the most frequently mentioned source 33 1% of the farmers having bought the seed from them Snap bean exporting companies were also a major source of seed as 24 5% of the farmers said that they had purchased seed from these companies through their agents Other sources of seed were snap bean growers (14 5%) the Horticultural Crops Development Authority (10 1%) and farmers own seed (10 1%) There was also bagged unlabelled seed which originated either from the crop rejected by field inspectors or from snap bean growers who let their crop mature and dry after prices fell below economic levels Only 21% of the farmers interviewed received advice on the best seed to plant

Farmers gave various reasons for their preference of seed source Seeds from some exporting and canning agents was preferred because they were supplying new varieties of snap beans which were high yielding had a lower percentage of rejected pods and consumed less labour for picking Many farmers were relying on neighbouring farmers seed or seed in local shops as it was much cheaper and more readily available than seed from registered seed companies Other farmers were planting their own seed because no costs were incurred

Farmers cited quality availability and price as the main problems with the various snap bean seed sources

Quality Seed quality problems cited by farmers include poor germination percentages off types thick pods with curly tips and low yields The farmers rarely associated seed with the diseases and pests attacking their snap bean crop The sources which were most frequently mentioned as having quality problems were farmers own seed neighbours seed unlabelled seed and some seed lots from registered seed companies

Availability Whereas farmers own and neighbours seed had no availability problems all the certified seed sources (registered seed companies and bean exporting company agents) did Certified seed was not readily available when needed and so farmers resorted to using their own seed neighbours seed or any other seed available from the local kiosks Certified seed was confined mainly to large towns and shopping centres and rarely found in rural areas where farmers are located New varieties were unavailable in shops and could be obtained only from agents of snap bean exporting companies Farmers mainly planted the Monel variety only a few were planting the new varieties HCL and Gloria

Price Farmers found all sources of certified seed highly priced ranging from Ksh 65 to 70 for Monel and from Ksh 345 to 350 for the new varieties The price of certified Monel seed compared to the price of seed bought from snap bean farmers or local shops differed by Ksh 30 35 The higher price of snap bean seed than of other seeds was the main reason for the small plots of land under snap beans Availability of the seed on credit eased the cash constraint imposed by the high prices

Seed production

There are five registered snap bean seed merchants in Kenya These companies produce seed on contract with farmers The company usually provides farmers with seed for bulking on credit Other inputs that may also be provided include fertilizers and pesticides and also field inspectors These costs are later recovered when the farmer delivers his crop to the company s depot or at a specified collection centre Companies paid farmers at different rates ranging from Ksh 14 to 24 per kg delivered

The major snap bean seed producing area is Loitokitok Other areas where seed is produced include Naivasha Kitale Isiolo Machakos Meru Rumuruti Mwea and Narok The total number of varieties of snap bean seed being produced in Kenya is 35 with each company producing different varieties (Appendix 1) Some companies were importing breeders seed from Europe and America and bulking it locally while the rest recycled seed several times before changing it The total acreage contracted by the companies for the purpose of seed bulking in the 1990/91 season was 1 855 ha about 40% of it being destined for the export market

Thirty percent of farmers sold seed to other farmers These farmers left their crop to mature and produce seed This mainly happened when snap bean prices fell thus making further picking uneconomic Some farmers contracted to produce seed for seed companies sold it to retailers This was usually seed that had been rejected by field inspectors due to disease or inadequate isolation from other bean varieties This seed was usually selected but rarely dressed by the farmer who was selling it Of the farmers who planted their own seed 73% carried out a selection procedure while 55% of them dressed their seed with a protective fungicide

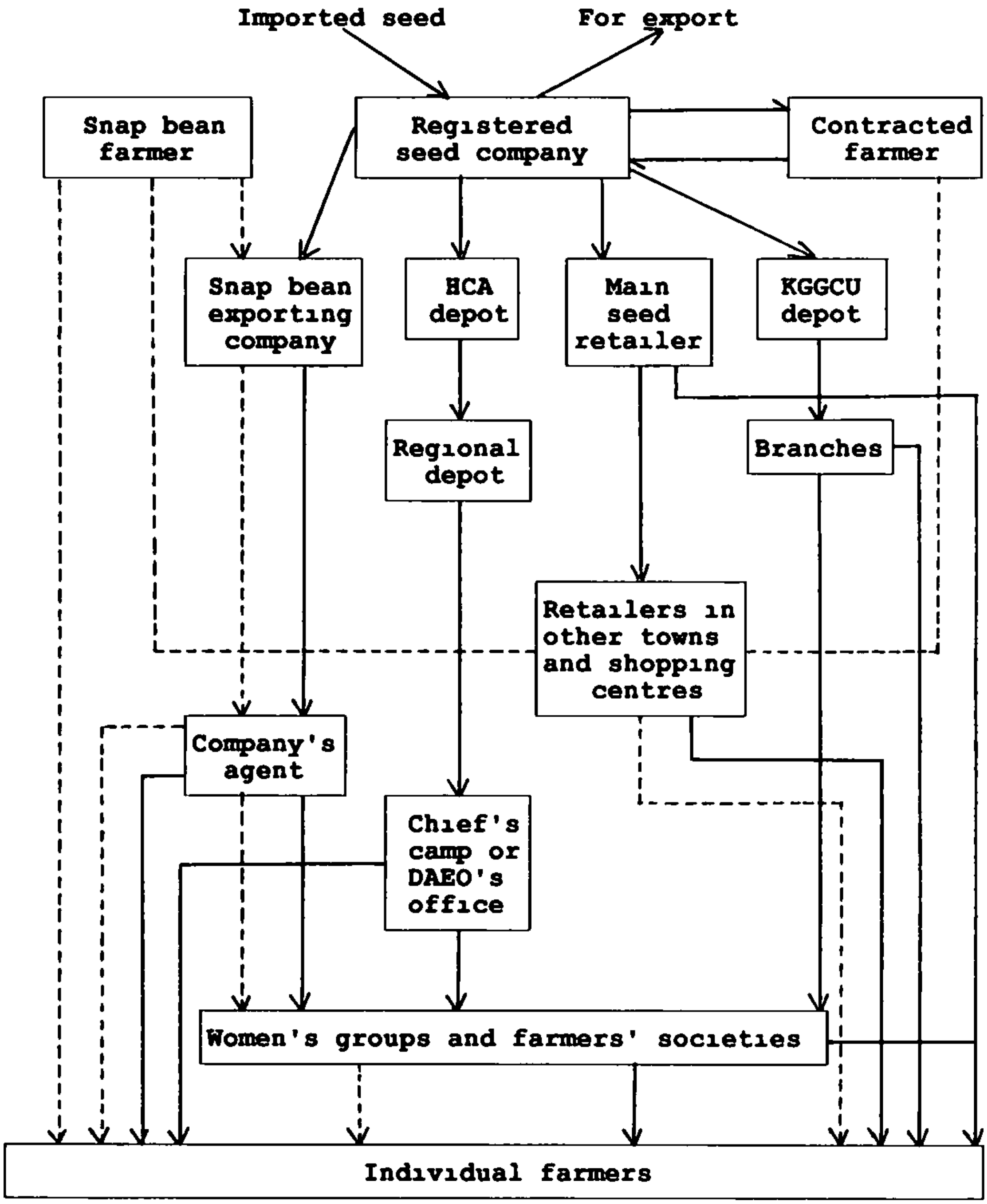
Snap bean seed distribution channels

These are all the operations involved in moving snap bean seed from point of production to place of consumption in this case the farmer (Figure 1) Various individuals and institutions are involved in channeling the seed from producers to consumers and various distribution methods were encountered

Contract arrangements Some snap bean exporting companies were in a contract arrangement with growers whereby the company delivered the seed to farmers on credit through their agents The agents provided the seed mainly to women s or any organized farmers group they also provided individual farmers with seed The exporting companies usually bought seed from registered seed companies although some were buying from snap bean farmers and delivering it to farmers Of the farmers interviewed 24 5% were obtaining their seed through this kind of arrangement

Horticultural Crops Development Authority (HCDA) This is a government parastatal involved in the promotion of production and marketing of Kenyan horticultural products This parastatal buys seed from some registered seed companies and distributes it to their selling centres namely divisional agricultural offices or chiefs camps 10 1% of the farmers interviewed said that they bought the seed from HCDA

Figure 1 Snap bean seed dissemination channels



Key certified seed ———— non-certified seed --------

Registered seed companies This was the seed that was planted by most (33 1%) farmers interviewed The two major seed companies packed their seed mainly in two kg packages and to a lesser extent in one kg packages The remaining companies packed their seed in 50 or 90 kg bags The two major registered companies marketed their seed through

(1) wholesalers located in Nairobi these wholesalers in turn sold the seed to retailers in different towns and smaller retailers in the large markets and also to individual farmers and

(2) the Kenya Grain Growers Co-operative Union (KGGCU) whose branches are found in every major town in the country some KGGCU branches in snap bean growing areas did not stock snap bean seeds

Other seed companies sold their produce through snap bean exporting agents HCDA and to individual large scale farms

Snap bean farmers Farmers were also supplying a large number (23 1%) of other farmers with seed They sold the seed at their farms or through local shopkeepers who in turn sold it to other farmers

Retailers Retail shops stocked snap bean seeds from various sources including

1) registered seed companies whose seed is usually packed in one or two well labelled kg packages and

2) contracted snap bean seed growers and other snap bean farmers this seed was neither packaged nor labelled

DISCUSSION

The factors found to be affecting farmers decisions on the type of seed to plant were

1) The price of the seed compared to the price of the produce Most farmers found certified seed too highly priced and uneconomic to use especially during periods when snap beans prices were low

2) Uncertainty on the availability of good quality seed when it is needed and the unavailability of this seed at nearby shopping kiosks

3) Uncertainty on the quality of seed This is usually based on the previous performance of the seed

4) Lack of cash or credit to purchase high quality seed

5) Lack of knowledge of the advantages of planting good quality seed

In order to encourage farmers to plant good quality seed it is important to

1) Increase awareness among farmers of the benefits of using good quality seed This may be achieved by demonstrating the profitability of good quality seed during barazas and field days and by demonstration plots

2) Improve standards of field inspection and certification of quality seed to eliminate uncertainty about the quality of certified seed

3) Increase the availability of quality seed by providing it to local kiosks

4) Improve farmers purchasing power by providing him with credit facilities in the form of seed

5) Reduce the high costs of certified seed to a level that farmers can afford High costs result from poor organization of seed multiplication distribution and storage

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Appendix 1 Varieties of snap bean produced seed companies and areas under seed production 1990 1992

Variety	Producing company	Acreage (ha)	Year
Super	Kenya Highland Co	162	1990/91
Micco		64	
Kaki		283	
Cropper		125	
Content		220	
Bingo		10	
Agora		273	
Bano	"	114	
Blue Royal		130	
Tdf		357	
MT86	Hortitech	8	
Naitec		685	
N90		79	
Red Beauty		64	
Simpson		6	
Solare		8	
Tilla		30	
Vernadon*		107	
Contender		79+	
Green Tec	"	18	1990/91/92
Purple Tec		2	
Strings Bean White		14	
Tech 86		1	
Monel*	East African Seed Co	259	1990 92
Super mishiri*	Kenya Seed Co	4 5	1990/91
Skil		7 5	
Extra Fine K	Kiplol Seed Co	147	
Extra Fine KA		11 5	1992
Extra Fine KB		1 5	
Katumani B II		16	1991
Kiplol Red		10	
Dark Red Kidney		10	
Light Red Kidney		10	

ANALYSIS OF BEAN SEED CHANNELS IN THE GREAT LAKES REGION

Louise Sperling

CIAT ISAR Rubona Butare Rwanda

ABSTRACT

Interviews with farmers in South Kivu Province of Zaire southern Rwanda and three areas of Burundi showed that beans were grown principally during the rains in Seasons A (September January) and B (March June) In Zaire and Burundi the two seasons were equally important whilst in Rwanda more beans were grown during Season A In Zaire and Burundi substantial areas were also grown on lowland marshes during the dry season and in Burundi during the counter season from January to April Sowings tended to be concentrated among the wealthier farmers especially in Rwanda and Burundi Most farmers but especially the rich obtained their original seed from relatives In one of the principal bean seasons (A or B) between 1990 and 1992 in all three countries about 60% of farmers used their own stocks for sowing About 30% of Rwandan and Burundian farmers and 59% of Zairian farmers obtained their seeds from markets Poor farmers consumed much of their production as green pods or seeds and so relied mainly on market sources rich farmers used almost entirely their own stocks using markets as sources of particular genotypes In Rwanda and Burundi varietal aspects (adaptation earliness small seed) and seed quality (no disease or pest damage chemically treated) acounted for most farmers definitions of good seed In all three countries there was very limited use of improved seed though there is evidence that genetically improved cultivars are being adopted and incorporated into local mixtures

INTRODUCTION

A prime concern with improved varieties is their accessibility new cultivars can increase food production only if they reach and can be maintained by growers Official seed services or development projects are often important in launching varieties but may be relatively ineffective in reaching the mass of farmers particularly the smallest and the most isolated (CIAT 1990) Further for the poorer farmers use of new cultivars may involve a repeated cycle of loss and restocking adoption for them may thus require continuing support rather than a one time cultivar delivery service (Sperling and Loevinsohn 1993)

With the aim of improving delivery systems for new cultivars research was carried out to examine the informal channels for bean seed acquisition in all three Great Lakes countries Studies aimed to assess seed needs by region by social class and by season to improve understanding of what farmers desire in seed quality and to evaluate the relative strengths of current seed channels for beans

METHODS

Seed investigations were carried out by means of questionnaire employing both open and closed formats depending on the complexity of the subject being pursued Seed samples of released cultivars were used to identify improved varieties and local measures (baskets and pots) helped clarify the quantities of seeds sown In the South Kivu Region 227 farmers were interviewed in two major areas Kabare the community surrounding the research station and Walungu the site chosen for the national programmes most intensive on farm testing In southern Rwanda 152 farmers were interviewed in Butare and Gikongoro Prefectures in the 14 communes located in proximity to ISAR headquarters In Burundi 295 farmers were interviewed in three major bean growing regions (about

100 farmers in each region) Kirundo was chosen due to large quantities of beans sown yet limited development project intervention Gitega was chosen to represent an area where bean cultivation is facing difficulties yet where project support has been significant and Makamba was selected due to the local tradition of growing climbing varieties Samples were chosen randomly with all wealth classes represented and interviews were held by preference with adult women those most experienced and knowledgeable about bean seed Aggregate national data are presented in this overview individual country reports highlight regional divisions where appropriate (i e in Burundi) Wealth divisions (poor medium and rich) were defined qualitatively according to house type and size land and livestock holdings tenure rights (in Zaire) and other notable factors such as off farm sources of income (particularly in Rwanda and Burundi) fertilizer use and labour hire (in the case of Burundi)

FINDINGS

Quantity of seed planted

The quantity of bean seed planted seasonally by year and by social class is summarized in Table 1 In Rwanda Season A (September to January) proves most important both in the quantities sown (on average 100 150% greater than season B March to June) and the number of farmers planting In Zaire these two seasons are more evenly matched along both parameters We see however a surprisingly large and relatively new off season production 1) farmers use the lowland marsh during the long dry season (Season C) and 2) many are taking the risks to plant the so-called counter season of January to April (Season D) In Burundi Seasons A and B are relatively equal with B being slightly more important (N B this conflicts with the common wisdom that farmers are abandoning beans in Season A) As in Zaire an increasingly large number of Burundian farmers (here 45%) are intensifying production by planting in the valley bottoms during the C season Overall the poor in Rwanda and Burundi sow only a quarter of what the wealthy sow on a yearly basis with the figure rising to 2/5 in Zaire

Table 1 Quantities of seed sown and percentages of farmers sowing beans in 1990 92 in South Kivu Zaire Southern Rwanda and Kirundo Gitega and Makamba Provinces of Burundi

	Zaire		Rwanda		Burundi	
	kg sown	% farmers sowing (n=277)	kg sown	% farmers sowing (n=152)	kg sown	% farmers sowing (n=295)
Seasons						
A	14 6	85	21 0	95	39 7	84
B	13 6	89	9 9	83	45 4	100
C	7 4	19			14 7	45
D	11 2	15				
Farmers						
Poor	20 6		14 6		36 9	
Medium	34 2		23 9		81 3	
Rich	48 9		56 6		161 9	

The number of seasons farmers plant significantly varies by wealth only in Zaire (P< 001 F= 7 6) with the rich planting an average of 2 33 and the poor 1 95 Further of those who plant a single season 85% were characterized poor No such wealth by seasons differentiation emerged from either the Rwandan or Burundian data

Evolution of seed sources

Most farmers in South Kivu (73%) southern Rwanda (84%) and Burundi (87%) obtained their original seed (at the time of household establishment) from relatives usually the man s parents The couple often resides near these relatives and such seed is preferred as it is said to be well adapted locally With time however many had also made partial modifications in the composition of their seed stocks (40% for the Zairian sample 60% for the Rwandan and 22% for the Burundian) with a good number changing their seed stock completely (14 18 and 61% respectively) When in need of seed very few felt able to go back to their parents for aid or rejuvenation of mixture types (less than 2% for all samples) It is important to note how wealth differences relate to original seed acquisition the rich generally get stocks from their parents (100% in Rwanda 95% in Zaire and 94% in Burundi) while comparable figures for the poor are 36% in Rwanda 44% in Zaire and a surprising 90% in Burundi In Rwanda where neighbours provide a second valued source of seed we find a particularly disadvantaged group of farmers who received original stocks neither from parents or neighbours 72% fall into the poorer category

Table 2 Percentage of farmers growing beans who used a particular source during the principal bean growing season 1991 2

Sources	Zaire (n=194)	Rwanda (n=144)	Burundi (n=248)
Own stock	59	63	66
Relatives	0	0	1
Market general	58	9	24
Market farmer seller	1	11	12
Market local merchants	0	3	11
Market large merchants	0	9	3
Neighbours	1	10	4
Development project	0	0	3
Church	0	3	<1
Cooperative	0	1	<1
ISAR/INERA/ISABU/State	0	1	0

no farmer used two of these sources one third of Rwandan farmers used the market

Current use of seed sources

Table 2 lists the varied sources identified by farmers for bean seed acquisition and illustrates their frequency of use during the principal bean season data from Rwanda and Zaire are drawn from Season A (either 1990 or 1991 depending on when the farmer last sowed) and for Burundi from the major B season (in this case 1992) In all countries about three fifths of farmers obtain at least some of their seed from their own production (own stock) with a market channel being the other very significant source When farmers speak of market sources in South Kivu they are generally referring to the many decentralized markets at which farmers themselves may sell their own bean seed hence the categories market general and market farmer merchant are not well differentiated for the Zairian data In Rwanda and Burundi in contrast farmers clearly distinguish among the large town markets (market general category) the town wholesalers who own their own shops (large merchants) the decentralized country or boutique vendors (local merchants) and the farmers who sell their own harvest in town or rural marketplaces (market farmer merchant) This last type is relatively rare in Rwanda as farmers who sell (or exchange) their own production usually do so in the countryside as one neighbor to another (hence the category neighbour) Note that this category of neighbour for seed is little found in South Kivu

Use of the two major categories of seed channels own stock and market (the latter being a composite category of all market types) varies considerably by wealth In all three regions only about half of the poorer farmers can draw on their own stock (for <u>any</u> quantity of seed) in contrast to the wealthy who use 100% of their own harvested seed for at least one season of the year (Table 3) However once farmers use a source (e g whether own stock or market) the proportion of seeds coming from that source varies relatively slightly by wealth for example poor or rich farmers who draw from their own stocks may do so for the great majority of their seed needs (Table 4) Similarly some farmers from all classes may exclusively rely on the market for seed needs In our sample a very small group of the rich (two cases in Rwanda and Zaire and one case in Burundi) sought to overhaul completely their seed stock for a single season in search of better performing mixtures Table 5 gives an idea of just how important the market may be in terms of quantities of seed purchased on average <u>each</u> Burundian farmer purchases 5 4 kg from the market in Season A and 15 kg in Season B

Table 3 Percent of farmers using the two major seed channels by social class and season 1990 92

	Zaire		Rwanda		Burundi	
	A	B	A	B	A	B
Own stock						
Poor	51	49	44	62	55	34
Medium	65	64	63	85	81	73
Rich	80	100	91	100	100	85
Market						
Poor	66	60	46	26	51	80
Medium	40	53	36	5	22	52
Rich	13	17	6	0	4	32

Table 4 Percentage of seed obtained from a source by those who use it review of the two major seed channels Seasons A and B 1990 1992

	Zaire		Rwanda		Burundi	
	A	B	A	B	A	B
Own stock						
Poor	82	85	92	93	85	71
Medium	84	90	87	96	98	80
Rich	98	88	99	98	98	84
Market						
Poor	84	88	92	93	93	92
Medium	80	78	83	100	81	70
Rich	100	54	100	0	62	64

these figures should be interpreted cautiously in all four cases the data refer to only 2 4 farmers

Table 5 Quantities and percentages of bean seeds Burundian farmers procured from the two principal seed sources for the two major growing seasons 1992 A and B

		Season A		Season B	
Class	Source	kg	% seed sown	kg	% seed sown
Poor	Own stock	7 5	44 7	5 8	28 1
	Market	8 0	47 9	14 7	69 5
Medium	Own stock	29 6	82 6	27 1	62 2
	Market	5 4	15 0	14 3	33 8
Rich	Own stock	76 2	97 6	60 0	70 4
	Market	2 6	3 2	16 8	20 2
Average	Own stock	33 7	83 8	28 1	61 5
	Market	5 4	13 4	15 0	32 8

Note totals do not add to 100% as other sources contributed small amounts to farmers seed acquisition

Note that the rich seem to use markets to find select genetic material rather than to top off or fill in for inadequate seed stocks The reliance of the poor on the market is quantitatively and qualitatively different In the Rwandan sample 33% of the poor purchase their entire seed at least one season 13% do so for two consecutive seasons and 18% purchase all of their seed from the market every time they plant whether it be one or two seasons yearly (this tally excludes those who depend on the church or the state for free seed) Farmers lament they may even consume their entire crop green either the pods or the fresh seeds The reliance on market seed is even higher in Burundi 70% of the poor obtain all of their seed from the market for at least one season 39% for at least two and 36% every time they sow Finally the reliance of the South Kivu poor on market seed is the most pronounced 52% buy all of their seed for one season 32% for two or three seasons and 40% of farmers buy all of their seed every time they plant whether it be one two or three seasons annually Here farmers are clearly seeking something to put in the ground that will sprout the concern is for seed quantity not for refining choice of varieties

Farmer assessment of 'good seed channels

Farmers in both the Rwandan and Burundian studies were asked to define what they considered good seed Rwandans (n=89) focused on varietal aspects in 76% of the responses (emphasizing adaptedness to local conditions and earliness as desired traits) with physical or phytopathological traits representing the rest of the criteria cited (good physical appearance good germination and seed treated with pesticides) Burundian responses for the entire sample (N=295) were similar and are detailed in Table 6 varietal aspects were particularly cited (65% of the responses) with a preference for small grained seed (does well on our poorer soils and is economic to sow) Formal seed service concerns such as good conditioning or healthy seed were given little prominence as farmers feel they can readily control these aspects themselves Given the varietal emphasis farmers generally prefer to use mixtures long tested on their own farms as through a process of selection such seed is regarded as well adapted to farmers specific agronomic conditions In Rwanda and Burundi in terms of both genetic and physical quality second best seed is said to come from neighbours whose planting conditions might be similar and who have an ethic to deliver well sorted beans (e g unbroken mature and neither discoloured nor damaged in storage) (CIAT 1988) In Zaire such neighbours seed may be found at the market where buyers search for faces and/or varieties with which they are very familiar

Table 6 Burundian farmers (n=295) definition of good seed

Criteria	Responses [1]Number	%	% farmers
Varietal factors	422	65	90 2
Seed quality	144	22	41 7
Economic factors	35	5	9 8
Conditioning	25	4	7 8
Seed health	18	3	5 8
Other	2	<1	0 7

[1]Note each of the categories represents a cluster of responses thus varietal reasons include such criteria as desire for small seeded varieties early maturing varieties varieties that resist drought and so on The major criteria are varietal factors small grain good yield known variety seed quality rotten immature and buchid-damaged grains eliminated economic factors grains economic to sow (small) seed health good germination and other appropriate moisture content Farmers were permitted to cite up to three criteria

The problem with such better quality seed is both its relatively high cost as well as availability Not surprisingly the wealthier may have greater access than the poor to better quality seed For example in Rwanda 50% of the sources they used in season A outside their own stocks fell into the categories of neighbours (better quality local seed) or development projects and government offices (better quality exotic seed) while such locales represented 18% of the sources used by poorer farmers for acquisition of seed off farm Ultimately farmers may be obliged to buy from commercial channels just because seed is available upon request Table 7 illustrates this point in reference to Rwandan assessments of their potential seed acquisition sources While some 17 criteria were used in the evaluation only a handful emerged as determinant The major advantage of market seed seems to be that one can obtain it its quality is not particularly appreciated Note the degree to which farmers fear being cheated in any commercial transaction In Zaire the only major non farm source evaluated the market was positively regarded in terms of seed availability and the wide choice of varieties on offer and negatively in terms of cost and poor physical quality Genetic quality of seed did not figure probably because much of the seed for sale is of relatively local origin

Table 7 Rwandan qualitative assessment of major seed sources

Source	Market general	Small local merchant	Large merchant	Neighbour
Positive attributes				
Good genetic quality	+	+		+++
Good physical quality				++
Appropriate storage				+
Easy availability	+	+	+	
Negative attributes				
Poor genetic quality				
Poor physical quality				
Expensive				
Erratic availability (scarcity)				
Inexact quantities (Client cheated)				

Note each symbol negative ( ) or positive (+) represents close to one third of the respondents who cited the source

Farmers use of improved seed

As seen above the use of improved seed i e phytopathologically superior seed (clean) coming directly from development projects seed services or national institutes was quite small in all three countries The use of genetically improved varieties however was more difficult to establish as farmers may not know the origin of the cultivars and varieties integrated into their mixtures Improved climbers are easier to identify than improved bush varieties as the former type may be totally novel to an area or local genetic diversity among climbers may be low The evidence from Burundi was promising and particularly surprising given that the national programme has made limited efforts to promote climbers 23% of those who grow climbing varieties (concentrated in Makamba) have adopted improved cultivars More targeted studies are under way within the Great Lakes Region to look at use of genetically improved varieties (Musungayi *et al* 1992 MINAGRI/ISAR/CIAT 1992 Scheidegger and Nyabyenda 1992)

DISCUSSION AND IMPLICATIONS

These results clearly show that relatively large numbers of farmers regularly procure a high proportion of seed from outside their own farms While neighbours (hence locally adapted) seed is preferred (whether purchased on farm or at market stalls) many farmers are obliged to purchase what they consider second quality seed through commercial channels which offer regular supplies of a range of cultivars Poorer farmers in particular are constant market clients unable to save seed harvested or at times forced to eat entire harvests as green beans or green seed Up to now development projects and national seed programmes have provided proportionally little of the bean seed in use although some genetically improved varieties are reaching farmers through informal channels For farmers the present seed procurement channels often represent a trade-off between quality seed (genetically and physically) and cost and availability Future strategies for the distribution of improved seed should place emphasis 1) on making available genetically superior varieties (vs a focus on phytopathological or physical quality) and 2) on distributing them through decentralized on going and existing seed procurement channels The key will be to keep down cost while maximizing farmers access

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[1] International Center for Tropical Agriculture (CIAT) B P 259 Butare Rwanda
[2] l Institut de Sciences Agronomiques du Rwanda (ISAR) B P 138 Butare Rwanda
[3] Programme National Legumineuses Mulungu Zaire B P 150 Cyangugu Rwanda
[4] United States Agency for International Development (USAID) Bujumbura Burundi
[5] Service National de Semences (SNS) Burundi B P Gitega Burundi

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DISCUSSION SESSION VII TECHNOLOGY TESTING, TRANSFER AND SOCIO ECONOMIC ISSUES

Chair R Buruchara Rapporteur J H Nderitu

General

Comment There are three areas dealt with bean production markets and marketing of seeds and on farm research There are many production systems providing many aspects of study Researchers should involve extensionists in on farm research How is technology best transferred to farmers? Who should be involved in such a transfer? Farmers are not prepared to pay for bean seeds except for new varieties How is the production and distribution of bean seeds best organized? How appropriate are formal and informal channels for distribution of bean seeds to the farmers

Paper by Aleligne Kefyalew

Kirkby You draw attention to seasonal fluctuations in bean production Since in Ethiopia this is largely due to large plantings of bean substituting for cereal crops in drought years policy interventions may have more effect than biological research upon the attempt to stabilize year to year production

Paper by Isaac Mulagoli

Otsyula It is interesting to note that GLP 1004 not used as a control in the field demonstrations in dry areas

Paper by S M W Munene

Wortmann GLP 2 (K20 in Uganda) is the most marketed bean However it is not most preferred for consumption Despite its relatively large supply it has an intermediate market value Please comment on this

Munene On consumer preference in three districts (Kisii Meru and Muranga) in Kenya Rose Coco (GLP 2) was most preferred due to its fast cooking and good sauce This suggests it is a preferred variety in some major bean producing areas The National Cereals and Produce Board pays a higher price for Rose Coco than for other varieties but very few farmers sell to the board

Kimani Does GLP 2 always command the best price in the markets surveyed?

Munene In some markets it is priced highly but not always Farmers prefer it because it cooks fast and has good sauce

Question What is the main source of beans in markets?

Munene Mostly surrounding areas

Paper by Aberra Deressa

Question You mentioned that around 1990 you replaced Mexican 142 with Awash 1 because the former was no longer productive It is a risk to promote a single variety at a time and I am wondering why you have chosen this strategy

Aberra Deressa In fact we are also promoting a new food variety These were the most promising of the new materials tested

Paper by Getachew Kassaye

Wortmann I understand that contact farmers are the recipients of seed of new varieties in the seed dissemination study Is this correct? Is there any evidence that certain local farmers are specifically recognized by their neighbours as seed experts or sources or seed? What role are NGOs playing in the promotion and dissemination of varieties?

Getachew Kassaye Not only the contact farmers but also the follow up farmers are recipients of seed of new varieties Farmers basically are expert in selecting seeds particularly for planting for the next season They choose seeds visually in the field harvest them and store them for long periods treating them with ashes and keeping them dry NGOs (for example CONCERN World Vision FARM AFRICA) are involved in development activities at regional district or village level They include food for work programmes training of farmers both men and women conduct of demonstrations of cereals pulses and horticultural and other crops and building of roads clinics schools and other infra structure They also play an important role in disseminating seeds of new varieties since they can easily multiply and distribute seed and planting materials to farmers

Wortmann I think it is important to study seed dissemination and am glad to see you plan to do so However in the meantime priority should be given to promotion and dissemination of these varieties What are your plans for this?

Getachew Kassaye Collaborate with NGOs around our demonstration sites and supply them with the varieties to multiply and distribute to nearby farmers Use MoA/MCTD farm plots to produce more of these seeds for future dissemination

Question Is IAR able to produce sufficient seed for large scale dissemination or do you have alternative strategies for such production?

Getachew Kassaye This programme aims to help resource poor farmers in the demonstration sites so that most farmers can easily obtain sufficient planting material for the following cropping season An alternative strategy is to collaborate with the NGOs who are involved in development activities in the area by supplying seeds to them to multiply and distribute to farmers

Sperling You have to be careful about using the Acceptability Index (% of farmers using the technology multiplied by per cent of surface area) because the larger the index the better If 80% of bean area is covered by one variety this would be considered success Recently however researchers have questioned the Acceptability Index because it supports reduction in diversity Such researchers believe that more farmers growing smaller areas to one variety and perhaps devoting other fields to another variety may be a more stable strategy

Paper by M W Wanjiru

Question Why are so many (36) snap bean varieties produced in Kenya? Are all of them available to farmers?

Wanjiru According to the National Seed Quarantine Control Service (NSQCS) 33 snap bean varieties were recorded as being produced in Kenya in 1992 The majority of these were produced solely for the export market Only the varieties produced by the East African Seed Company and the Kenya Seed Company were readily available to farmers since these were the only companies producing seed for the Kenyan market (see Appendix 1) A few other varieties find their way to farmers fields if and when snap bean exporting companies and seed merchants import seeds

Question Are the snap bean varieties from seed companies held by the National Horticultural Research Station?

Wanjiru The National Vegetable Research Station is collecting the seeds from export companies

Paper by L Sperling

Question Why do you think farmers are prepared to pay a little more for unknown varieties in the Great Lakes Region?

Sperling Farmers in Rwanda regularly experiment with varieties themselves (remember there are at least 500 varieties country wide) They have also had some good successes with research delivered varieties Now there is a huge demand for the new climbing varieties At the beginning these were not easy to get at all on the market and now farmers are eager for a greater diversity of climbers

Question Is there a danger that the identity of a variety may be lost over time because the initial amounts are so small?

Sperling Danger for whom? Farmers will multiply the seed if it proves interesting otherwise they will discontinue its use The small amounts sold represent true farmer test sizes (that is what they do on their own a handful) If farmers do lose a desired variety they can access it again (through the market or a neighbour) if the initial distribution was extensive in space which is the object of making small amounts available to many farmers

Question How can you measure impact after diffusing a variety in small bags?

Sperling Measuring impact in a situation where new varieties are usually incorporated in existing mixtures is difficult whether they have been diffused in small bags or otherwise In the Great Lakes seed samples are taken from farmers to the laboratory separated into their components and compared with released varieties first on the basis of grain characteristics then by growing out the seeds and comparing morphological descriptors

Sengooba Is there a danger that farmers may mix new varieties and lose their identities?

Scheidegger When farmers acquire a new variety they test it for 2 5 seasons in small plots separate from their mixture In addition farmers may have 20 different names for the same variety Reaching 10% of the population directly with small bags which have the variety name printed may even improve the situation

Getachew Kassaye In disseminating seeds we have to consider farmers preferences such as taste/appearance price yield and cooking time physical and socio-economic characteristics of sites such as climate topography soils and infra structure and farmer circumstances such as family and farm size In distributing seeds in the Great Lakes area what is the average farm size and cropping pattern e g do farmers grow beans as a monocrop or intercrop?

Sperling Farmers are particularly interested in the ability of a variety to perform under stress conditions e g on poor soils or in densely intercropped situations Colour shape and uniformity of grain are relatively unimportant as commercial forces have yet to create distinct urban (vs rural) preferences Of course as everywhere they like high yielders with short maturity cycles

General Although low soil fertility was originally expected to limit the spread of climbing beans in Rwanda this has not happened The aspect is now being examined in some Great Lakes regional sub projects Stakes increase the production costs of climbing beans A local market in stakes has developed and these market costs have been included in economic assessments of the impact of climbers Labour studies show that poor even female headed households have readily adopted climbing beans The fact that farmers have found *Umubano* (G 2333) to have good tasting leaves has also helped adoption by the poorest sector of the population

SESSION VIII REVIEW OF REGIONAL PRIORITIES

RESEARCH FOR IMPROVING BEAN PRODUCTION SYSTEMS IN AFRICA APPLICATION OF INFORMATION AND ADAPTIVE RESEARCH

Charles S Wortmann

CIAT, Kawanda Agricultural Research Institute, Kampala, Uganda

ABSTRACT

Bean research networks in eastern and southern Africa are proving effective in conducting strategic and applied research to generate potentially useful information about priority problems Application of this information as well as other existing information to aid farmers to improve their management practices has not been as well served Production environments and systems are very diverse and we lack efficient means of extrapolation to accurately target information to production systems Adaptive research with farmer involvement is needed Opportunities for collaboration in research with those having shared interests in improving bean production systems must be exploited

INTRODUCTION

The bean research network is probably the best functioning agricultural research network in eastern and southern Africa While there have been major difficulties in the conception and implementation of some regional research sub projects others have proceeded well with researchers conducting research of strategic interest to national research programmes Researchers have developed expertise in specific areas and gained recognition for this expertise National and regional planning workshops and working group meetings have given useful guidance to research by setting priorities and evaluating on going activities The approach is effective in generating information which is potentially useful for solving bean crop related problems Similarly collaborative research by Africa based CIAT and national programme staff has been of value in generating information about important problems

Utilization of this information as well as other existing information to aid farmers to improve their management practices has not been as well served While the sub projects and regional scientists generate information on topics of regional interest responsibility for adaptive research rests with national programmes or other within-country institutions This area of research has not gone well especially for the benefit of resource poor farmers (RPF) in less favoured production environments This paper explores the issue of utilizing available information more efficiently for actual improvement of production systems

THE FARMER RESEARCHER INTERFACE

The following characterizations of conventional research are relevant to the farmer researcher interface

1 Conventional research has not been very effective in assisting RPF especially those outside more favoured environments Production conditions are often diverse due to climatic edaphic and socio economic variation and resources have been insufficient for conventional research to deal with this diversity of demands When potentially suitable technologies are available availing these to farmers is often difficult due to inadequacies in extrapolation of information and insufficient adaptive research

2 There is a need to go beyond conducting NPK level trials herbicide testing and plant density trials Much information generated within or outside our regions exists on these topics and is generally poorly utilized Failure of utilization may be because of lack of awareness of its existence of agronomic or economic inappropriateness or of poor extrapolation of results to farmers conditions

3 Research results need to go beyond annual reports Research is not complete until it has found a place in farming systems or until it has been found inappropriate Information is of value only if it is utilized

4 Blanket recommendations even for agro-ecological zones (AEZs) are inefficient as there is much heterogeneity within AEZs and even within farms It is more important to offer guidelines to aid farmers to find the optimum practice or level for various niches of their farms Questions arise as to how researchers can aid farmers to identify these optimal levels

5 For traditional crops farmer management practices are generally not bad i e their planting rates and other management practices are usually reasonable given farmers circumstances While cases of poorly tended crops are often observed these frequently are due to unexpected deficits in the resources required for a task or to poor management rather than to lack of knowledge Traditional production systems rather than exotic systems developed for high input and mechanized agriculture should be the starting point for adaptive research

6 Agronomic research especially the identification of worthy research topics is difficult It is often difficult to develop technologies which are better than those the better farmers are using given their available resources At the same time many farmers are not using their resources efficiently While the researcher farmer gap is often discussed the gap between the most and the least efficient farmers may be more noteworthy

7 With the recognition that farmers do try alternative practices on their own and that they are knowledgeable of their production environments comes a realization that farmers are potentially valuable partners in research

RESEARCH APPROACHES FOR INCREASED BUT SUSTAINABLE PRODUCTION

The following discussion focuses on improved utilization of existing information through improved extrapolation and adaptive research Available information needs to be better applied to constraint identification pre screening possible solutions and targeting of technical innovations Adaptive research with much farmer involvement is needed to develop the innovations needed to improve production systems Research requirements are expected to differ for resource rich farmers (RRFs) and RPFs

Resource rich farmers

Conventional agricultural research approaches will continue to serve RRFs well but the efficiency of research is likely to improve with greater farmer involvement Many RRF are already using the more easily adopted technologies such as high yielding varieties and input use Further improvement of systems is likely to be more difficult possibly involving input use efficiency through more precise farming practices integrated pest and soil management as well as higher yielding varieties More precise farm management (Runge 1992) will require accurate targeting of information such as results of fertilizer use research

Running parallel to upstream research on extrapolation of research results downstream research will be needed to better adapt technologies to the various niches of RRF Farmer participatory research (FPR) is likely to be especially important in the development of technical innovations The research must adequately consider the resources available to farmers including managerial and labour resources

Resource poor farmers

Effective research for RPFs is more difficult than for RRFs and conventional agricultural research has been of relatively little benefit to them Production conditions and systems are diverse Inputs are often not available and not affordable to RPFs Crop responses to applied inputs are often inconsistent A range of technical components or innovations is likely to be required to meet the needs of the diverse systems And yet production systems of RPFs have evolved and are continuing to change over time as conditions change

Researchers have much information that is potentially applicable to RPFs even though there may not be many off the shelf technologies ready to use How can available information be efficiently targeted to the many and varying production environments? How can the required adaptive research to produce a range of alternative practices be conducted efficiently? In view of the diversity of production environments Harmsen and Kelley (unpublished) suggest that a range of elements be considered to enable development or identification of alternatives from which farmers can select They suggest that such basic elements should include techniques for soil conservation water harvesting and conservation integrated nutrient management IPM and alternative cropping systems including animal components As with RRFs both upstream and downstream research is needed to improve information utilization and adaptive research respectively

Information utilization

More efficient application of available information and extrapolation of research results is especially important because of the ranges of environments and information involved The basis of extrapolation between and within agro-ecological zones might be single or combinations of soil properties (Janssen *et al* 1990) a local or introduced soil/land classification system such as the Fertility Capability Classification System (Boul *et al* 1975) or expert system or simulation models such as ADSS (TropSoils 1991) the DSSAT crop growth models (IBSNAT 1989) and the WEPP model for water erosion (NSERL 1989) Model development together with the GIS data compilation and management services offer promise of greatly increased information utilization in the near future Upstream research is needed to determine and validate the basis for extrapolation and to compile needed minimum data sets

Adaptive research

Downstream research is needed to adapt information or technologies to various situations The farmer s role in this adaptive research is essential as the outcome is dependent on the farmer finding the technology to be acceptable and adopting it The researcher also has an important role to play Because of complementary skills and knowledge the probability of adaptive research yielding success is likely to be greatest when researchers and farmers collaborate fully in FPR

The structure of the FPR process may vary as may the relative importance of the ultimate goals Two scenarios are considered

1 In the first scenario the contact between researchers and farmers is temporary and loose FPR attempts to find solutions to real problems but the primary objective is to improve the problem solving/technology development capacity of farmers so that they are better able to continue with system improvements on their own A part of the improved capacity might be the links formed between the group of farmers and researchers to enable farmers to more easily seek the assistance of researchers in future

2 The alternative scenario calls for on going collaboration between researchers and groups of farmers at research locations The primary objective in this case will be the development and dissemination of alternative technologies suitable for the group of farmers as well as many other farmers producing under similar conditions The objective to strengthen farmers problem solving/technology developing capacity is secondary

Extension

A concern in research for RPFs is the extension of technical innovations once they have been adapted It is probable that their promotion and adoption will not be so simple as for a new variety or the use of fertilizer An innovation may have several components and may require new managerial skills If poorly applied its benefits may not be obvious Its benefits may not be obvious in the short term In both of the above scenarios participating farmers might play an important role in promoting the technology The transfer will be a farmer (or farmer/researcher) to farmer transfer rather than a researcher to farmer transfer of technology In the second scenario research locations may become recognized as places where alternative technologies are applied and bases for farmer to farmer transfer The role of extension staff may need to change from that of technology delivery to assisting farmers to analyze their farming systems and adapt technologies for the various niches of these systems

IMPLICATIONS FOR THE BEAN RESEARCH NETWORKS

The bean research networks have a sound mechanism for conducting research to answer technical questions through the regional sub project approach The approach has been less effective in improving farmers production systems Two broad areas of research needing additional attention have been identified above Upstream research is needed to improve the extrapolation of available information to the many diverse production environments Downstream research with farmer participation is needed to adapt technologies to these environments

The resources required to accomplish the needed research for bean production exceed those available in the networks While the networks remain responsible for ensuring that the needed research is done they need not act alone Opportunities for collaboration with others having mutual interests must be effectively exploited

Promising up stream research to improve extrapolation of information is under way by those involved in geographic information services (GIS) and in development of simulation or expert systems models The Fertilizer Use Research Project in Kenya has yielded results on the responses of different crops to applied fertilizers in many locations over several seasons (Mochoge 1993) The project data are potentially useful to test the utility of alternative measured soil properties soil classification systems and models in extrapolation of such information The bean research networks share responsibility to ensure that the work is accomplished and at times to play a more active role such as conducting research to further develop and validate the BEANGRO model (IBSNAT 1989)

Accomplishment of the needed adaptive research is a large task considering the wide diversity and large number of production environments Again there are opportunities for collaboration which the networks must exploit We have mutual interests with researchers national programmes and IARCs concerned with other commodities since beans are usually produced in association with other crops This implies that while we give attention to production systems involving their crops they should give attention to bean research Often government organizations including extension services and non government organizations can be very useful collaborators in adaptive bean research

The greatest opportunity for more effective collaboration in adaptive research is with farmers In Uganda farmers have long been active in variety evaluation through an extensive system of on farm variety trials which are managed and evaluated by farmers More recently the bean programme has embarked on an intensive approach to FPR aimed primarily at addressing management related problems where researchers make an on going commitment to work closely with farmers at research locations which are representative of larger agro-ecological zones It is anticipated that these FPR research locations will become an integral part of agricultural research and extension institutions in Uganda

CONCLUSIONS

Research is needed to enable farmers to improve their bean production systems over a great diversity of production environments Existing information must be better utilized through improved extrapolation especially to address the problems of the diverse low potential environments of RPFs More adaptive research is needed and the bean research networks need to seek collaboration from other commodity research programmes government and non government organizations Most important is to accept farmers as full partners in the research process to utilize their knowledge and skills and to improve their own capacity to further develop their systems While conducting research to improve extrapolation of information or to adapt technologies to farmers conditions important information gaps will certainly be identified which require strategic or applied research

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SADCC/CIAT BEAN RESEARCH NETWORK IN SOUTHERN AFRICA

C S Mushi, M E T Mmbaga and I K Kullaya

Selian Agricultural Research Institute Arusha Tanzania

ABSTRACT

Progress achieved in SADCC/CIAT supported bean research sub projects is described with emphasis on those in which Tanzanian scientists were involved In the drought sub-project nurseries at Selian and Miwaleni in Tanzania identified six lines which performed well under drought stress In trials in Malawi drought imposed during vegetative growth depressed total biomass leaf area canopy height and width pod number and seed yield Canopy characteristics were unaffected by drought during reproductive growth Domino performed well when stressed during vegetative growth and four other lines when drought was imposed during reproductive growth A survey in northern Tanzania established that farmers were concerned about the increase in drought problems which they attributed to deforestation Crosses of drought tolerant and adapted lines have been made in Zambia In the bean stem maggot (BSM) sub-project crosses have been made in Tanzania of Ikinimba and ZPv 292 (BSM resistant) with Lyamungu 85 Dore de Kirundo and Canadian Wonder Tests of parents and F_2 and F_3 populations suggest that resistance is predominantly additive Nematode species infesting beans in northern Tanzania have been identified and a start made in mapping their distribution Beans are important alternate hosts for coffee and banana nematodes Resistance has been located among local bean germplasm Technology has been developed for screening for tolerance to P deficiency in beans and lines that perform well in low P conditions have been identified in the First ANSI S Nursery A survey of farmers growing maize and beans in association has been conducted in northern Tanzania Progress to date with the sub-projects is encouraging and results are available for scientists in other regions

INTRODUCTION

The common bean (*Phaseolus vulgaris* L) is the most important grain legume for human consumption in Tanzania and an important component in the diets of people of other member states of the Southern Africa Development Coordination Conference SADCC (now renamed Southern African Development Conference SADC) The SADCC region covers Angola Lesotho Malawi Mozambique Swaziland Zambia Zimbabwe and Botswana (and now Namibia)

Bean production in the SADCC region is mostly by peasant farmers who realize very low yields due to the many biotic abiotic and socio-economic constraints facing bean production Bean production from the SADDC region amounts to over 440 thousand t of dry seed which is approximately a quarter of African total production Tanzania produces about 230 thousand t or 52% of SADCC production (Table 1) Within Tanzania the major zones of bean production are the northern highlands of Arusha Kilimanjaro and Tanga Regions including the Pare and Usambara mountains the highlands of central Tanzania including the Uluguru and Ukaguru mountains of Morogoro Region Kagera and Kigoma Regions of western Tanzania and the southern highlands of Iringa Mbeya Ruvuma and Rukwa Regions Elsewhere areas of food bean production include northern Zambia the highlands of Malawi Niassa Tete and Manica Districts of Mozambique the central and eastern high veld of Zimbabwe and parts of western Angola

Table 1 Average annual bean production in the SADCC Region for the period 1986 88

Country	Area (000 ha)	Productivity (kg/ha)	Production (000 t)
Angola	110 0	364	40 0
Lesotho	7 3	343	2 5
Malawi	133 7	559	74 7
Mozambique	131 4	343	62 2
Swaziland	1 7	471	0 8
Tanzania	472 7	620	230 0
Zambia	24 0	653	16 0
Zimbabwe	24 0	691	16 6
Total	904 8	506	442 8

Source Grisley (1990)

A large number of professional scientists is concerned with bean research in these countries they each operate over a wide range of sites in diverse environments with severely limited resources There are climatic similarities among locations in the SADCC region (Table 2) and hence also in constraints to bean production To increase the efficiency and impact of bean production in SADCC a research network through collaborative sub projects is inevitable

Table 2 Environmental characteristics of bean research centres in the SADCC Region

Centre	Country	Season	Latitude	Altiude (masl)	Rainfall (mm)	Temperature (C) Maximum	Minimum
Lambo	Tanzania	Feb Jun	3 16	1067	786	27 2	19 2
Bunda	Malawi	Dec Apr	13 58	1134	786	27 0	17 2
Msekera	Zambia	Dec Apr	13 33	1032	958	27 4	18 0
Mbala	Zambia	Sep Jan	8 51	1673	736	24 8	15 0
		Jan May			816	24 1	14 1
Lichinga	Mozambique	Nov Mar	13 17	1364	938	25 0	15 7
Arusha	Tanzania	Mar Jul	3 17	1402	600	24 2	14 8
Lyamungu	Tanzania	Feb Jun	3 13	1250	1256	23 9	14 9
Mbeya	Tanzania	Jan May	8 55	1736	662	22 4	12 0

Source Smithson (1989)

This paper describes the progress achieved so far in SADCC/CIAT supported sub projects with particular emphasis on the sub projects in which Tanzanian bean researchers participated

DROUGHT SUB PROJECT

This was initiated in May 1988 under the leadership of Dr Alex Mkandawire bean research team leader Bunda College of Agriculture Malawi (Edje 1988) The objective of the sub project is to improve bean yields under conditions of moisture stress The sub project has four components

1 Regional Bean Drought Nursery
2 Screening for drought tolerance in beans
3 Agronomic studies on strategies for alleviating drought
4 Breeding for drought tolerance

The coordination of the Regional Bean Drought Nursery and breeding for drought tolerance components were assigned to Zambia Malawi coordinated research on screening for drought tolerance in beans and Tanzania undertook agronomic studies on strategies for alleviating drought

Regional Bean Drought Nursery

A multilocation yield trial was conducted under rainfed conditions by interested SADCC countries including Malawi Tanzania and Zimbabwe The trial in Tanzania was conducted under both rainfed (Selian) and irrigated (Miwaleni) conditions The trial at Miwaleni was severely moisture stressed and six lines appeared to be tolerant to drought Seeds from all these lines were small and either black or white in colour The data from the trials have been sent to the sub project leader for statistical analysis

Screening for drought tolerance in beans

In 1988 four trials of 52 lines were conducted at Bunda College of Agriculture to identify genotypes that are high yielding under moisture stress The 15 best and 10 poor lines were identified Apart from total biomass easily observable characteristics were not associated with seed yield

In 1989 trials were conducted at Bunda and Kasinthula in Malawi in which 25 selected genotypes were grown either well watered throughout or drought stressed during their vegetative or reproductive periods (Mkandawire 1990) Drought was imposed by suspending irrigation Drought imposed during the vegetative period led to significant reduction in total biomass leaf area, canopy height and width number of pods per plant and seed yield Canopy characteristics were not affected by the later drought period Cultivar Domino produced good seed yields when drought was imposed during vegetative growth whereas Sapelekedwa A 268 A 286 and 8 7 produced good seed yields when drought was imposed during the reproductive period Based on canopy characteristics and yielding ability seven genotypes were selected for further screening

In 1989 90 two further trials were conducted at Bunda College of Agriculture to determine the response of bean genotypes to moisture stress and it was found that pod number was significantly associated with yield

Agronomic studies on strategies for alleviating drought

Drought is a major concern to farmers Areas which have experienced plentiful rainfall in the past are now prone to drought With this background a drought survey was conducted in Monduli and Babati Districts of Arusha Region and Same and Rombo Districts of Kilimanjaro Region in Tanzania A total of 130 farmers were interviewed of which 91% were male and 9% were female Fifty eight of these farmers grew their beans in association with other food crops

About 80% of the farmers said that drought was not a problem 30 years ago and associated the problem with deforestation (70%) Small seeded beans yielded better during drought than large seeded bean Early maturing bean varieties were recommended in preference to late ones Effects of drought were numerous but reduced crop yields inadequate water supply desertification lack of development and greater disease incidence were ranked highly Traditionally farmers minimized drought effects by afforestation use of early maturing cultivars early planting and by preventing forest fires

Breeding for drought tolerance

PV 508 Noweveld A 286 C 20 PVA 1082 A 268 2 10 PVBZ 158 8 7 and Diacol Calima identified in the drought tolerance mechanisms study as tolerant to drought have been crossed with desirable genotypes in Zambia There has been no progress with this project due to the departure of Mr Martin Mbewe (Bean Breeder) from Msekera Regional Research Station

BREEDING FOR BEAN STEM MAGGOT RESISTANT CULTIVARS SUB-PROJECT

The objective of this sub project is to develop appropriate breeding strategies for resistance to bean stem maggots and ultimately develop resistant bean varieties

In February 1991 ZPv 292 and Ikinimba with high levels of resistance to bean stem maggot were crossed with the susceptible but adapted varieties Lyamungu 85 Canadian Wonder and Dore de Kirundo at Lyamungu in Tanzania The F_2 and F_3 populations and parents were sown at Selian Agricultural Research Institute in 1992 after the *masika* rains when bean stem maggot populations are very high The entries were arranged in a randomized complete block design in three replications and two checks of Lyamungu 85 treated with Fernasan D and untreated were sown after every seven plots Dead plants were collected twice weekly until flowering counted dissected and the numbers of black and brown pupae per plant determined The reactions of the crosses and their parents to bean stem maggot are summarised in Tables 3 and 4

Table 3 Percent cumulative mortality mortality due to BSM and numbers of black and brown BSM pupae/plant among parents and F_2 and F_3 populations at Arusha in 1992

	First sampling date				Second sampling date			
	% cumul mort	Mort by BSM	Black pupae/ plant	Brown pupae/ plant	% cumul mort	Mort by BSM	Black pupae/ plant	Brown pupae/ plant
Crosses	0 096**	0 087**	5 688**	0 081^{ns}	0 247**	0 234**	10 404**	0 239^{ns}
Parents	0 183^{ns}	0 174^{ns}	6 653^{ns}	0 096^{ns}	0 350^{ns}	0 327*	0 346^{ns}	0 346^{ns}
F_2s	0 082	0 076	6 615	0 084	0 228	0 218	10 741	0 196
F_3s	0 097	0 084	6 081	0 110	0 263	9 248	12 970	0 248
ZPv 292	4 66	4 33	8 54	0 33	8 57	6 67	5 46	0 19
Ikinimba	2 00	1 33	3 08	0 00	3 67	3 21	14 19	0 58
Lyamungu 85	11 67	11 67	7 88	0 19	18 0	19 3	19 8	0 5
Canadian Wonder	2 33	2 00	7 50	0 0	6 3	5 7	10 0	0 3
Dore de Kirundo	7 33	7 33	7 26	0 27	13 3	12 7	18 8	0 4

Table 4 Reactions of crosses of Ikinimba and ZPv 292 with Dore de Kirundo Lyamungu 85 and Canadian Wonder to bean stem maggots (BSM)

	1st sampling date			2nd sampling date			
	Dore de Kirundo	Lyamungu 85	Canadian Wonder	Dore de Kirundo	Lyamungu 85	Canadian Wonder	Mean
Crosses with Ikinimba							
Mortality by BSM	0 084	0 09	0 10	0 223	0 26	0 23	0 16
Black pupae per plant	6 056	5 82	9 47	8 115	11 96	9 39	8 5
Brown pupae per plant	0 0	0 07	0 0	0 208	0 29	0 13	0 1
Crosses with ZPv 292							
Mortality by BSM	0 109	0 082	0 085	0 206	0 220	0 250	0 16
Black pupae/plant	7 453	6 155	6 794	11 338	10 677	13 401	9 30
Brown pupae/plant	0 056	0 108	0 131	0 153	0 138	0 271	0 15

Data collected indicated that the resistant parents showed higher levels of resistance to BSM and were similar in performance indicating that they can both be used to develop resistant cultivars The F_2 and F_3 populations reacted similarly for all traits measured suggesting that gene action for resistance to BSM *is predominantly additive* There was *an indication that general combining ability* was predominant over specific combining ability suggesting further that the gene action is additive

NEMATODES ASSOCIATED WITH BEANS SUB PROJECT

Preliminary investigations of the nematode species associated with beans in Tanzania was conducted to detemine their distribution incidence and species range (Cuthbert 1990)

The nematode genera associated with common bean in Tanzania were *Meloidogyne Aphelencoides Tylenchus Trichodorus Ditylenchus Helicotylenchus Pratylenchus Hemicycliophora* and *Aphelenchus* *P vulgaris* was an alternate host for the main nematode species associated with two common intercrops coffee (*Meloidogyne* n sp) and banana (*M incognita incognita P goodeyi* and *Helicotylenchus multicinctus*) *P goodeyi* and *H multicinctus* numbers were significantly higher in association with *P vulgaris* than they were with their original host (banana) *Meloidogyne* was found on *P vulgaris* at 62% of all sites in Kilimanjaro and Arusha Regions in northern Tanzania

Through this work a high degree of resistance has been found in existing germplasm to at least some *Meloidogyne* species These lines are known to be fairly good yielders Further distribution identification and screening work is necessary in connection with the present studies as well as pathogenicity studies

SCREENING FOR LOW PHOSPHORUS TOLERANCE IN BEANS SUB PROJECT

Introduction

It has long been recognized that phosphorus (P) is critically needed to improve soil fertility for bean production in large areas of eastern and southern Africa The high costs of conventional water soluble P fertilizers such as TSP constrains their use by the resource poor bean producers that dominate the region Screening for bean genotypes tolerant to P stress is being conducted in this sub project with the ultimate goal of improved bean yield with a minimum of fertilizer input

Over 200 varieties of common bean are currently being evaluated for their tolerance to low P at Mulama (primary site) in northern Tanzania and promising materials will be tested at multiple secondary sites in the region to confirm their superior adaptation to P stressed soils before they are passed to the breeder for subsequent genetic improvement work and/or farmers for production in low P soils

Screening protocol

1 Establish optimum field bean screening P stress level

2 Screening Season 1 field evaluation of large number of bean varieties at a primary screening site under P stress

3 Screening Season 2 field evaluation of 50% of best yielders from Season 1 at a primary site in stress and no stress conditions to select for responsive and efficient plants

4 Screening Season 3 field evaluation of about 60 bean varieties at several secondary sites Selection as in Season 2

5 Screening Season 4 repeat of Season 3 for confirmation of performance

6 Recommend promising materials to breeders for genetic improvement work

Work accomplished

Experiment 1

Objective to establish optimum P level for screening bean genotypes for tolerance to P stress and identify constraints (if any besides low P) to be alleviated to create ideal conditions for bean production

Materials and methods Soils from Mulama were sampled analyzed and characterized for soil fertility parameters Towards the end of June 1991 a field trial was sown at the site to assess the performance of AFBYAN II entries (sub plots) at seven levels of P (main plots) in a split plot design with two replications The trial was scored for disease incidence and grain yield

Results and conclusions On the basis of grain yields native levels of P at Mulama were found to be the optimal stress level for evaluation of bean genotypes for tolerance to low P after correcting for low soil N This is the level at which large yield variations were observed

Experiment 2

Objective Season 1 screening trial To screen the first set of bean varieties for tolerance to low P

Materials and methods Towards the end of 1991 280 bean varieties from the First ANSES (African Network for Screening for Edaphic Stress) set were field screened at Mulama at the established optimal P stress screening level under furrow irrigation

Results No useful data were obtained as practically all plants were severely damaged by bean stem maggot and fusarium wilt despite the use of insecticides

Experiment 3

Results This was a repeat of the Season 1 screening at Mulama conducted in July 1992 the ideal bean season at the site The trial was successful and the best 50% of the entries will be advanced to the second field screening season to begin towards the end of June 1993 No attempt was made to screen in December 92 for lack of irrigation water and anticipated high incidence of bean stem maggot during the dry season

INTER-CROPPING SURVEY SUB PROJECT

Over 80% of maize and bean production in Tanzania is in association presumably due to land and labour shortage and for risk avoidance An intercropping survey was conducted in Rukwa Kigoma and Kilimanjaro Regions covering seven districts with a total of 133 farmers of which 76% were male and 24% were female

Maize and beans were the staple foods and grown in association in the areas surveyed In some areas the two crops also provided cash flow to the family Bush rather than climbing beans dominated in the association 86% of farmers produced their beans in association with maize However intercropping was associated with poor bean seed yields high disease and insect incidence difficulties in field operations and insufficient radiation for beans

OTHER SUB PROJECTS

1 BCMV regional collaborative trial SUA

2 Anthracnose sub project UAC

At the time of preparing this paper progress reports on the above sub projects were not available

In conclusion the progress made so far in the above sub projects is encouraging and findings are readily available for use by other scientists in the region and other regions with similar bean production problems

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REGIONAL BEAN RESEARCH IN THE GREAT LAKES

U C Scheidegger

CIAT, ISAR Station Rubona, Butare Rwanda

ABSTRACT

The bean research network in the Great Lakes called RESAPAC has slowly evolved since 1983 when the first CIAT staff member was posted in the region The network has been efficient in dividing responsibilities for bean research between the countries and its research has lead to innovations which are already visible at the farm level or whose acceptability has been positively assessed by farmers so that adoption is just a question of time and extension Crucial for the success of RESAPAC were gradual evolution from a forum for information exchange to a network of joint planning and evaluation allowing confidence building to take place commitment to a bottom up approach in guiding network activities clear orientation towards impact in farmers fields full responsibility of national programmes for network management and consequently full transparency in financial and administrative aspects and a set of rules for management elaborated and tested over time by all involved partners RESAPAC operates a system for joint disease evaluation of advanced lines which also serves for exchange of these lines between countries A common work plan is elaborated each year organized in regional research sub-projects which treat a topic of regional importance and may receive a financial contribution (up to 50% of total operating costs) from RESAPAC In 1993 41 sub-projects were co funded by RESAPAC This paper outlines objectives and in some cases results of these sub-projects RESAPAC will in the near future become fully independent from CIAT in terms of administration so that CIAT scientists in the region may concentrate entirely on research and advisory aspects of regional activities

INTRODUCTION

The Great Lakes Region of Central Africa includes the francophone countries of Burundi Rwanda and Zaire While Rwanda and Burundi are growing approximately 300 thousand ha of beans per year statistics for Zaire appear to considerably underestimate bean area estimated at between 500 and 750 thousand ha annually by the Zairian National Legume Program (PNL) Most important bean growing areas are located in the east of Zaire bordering Burundi Rwanda or Uganda Ecological conditions for bean production are thus similar throughout the region with altitudes ranging from 800 to well above 2000 m asl

The importance of beans is difficult to overestimate In Rwanda beans supply more than half of all protein consumed by the population (MINIPLAN 1988) and in Burundi bean consumption is the highest in the world

Despite the similarity of ecological (and socio-economic) conditions for bean production between the three countries at the micro level bean production systems are widely diverse Beans are produced in association with a wide range of other crops including banana maize cassava sweet potatoes and soybeans They are grown on fertile volcanic soils as well as on marginal soils Most of the production is for home consumption as dry beans green pods green seeds and leaves but some surplus areas produce for urban markets

Farmers respond to this diversity and to the adverse climatic conditions (high rainfall leading to the presence of virtually all bean diseases reported from Africa) with two strategies 1) wide genetic diversity and 2) varietal mixtures

This establishes favourable conditions for regional collaboration and division of responsibilities in bean research great importance of the crop agro ecological similarity among countries common language and common problems which are in some respects distinct from most other bean production areas in the world This paper describes the development of an efficient research network reports on important achievements to date and analyzes key aspects responsible for the success of this network

EVOLUTION OF THE REGIONAL BEAN RESEARCH NETWORK

The Great Lakes bean research network has evolved gradually over a long time In colonial times agricultural research was conducted in INEAC (Institut National pour l Etude Agronomique du Congo Belge) and considerable exchange of information took place among research stations now located in the three countries Yet here we concentrate on recent collaboration in bean research which gradually led to an informal network and now includes a joint work plan documenting the division of responsibilities

CIAT posted its first staff member in Rwanda in 1983 This triggered a series of research and training activities across the region In 1985 the first regional bean seminar was held in Bujumbura (IRAZ 1985) allowing for exchange of information and results A Steering Committee was constituted to guide the development of the network and its activities in 1986 In 1989 a first planning workshop (PPO Participatory Planning by Objectives) was held (Scheidegger 1989) In this workshop a three years planning framework for the network was elaborated by all participants together (national programme researchers and representatives of CIAT and the donor) and rules for Regional Research Sub Projects were established

In 1992 a second planning workshop (PPO) was organized this time with most bean researchers of the Region participating as well as representatives of extension and seed services development projects CIAT and the donor (Nyirarukundo and Scheidegger 1992) This workshop yielded a detailed planning framework for five years with research activities prioritized An acronym for the network was established (RESAPAC Reseau pour l Amelioration du haricot [*Phaseolae*] dans la region de l Afrique Centrale standing for Network on bean improvement in the region of Central Africa) In the same workshop a timetable for the network becoming more independent of CIAT was established By 1994 a network coordinator will be appointed by the Steering Committee and will work with the CIAT Coordinator for a year and work out the institutional setting for the network to allow for administration independent of CIAT

INTERNAL RULES OF THE NETWORK

After ten years of network operation and evolution based principally on the goodwill of all participants and verbal agreements the Steering Committee saw the need to document the rules which had developed over time for managing the network Therefore the Steering Committee of RESAPAC was established in March 1993 (RESAPAC 1993) Some aspects of these rules are summarized hereafter

Objectives

Promotion of bean research in the Region with emphasis on research projects likely to have impact in farmers fields

Exchange of results and germplasm between the institutions involved in bean research in the Region

Joint planning of bean research and training activities to arrive at a division of responsibilities between institutions and countries (i e to avoid duplication)

Means

Researchers From National Research Institutes Universities Development Projects and Non Governmental Organizations (NGOs)

Regional nurseries and trials

Regional Research Sub projects

Ruling bodies of RESAPAC

1 Committee of Directors (of National Research Institutes)
2 Executive Committee (constituted by the leaders of the Bean Programs of each country)
3 Regional Seminar (involving all bean researchers)

The above bodies meet at least once a year 1) and 2) are sometimes referred to as the Steering Committee The Regional Seminar is the interdisciplinary forum for exchange of research results A progress report on each regional sub project has to be given as a condition for continued contributions In working groups the results of each regional sub project are evaluated and the next year s workplans are discussed Proposals for new regional sub projects are presented and discussed This provides an excellent opportunity for peer review of the past and future of all regional sub projects Selected collaborators in extension and seed services development projects and NGOs of the host country are invited to the Regional Seminar to provide input

REGIONAL NURSERIES AND TRIALS

The most important of the regional nurseries is PRELAAC (Pepiniere Regional pour l Evaluation des Lignees Avancees en Afrique Centrale) a disease evaluation nursery The network assembles the nursery each year by contibution of the best lines from inermediate yield trials of individual breeding programmes The 1993 nursery (PRELAAC 6) consists of 100 bush lines and 49 climbers and is planted in two replications

The nursery is planted in 12 15 strategic locations throughout the Region and evaluated for all diseases occurring naturally To ensure that important diseases are evaluated under adequate and uniform inoculum pressure nurseries are artificially inoculated with the following diseases (one nursery per disease and site) (Buruchara 1991)

Burundi anthracnose halo blight
Rwanda anthracnose ascochyta blight rust BCMV
Zaire angular leaf spot BCMV

Assembly evaluation (two seasons) and compilation of results are scheduled in such a way that national programme breeders can use the results for taking their national decisions on whether to advance a line or not (Scheidegger and Nyabyenda 1991) This is possible by meeting anually to discuss results and to assemble new nurseries Presently the Rwandan National Programme is responsible for multiplying and distributing seed producing field plans and compiling results

REGIONAL RESEARCH SUB PROJECTS

As the network started out with disease evaluation and breeding activities shared among the participating countries the need to study diseases in greater detail (pathogenic variation identification of hot spots inoculation methods breeding plans) led to the first regional sub projects Consequently regional sub projects concentrated until 1989 mainly on biotic constraints

As progress was made in disease resistance soil fertility problems and other biotic stresses became more evident Intercropping situations needed to be addressed and it became clear that technologies developed without taking account of socio-economic constraints and their diversity would often not be acceptable to farmers In 1989 the Steering Committee decided to aim for the following allocation of resources in regional bean research

Policy on allocation of resources (1989)	
	Biotic stresses 35%
	Abiotic stresses 30%
	Socio-economic constraints 35%

In the same year participants in the network agreed on the following rules for the approval of sub projects (Scheidegger 1989)

Table 1 Rules for approval of regional research sub projects (from Kigufi 1989)

The topic of the sub project must be of regional priority (of interest to at least two countries)
The sub project must make a methodological or substantive advance
The proposing national programme must bear at least half of the total research costs
The national programme must have an interested researcher to conduct the sub project
The national programme must have the necessary ecology and infrastructure
The sub project must have verifiable indicators on a three years horizon
The sub project should be likely to lead to impact in farmers fields

Regional sub projects are typically proposed by a team or individual researchers and discussed in working groups during the regional seminar Based on the comments and suggestions from peers and Steering Committee members during these discussions the researcher then elaborates the project into a logical framework format (stating objective expected results indicators activities etc) with a workplan and budget (showing contributions by the national programme and the contribution requested from the network) for the first year It is the leader of the respective national programme who submits a proposal to the Steering Committee

For existing sub projects discussions during the Regional Seminar concentrate on obtained results and the future workplan Objectives are only revised if a major change in the orientation of the sub project is suggested

During its meeting in January the Steering Committee discusses and modifies each sub project integrates all sub projects into a coherent workplan and allocates the contributions of the network If activities of one sub project are to be conducted by different institutions the Steering Committee makes sure that workplan and budget are sufficiently detailed to avoid all future misunderstandings between these institutions

Table 2 gives a summary of the workplan for 1993 and illustrates how the Steering Committee allocates responsibilities and resources based on the above rules and the proposals of individual researchers The number of sub projects conducted by each country reflects the strength of national programmes in terms of human resources CIAT scientists may conduct sub projects yet they take care to propose only topics for which national programmes do not have the capacity

Table 2 Summary of the 1993 workplan of the Great Lakes bean research network (RESAPAC)

Country/ Institution	Number of sub projects con ducted	Financial contribution of RESAPAC to the sub projects (in 1000 US$)
Burundi	8	14 4
Rwanda	12	26 0
Zaire	17	22 0
CIAT	4	9 4

Table 3 gives the full list of sub projects for 1993 The workplan is made up of 41 sub projects Sub projects dealing with biotic stresses receive 41% of the total network contribution while 32% are reserved for abiotic stresses and 27% for socio-economic constraints However classification of individual sub projects into one of these groups is somewhat arbitrary Increasingly socio-economic constraints need to be tackled in all research projects and Table 3 indicates those sub projects containing a significant socio-economic component Similarly the heavy emphasis on genetic solutions observed in the past could now be complemented with agronomy components

Table 3 illustrates the nature of collaboration between countries followed in RESAPAC Each country has for example sub projects dealing with pathological aspects This allows each national programme to build up its pathology expertise But pathologists are specializing on different diseases In some cases it may be necessary to study similar aspects in two countries (two sub projects) as with anthracnose where it was judged safer to study the variability of the pathogen in Burundi and Rwanda separately rather than moving the isolates over the border

Many of the sub projects started recently This of course means that others were concluded Increasingly sub projects are proposed on the basis of preliminary trials or studies and if not they are allocated only small amounts of funds to allow for such exploratory work which will then lead to a more detailed proposal (or to abandoning the topic)

Table 3 Regional research sub projects funded in 1993 Great Lakes

Title	Institute	First year	Funding 1993 000 US$	Agronomy component	Socio economic component
Biotic stresses					
CBB resistance	PNI	91	1 6		
Halo blight resistance	ISABU	90	2 2		
Black root screening	ISAR	93	1 4		
Anthracnose pathogen	UB	92	0		
Anthracnose varieties/pathogen	ISAR	90	1 7		
Ascochyta integrated control	ISAR	88	3 0	*	
ALS resistance	PNI	89	1 6		
ALS pathogen	PNI	90	1 3		
Root rots incidence resistance	UNR	89	2 1		
Root rots cultural methods	CIAT	90	3 8	*	*
Diseases and mixtures	PNI	92	1 2	*	*
Multiple resistance low altitudes	PNI	93	1 7		
Multiple resistance mid altitude	ISAR	92	1 4		
Interaction root rots bean fly	ISABU	93	2 4	*	
Bean fly integrated control	PNI	93	0 4	*	
Storage technologies	PNI	93	0 5	*	
Abiotic stresses					
Intercropping with bananas varieties	ISAR	90	0 9		*
Intercropping climbers with bananas agronomy	PNI	91	1 7	**	
Intercropping with maize varieties	PNI	89	1 3		
BNF strains	ISABU	92	1 7		
BNF varieties and extension	ISAR	89	2 6		*
BNF soils and agronomy	PNI	92	2 2	*	*
Production on acid soils	PNI	90	2 0	*	
Fertilization long term	ISABU	92	2 3	*	
Effect of climbers on soil fertility	PNI	93	1 4	*	
Drought tolerance	ISAR	93	0 9	*	
Adaptation to valley bottoms (low altitudes)	PNI	90	1 2		
Adaptation to valley bottoms (mid altitudes)	ISABU	93	2 6		
Socio-economic constraints					
Farmer experimentation concepts	PNI	92	1 4	*	
Farmer perceptions on soil fertility	PNI	93	0 5	*	*
Stake production	ISAR	92	1 1		*
Climber promotion	ISAR	90	2 0		*
Climber adoption	PNI	92	1 1		*
Impact/adoption studies methods	CIAT	90	2 8		*
Farmer participation in breeding	CIAT	90	1 7		*
for enhancing genetic diversity	PNI	93	0 9		*
Dynamics of local mixtures	ISAR	93	1 7		*
Seed systems	CIAT	90	1 1	*	*
Variety diffusion circuits	ISABU	93	1 1		*
Limiting factors for production	ISABU	93	2 1	*	*
Nursery multiplication	ISAR	90	7 2		
Total (41 sub projects)			**71 8**	**15**	**18**

National Agricultural Research ISABU = Burundi ISAR = Rwanda PNL = Zaire UB = University of Burundi UNR = National University of Rwanda

Summary of objectives and selected results of regional research sub projects

Common bacterial blight (CBB) threatens bean production especially in lower altitudes Considered of secondary importance for the region it was included in the research agenda after problems arose with susceptible new varieties The major activity is resistance breeding carried out in two lowland bean research stations in Zaire

Halo blight was especially notorious in the highland areas of Burundi where several releases made ten years ago are susceptible The sub project is making back-crosses with those releases and sources of resistance of local origin

Black root screening was considered necessary because of the more and more active breeding programmes in the region They often have to use I gene material as sources of resistance which makes it necessary to screen obtained materials for the presence of the unprotected I gene National programmes will not release lines with unprotected I genes Exploratory trials showed that a simple design using seed infected AFR 13 spreader rows may be very efficient in detecting I gene lines

Studies of pathogenic variation are conducted for anthracnose and angular leaf spot (ALS) and have the following goals first a region wide sampling is to give a general picture of race distribution intensive sampling in currently used or possible 'hot spots should show how the regional race spectrum is represented in the hot spots This then allows us to elaborate a more efficient strategy for disease evaluation and gene deployment Preferably this is done in one hot spot under artificial inoculation with races occurring naturally there Yet it may be necessary to work in two or more hot spots to cover the whole race spectrum In the worst (most expensive) case inoculation with all races found in the region may be necessary which would be done in greenhouses

Anthracnose is dealt with by two sub projects In Rwanda resistance breeding produces some several hundred F_2 populations per year which are then subjected to field inoculation (Gasana and Buruchara 1992) and later to inoculations with races identified in Rwanda in the screenhouse In Burundi a pathologist concentrates on mapping the anthracnose race spectrum and contrasting it with extensively sampled 'hot spots Both sub projects are coordinated in such a way that direct comparisons are possible (e g same set of differentials) and should allow for developing a more efficient (regional) breeding strategy to deal with this pathogen

The **Ascochyta** sub project complements resistance breeding with research on cultural methods to control the disease

Angular leaf spot (ALS) is together with anthracnose the economically most important disease in the region (Buruchara 1992) A sub project on resistance breeding started in 1989 and has already identified promising lines in Zaire which are now also in on farm testing in Rwanda Later a study of pathogenic variation was initiated confirming to date the validity of Mulungu (1750 masl) as a hot spot for ALS An earlier sub project on ALS (concluded in 1989) focused on the effects of including resistant components into farmers mixtures It was shown that proportions of 25 and 50% of the resistant variety A 285 reduced the development of ALS also on susceptible farmers varieties (Pyndji and Trutmann 1992) and that a mixture containing 50% of A 285 yielded as much as (or even more than) A 285 alone and considerably outyielded local mixtures (Pyndji and Trutmann 1989)

Root rots became a topic for bean production in 1988 when a major outbreak destroyed bean crops in large areas of the southern less fertile areas of Rwanda A first sub project concentrated on species determination responsible for damping-off as a basis for subsequent screening of material for resistance and tolerance The main problem for resistance breeding is that several species are involved

(Rusuku 1991) which makes resistance breeding slow Therefore short term solutions have to be found in the form of cultural practices By incorporating fast decomposing biomass (foliage of some leguminous agro forestry species) shortly before planting beans it was possible to reduce damping-off and disease severity and to increase yields considerably (Buruchara 1995) In fact the effect was so evident that farmers who have long been exposed to the concept of agro forestry for soil fertility improvement but did not adopt it have now started to grow these species to control root rots

Diseases and their interaction in varietal mixtures are studied in a sub project to see if the encouraging results achieved with ALS can also be realized with other diseases A special challenge of this sub project is to find a realistic approach to extension of the concept It will always be farmers who design their specific mixtures but in this case research not only provides components (varieties) but also the biological principals on how best they are integrated into farmer designed (customized) mixtures

Multiple resistance i e the development of bean varieties that are resistant to several diseases occurring in a eco zone is the ultimate goal of all breeding efforts in the region The two sub projects look for the most efficient way to achieve this In both sub projects making available segregating populations (F_3) to other breeding programmes should allow for a short term benefit of regional collaboration

Bean stem maggots have been studied extensively in Burundi over the last ten years Recently a sub project was initiated to learn more about their interactions with root rots Another sub project looks into the possibility of non-chemical control

Bananas are the most frequent intercropping partners for beans in the region One sub project is addressing the question whether a separate screening programme is necessary to select varieties suitable for growing in banana plots As in Uganda (Wortmann et al 1992) no genotype x system interactions were found with bush type beans but with climbers such interactions exist (Cishahayo *et al* 1992) The question now is whether performance under bananas may be predicted by farmers during evaluation of normal sole crop trials Climbers were until recently rarely planted under banana and in some areas not even bush beans are associated A second sub project looked into the agronomy of the climber banana association in an area of low soil fertility There this association may deal with two problems at a time Soil fertility in the banana plots is the highest on the whole farm (Elukesu 1992) and banana stands and residues may provide an alternative for staking climbers Trials have shown that the potential of this association is such that it incites farmers to plant climbers into their bananas even if it means a considerable change in the traditional gender pattern of responsibilities Together with farmers several options were developed which replace wooden stakes partially or fully as support for the beans with banana leaf fibers and banana pseudostems (Elukesu 1992)

Intercropping beans with maize is common in some areas of the Great Lakes As for bananas the question arose whether a separate screening program was needed to identify suitable genetic material for this association Both on station trials and reactions from collaborating farmers show that for the common maize genotypes less vigorous climbers are needed if maize is to replace wooden stakes Farmers stake the present climbing varieties when intercropped with maize It was shown that breeding trials may well be done in rows (easier to manage on station) instead of the broadcast planting usual for farmers

Biological Nitrogen Fixation (BNF) is the topic of three sub projects First results with a selected *Rhizobium* strain on local varietal mixtures have shown that the effect of *Rhizobium* inoculation is only moderate (12% yield increase) Work is therefore proceeding on the three components of BNF *Rhizobium* strains (where many local isolates are included) the bean variety and soil conditions as they affect BNF (including conditions which may be altered by cultural practices) The goal is to better target the use of *Rhizobium* Especially for climbers which are often grown as a single variety results show that response to inoculation may be highly profitable (Hakizimana *et al* 1992) Response also seems to be more consistent on plots where organic manure has been applied the season preceding the trial

Production of beans on acid soils is frequent in the region In the context of this sub project primary screening for tolerance to aluminium toxicity is conducted More recently trials have been conducted to alleviate aluminium toxicity with green manure

Fertilization of beans with mineral fertilizers is being studied in a simple rotation over several years in Burundi where mineral fertilizers are readily available to farmers

Effects of climbing bean production on soil fertility are being examined as climbers with their higher yields are likely to increase export of nutrients from the soils as compared to bush beans

Drought tolerance is important especially in lower altitudes The sub project concentrates on selection under drought conditions which are obtained by varying planting dates Production under drought stress is being studied in varietal mixtures

Adaptation to valley bottoms is sought in two different ecological conditions Production of beans on residual moisture in valley bottoms is likely to require very different genotypes to those grown during the more important rainy season

Farmer experimentation concepts are important to understand as the network s strategy leaves research and fine tuning of many aspects explicitly to farmers (varietal evaluation for quality characteristics design of varietal mixtures planting dates and densities etc Scheidegger 1991) A first study shows the extent of farmer experimentation All of the 80 farmers interviewed in Zaire (only farmers without contacts with research or extension were considered) had experimented on their own with several alternatives of growing climbers Climbers are a new technology in the area and this intensive farmer experimentation has taken place only over the last 2 3 years

Farmer perceptions of soil fertility are studied in a new sub project with the goal of more efficiently involving farmers in the development of respective technologies

Climber promotion was originally conceived as a sub project to systematically study different alternatives and prerequisites for the promotion of this promising option Given the very dynamic adoption of climbers by Rwandan farmers over the last four years the sub project now focuses more on learning most from this development for the benefit of the two other countries and of other technologies Stake production originally part of this sub project developed into a sub project of its own when the goal was no longer to develop possibilities as a prerequisite for climber adoption but rather to offer options for sustained use of climbers

Climber adoption is being studied in Zaire with two goals studying socio-economic and agronomic conditions for climber adoption should help to better target promotion in other areas and careful planning and documentation of the study should constitute progress in methodology

Impact and adoption studies in the region pose several methodological problems the most important in relation to varieties being that most beans are grown in mixtures Several methods for measuring adoption were tested and compared

Farmer participation in breeding may help speed up variety development and result in varieties that are more acceptable to farmers Earlier results showed that farmers can put to use a much wider range of varieties than conventional breeding schemes can produce The sub project compares a scheme with full responsibility for selection given to farmers like the intermediary yield trials with the conventional Rwandan scheme A new sub project conducted in Zaire aims at implementing farmer participation in breeding by working through local NGOs and extension agencies Here the effect of farmer involvement on genetic diversity used at farm level will be studied

Dynamics of local mixtures is studied to better understand the evolution of mixtures over time and how this is influenced by the incorporation of improved varieties The composition of varietal mixtures changes considerably between seasons without deliberate selection Farmers adjust varietal composition to correct for this but sometimes they purposefully constitute different mixtures for different seasons and they often add or subtract entire components This interaction of biology and man may have implications for variety development extension strategies epidemiology and genetic diversity

Seed systems are crucial for ensuring that new varieties become available to farmers The sub project studied existing systems to identify the most promising points and flows to inject the seed of new varieties It was found that formal channels reach a very small percentage of farmers Most farmers try out a new variety on small scale Test sales of new varieties in such trial quantities (50 250 g) showed that farmers readily paid two to three times the market price for common seed (Sperling *et al* 1993) The new sub project on variety diffusion is studying farmer to farmer diffusion at village level

Limiting factors for bean production are being studied at the micro level to better understand the importance of different constraints and their interactions

Nursery multiplication Regional nurseries and trials are multiplied centrally in Rwanda for subsequent distribution to all test sites

CONCLUSIONS AND FUTURE PERSPECTIVES

RESAPAC has made bean research in the Great Lakes more efficient by dividing responsibilities between its partners in other words by avoiding duplication Even where duplication still seems to persist the individual actors are well aware of it and it is often intentional responding to specific situations In discussions with their management and policy makers bean programme researchers in the three countries regularly stand out by knowing exactly what is done in terms of bean research in neighbouring countries and throughout Africa and how this complements their national efforts

This division of responsibilities in the context of RESAPAC is the result of ten years of evolution Simple exchange of information was crucial for the partners to know eachother Common planning and execution of nursery evaluations further helped to build confidence in the strengths of eachother These were important intermediate steps towards joint planning resulting in a division of responsibilities between partners

Regional collaboration in RESAPAC was specifically efficient in the following situation

sharing the work of disease evaluation by taking advantage of ecological differences between the different research stations and the concept of hot spots (regional nurseries)
region wide studies with similar methodologies (seed systems)
development of a research methodology in one site (farmer participation in breeding impact/adoption studies)
development of ideas and options in one site to make adaptive research in other sites easier and faster (introduction of climbers staking intercropping climbers with bananas)

Varieties are the most evident output of regional collaboration which can be transferred with relatively little further testing to other areas Agronomic practices and options to overcome socio economic constraints are often more site specific Many proposals for sub projects in these domains have been refused by the Steering Committee for their site specificity Yet in order to make more progress in non genetic solutions it may be justified in the future to support more projects aiming at the development of options for specific sets of agro-ecological conditions RESAPAC has shown that if options are adapted and adopted by the target farmers adaptive research needed to develop similar options for other areas and conditions is much easier and faster

Bottom up approach to management of RESAPAC is crucial to the success of the network Most potential researchers participate in planning workshops and thus feel committed to the mid term planning framework The Steering Committee has several times resisted the temptation of imposing sub projects even if the respective topic had been given high priority in the planning framework All sub projects to date were initiated by teams of individual scientists This ensures their commitment to the work

In spite of this bottom up approach RESAPAC has demonstrated that it is possible to change the orientation of research and to respond quickly to new situations In 1993 the allocation of resources to the three groups of constraints as shown in Table 3 is reasonably close to the goals set in 1989

Self-evaluation is crucial in ensuring efficiency and transparency within RESAPAC It takes place at two intervals annually all sub projects are evaluated technically during the Regional Seminar in a peer review process and sub project leaders have to give their own account on execution of activities to the Steering Committee Indicators for the whole network as well as for individual sub projects are formulated for phases of three years Table 4 illustrates indicators at network level for the present phase ending in 1995 (Nyirarukundo and Scheidegger 1992) Most of these indicators ultimately stress impact at farm level For individual sub projects their leaders have to specify with their indicators if they aim directly at technology development or at methodological advance which in the long run may be equally important for the overall progress of agricultural research

Both technical planning and evaluation as well as administrative procedures in the network aim at maximum transparency and decentralization of responsibility This seems to be crucial for the efficiency of RESAPAC Researchers national programme leaders and members of the Committee of Directors are highly committed to the network activities because they have been jointly responsible for shaping RESAPAC for elaborating the mid term planning framework and for putting up the annual workplan and budget Presently CIAT personnel in the region acts as some kind of executing secretary in network management executing the decisions of the Steering Committee and reporting back to it

Table 4 Introductory part of planning framework RESAPAC 1993 1995

Logic of intervention		Indicators (due in 1995)	Sources of verification
Global objective	Increase of bean production		
Specific objective	Increase of bean productivity	2000 farmers in each of two areas per country have adopted a technology which increases their yields by 25%	Reports of sub-projects and National Programs
Expected intermediary results	1 Several high-yielding varieties are available	Per zone ten varieties with specific adaptation made available (exploit the potential of niche varieties)	Reports of National Programs
		25% of entries in the multilocational trials outyield the local mixture (effectiveness)	Reports of trials
	2 Yield potential of beans is better exploited	For each long term research project there exists an *ex ante* evaluation and an acceptability study (relevance)	Workplan and reports of sub-projects
		30% of farmer collaborators have increased their yields through non-genetic technologies by 15% (effectiveness)	Reports of sub-projects
		Two non-genetic technologies are adopted by 30% of collaborating farmers (acceptability)	Reports of sub-projects and National Programs
		For each of nine different zones in the region one acceptable technology is identified (cope with diversity)	Reports of sub-projects and National Programs
	3 More of the improved varieties are present at farm level	80% of released varieties are cultivated by at least 1% of target farmers (genetic diversity)	Reports of National Programs
		10% of farmers in the whole region use at least one released variety (impact)	Adoption studies

* Acceptability studies (acceptability defined as continued use by collaborating farmers) are to be part of most sub projects

All partners in the network agreed that in times of decreasing CIAT presence in Africa CIAT scientists should concentrate on their role as researchers rather than on administrating the network Therefore as outlined above the network is evolving towards even more independence from CIAT The Steering Committee is presently recruiting a regional coordinator to be hired locally in 1994 He will work alongside the CIAT regional representative as coordinator of the network for one year During this time the legal context for the network will have to be defined so that the network will be in a position to hire personnel and to receive funds As of 1995 CIAT will no longer play a role in network administration and management By 1995 the network should be in a position to take care of all administrative aspects (including receiving funds directly from donors) which will allow CIAT researchers based in the Region to concentrate fully on research and on scientific and technical advisory aspects of regional activities CIAT will continue as a partner in the network thereafter

This process will be easier as the culture of full transparency is already part of the network and suitable administrative procedures are already established The Steering Committee of RESAPAC declared its intention of keeping the legal and administrative structures as sleek as possible Using the umbrella of a National Program or founding a non profit organization registered in the country of residence of the regional coordinator will be evaluated as alternatives in 1994 The donor has declared its intention of continued support to RESAPAC

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DISCUSSION SESSION VIII REVIEW OF REGIONAL PRIORITIES

Paper by C Wortmann

The presentation stimulated discussion on what should be done by Network members to achieve better adoption and impact at the farmer level

As the current shortage of research resources is apparently here to stay research needs to be better targeted greater use should be made of farmer participatory techniques to achieve development in a less expensive manner and the development and use of better techniques for extrapolating successful technology should be promoted The Steering Committee could give emphasis to lower input technology

Many participants have worked with farmers but perhaps we need to pay more attention to whom we are working with to ask ourselves if this person is of the kind for whom the technology was conceived and is this the person who will make the decision in the family as to whether this technology will be adopted (remembering that these are not necessarily the same person)

Techniques exist both for ensuring that the sample of collaborating farmers is representative and for eliciting accurate responses from farmers These methods should be used Social scientists employ methods which are as precise as those routinely used by biological scientists

Paper by U Scheidegger

There is a RESAPAC sub project on FPR in breeding This started from the concern that specific ecological and wealth class niches can be found by farmers for many of the lines discarded in a classical breeding scheme In this sub project farmers visit the station to select from among 50 80 materials make comments on their selections and are allowed to take their selections home These farmers subsequent decisions and management of the materials are monitored

On institutionalization of the Network it is expected that RESAPAC by 1995 should be able to receive funds direct from donors Dr Scheidegger expressed confidence that the impact being achieved will continue to generate financial support for the Network CIAT would then participate in the Network as a technical partner and not as administrative coordinator The transitional period leading to 1995 has already been budgeted with the donor

WORKING GROUPS ON PRIORITIES FOR SUB PROJECT RESEARCH AND SUPPORTING ACTIVITIES IN EASTERN AFRICA

TASKS

Four working groups of participants met to contribute to the Network s efforts to improve its orientation and performance Each working group was asked to do the following

*To review the EABRN planning framework drafted by the Steering Committee (1992) to identify any important gaps in priorities and suggest improvements in corresponding activities

*To identify a set of independently verifiable indicators of network performance

*To suggest indicators by which the performance and achievements of each of the regional sub projects should be monitored over the next two/three years

Participants worked in four groups formed according to their areas of intended research impact

(a) Resource poor and semi arid environments
(b) Higher rainfall environments with potentially higher levels of external inputs
(c) Soil related constraints
(d) Seed related constraints

AMENDMENTS TO EABRN PLANNING FRAMEWORK AND INDICATORS OF NETWORK PERFORMANCE

Objective 1 To strengthen and sustain national research programmes

Amendments

The role of NARS in implementation of EABRN priorities needs strengthening in the Network s organogram including NARS research national extension efforts

Circulation of research results within the region is still inadequate and needs more attention

Indicators

Farm level production constraints better understood and reflected in national work plans Annual national bean research work plans available Review meetings on bean research held regularly Bean research priorities developed formally approved and reviewed periodically

Improved utilisation of available resources by NARS through more cost-effective methods

More technology being adopted by farmers

Number of research publications

Objective 2 To improve sustainability of the Network

Amendments

Improved flows of information among national programmes e g routine circulation of national bean researcher lists national strategic priorities annual bean research plans and annual reports

More sub projects should specify the interactions to be catalysed among participants including across countries

Pan African collaboration would be particularly effective in some areas such as drought and the development of climbing beans (both for strategy development and for distribution of germplasm) Greater focus by the Steering Committee (SC) on overcoming problems especially through multi disciplinary approaches The SC could also define and publicise its balance among areas of intervention (biotic vs abiotic constraints technology transfer training etc)

Regional workshops working group meetings trials and nurseries should continue Continuation of monitoring tours received strong endorsement

Indicators

At least 20% of farmers collaborating in trials have adopted new technology

Bean yield increased by 5% and production by 7% across the region in 3 years

Objective 3 To reduce biotic and abiotic production constraints through genetic improvement

Amendments

Countries vary greatly in the extent to which they have attempted to target the collection of local germplasm and increase germplasm diversity by means of multiple releases of new varieties

The need for more exchange of germplasm among countries was a recurring theme Germplasm nurseries organised by agro-ecological zones (and in some case on a pan African basis) require more attention in their implementation

Indicators

National germplasm collections catalogued and simple low-cost reliable storage methods in use National collections duplicated elsewhere for safety Better representation of this zone in global collections

Wide genetic array available for selection by farmers and by researchers

Eastern Africa zonal nursery and yield trial (EAZBEN and EAZBYT) in operation and breeders seed directly exchanged between national programmes

More bean varieties released 2 3 new varieties per zone of intervention At least 10 advanced lines developed per zone of intervention Multiple variety releases accepted as desirable practice

Objective 4 To improve cropping systems

Amendments

Give more attention to non genetic solutions to biotic constraints e g IPM

Improved utilisation of available resources by farmers

Indicators

Increased productivity in target areas (e g in low potential or marginal environments bean production increased by 5% through improved cropping systems)

Losses from target pests and diseases reduced

Objective 5 To increase the market potential of beans

Amendments

Much progress was noted in assessing market preferences but further efforts are justified The development of new bean products such as the Kenya samoza warrants following up in other countries

While export trade in snap beans is well documented the important cross border trade in dry beans deserves similar attention

Indicators

Increased market demand for beans

Storage losses due to bruchids reduced at least 10% in target zones

Add a study on human nutritional aspects including bean quality

Objective 6 To improve technology transfer

Amendments

It should be a major Network activity to increase farmers participation in research On station evaluations by farmers has been tried in some countries but elsewhere needs more encouragement Researchers need more exposure to FPR techniques

Developing research extension linkage by reciprocal invitations to meetings is important but not adequate Experiment with inexpensive research-extension linkage approaches during on farm testing and aim at solid output of technical bulletins

Too little is being done outside the Great Lakes region on documenting non formal seed systems that could be used in disseminating new varieties Financial support here would be useful

A pan African beans newsletter would be appreciated

Indicators

Sub project on non formal seed systems in operation in all countries where these systems are not currently utilised Non formal seed systems better understood

Pamphlets available to extension and farmers on new agronomic practices and on varieties

At least one evaluation visit annually by farmers to each bean research station in the region At least one technology per zone selected by farmers from on station trials and being tested by farmers

More farmer managed trials in all zones At least one farmer designed trial in each zone

FPR training for all disciplines in bean research At least one FPR course held in each principal group of researchers/technicians Each researcher demonstrates that knowledge gained from FPR is incorporated in his/her programme

Farmers in all major socio-economic categories have better understanding of the formal research agenda At least 25% of a sample of farmers in each zone have tried at least one new variety released within previous three years

SPECIFIC INDICATORS SUGGESTED FOR CURRENT REGIONAL SUB PROJECTS

(a) Resource poor and semi arid environments

Sub project	Indicators
Variety development for semi arid areas (Kenya)	Selected genotypes perform well in on farm trials and evaluated by national bean program Regional nursery of selected lines distributed
Drought tolerance (Ethiopia)	
Tolerance to low nitrogen soils (Ethiopia)	
Biological nitrogen fixation (Ethiopia)	
Minimum tillage (Kenya)	Cost effective good return to labour Farmers adopt the technology Technical manual produced
Water harvesting (Kenya)	

(b) Higher rainfall environments with potentially higher levels of external inputs

Anthracnose (Ethiopia)	Yield losses assessed in the region Pathogen races identified in areas at risk 15 advanced lines with resistance available
Phoma blight (Uganda)	10 resistant varieties available Yield losses determined in main areas at risk
Rust (Ethiopia/Madagascar)	Two or three resistant varieties released 20 resistant lines advanced in natl programmes
French bean varieties development (Kenya)	5 advanced lines with improved rust resistance in on farm trials 100 segregating populations at F_6 collection of snapbean genotypes undergoing characterisation
IPM in French beans (Kenya)	Number of insecticides reduced from 24 to 3 Farmers using alternatives to pesticides increased from 6% to 80% Pesticide residues reduced to a level acceptable to the export market

(c) Soil related constraints

Tolerance to low phosphorus soils (Kenya)	Tolerant varieties identified and adopted Parental lines identified and used in crosses Varietal screening method available
Tolerance to manganese toxicity (Uganda)	Rapid lab screening technique available Tolerant materials identified Farmer adoption of tolerant varieties Tolerant genotypes utilised in breeding
Resistance to *Macrophomina* (Kenya)	Availability of resistant materials Effective screening method in use Resistant lines used in breeding Resistant varieties adopted in dry areas
Plant nutrient fluxes (Kenya)	Database developed on nutrient transfer
Management of acid soils (Madagascar)	[not attempted]
Farmer participatory research on soil fertility (Uganda)	No of trials successfully completed No of farmers adopting practices No of scientific papers published
Bean stem maggot (Ethiopia)	Resistant sources identified Resistance breeding programme in operation Cultural control methods developed

(d) Seed related constraints

Seed dissemination channels (Kenya)	Survey completed and findings documented Recommendations disseminated
Seed dissemination methods (Ethiopia)	No of farmers receiving seed and amounts distributed documented annually Adoption and persistence of varieties assessed
Bruchids (Uganda)	Technologies generated resistant varieties and management practices are available Technologies made available within region (publications availability of varieties) Technology adopted by farmers
Angular leaf spot (Kenya)	ALS pathogen variation understood in the region Losses quantified Resistant sources identified Regional resistance nursery distributed
Common bacterial blight (Uganda)	Pathogenic variation understood Pan African nursery distributed and utilized in 5 countries Resistance is incorporated into 6 landraces More varieties with CBB resistance are released Presence or absence of linkage of resistance with undesirable traits determined
Bean common mosaic virus (Uganda)	500 lines screened for resistance in 10 countries Regional nursery distributed 100 genotypes screened for seed transmissibility Improved procedure for large scale screenhouse screening 50 suspected wild hosts evaluated Crop losses assessed

PLENARY SESSION TO DISCUSS WORKING GROUP REPORTS

The role of farmers is mentioned in all sub projects but why is this not explicit in the EABRN organizational chart? Agreed that the chart needs to be modified accordingly

Is seed quality really of concern to farmer producers of this crop? Most available studies suggest that producing clean bean seed is not economic (expensive seed little yield benefit and no yield benefit beyond the first season) Exceptions seem to be snap beans and dry beans in Mauritius both probably present new requirements in this respect

Should regional germplasm nurseries be decentralised (i e organised separately for specific constraints by the principal researcher or sub project) or centralised (with the CIAT regional programme)? It is logistically easier to send out a single unified nursery but this means more work for collaborators in evaluating it There was a consensus in favour of sub projects (and others) developing more specific targeted nurseries

Should the performance indicators being developed for the Network and for individual sub projects be applied by Network members or should those outside the Network have the responsibility for monitoring? Participants agreed that indicators should be used by each sub project in self-evaluation with resulting information being provided in reports for others (e g the Committee of Directors) to review

In conclusion the Steering Committee is expected to provide feedback to sub projects on their performance indicators as soon as possible

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CLOSING ADDRESS

Mrs M N Wabule Assistant Director (Horticulture), Kenya Agricultural Research Institute[1]

Mr Chairman Distinguished Guests CIAT Officials Participants Ladies and Gentlemen I feel much privileged to be invited to come and close this workshop which I consider to be very important because beans play a great role in human nutrition in eastern Africa It is therefore important that bean scientists should develop appropriate technology quickly in order to meet the ever increasing demands of this commodity I believe workshops of this nature will help a great deal to exchange ideas on the latest development of this crop I have noted with great satisfaction that the workshop has drawn scientists of various countries who are practitioners in this field It is my belief that in the course of your five days deliberation you have been able to examine the bean crop much more closely and identify some teething troubles affecting it I would assume that you have in addition come up with practical suggestions on how these problems can be solved in order to improve bean production I must assure you that KARI will critically study your recommendations and see how best they can be implemented for the sake of assisting farmers

Mr Chairman before declaring this workshop officially closed allow me to make some few remarks which I consider to be important to bean production in Kenya We all know that beans play a vital role in the economy of this country as has been clearly recognized by government in its various policy papers and statements notably the sessional paper No 4 of 1981 on National Food policy and the sessional paper No 1 of 1986 on Economic Management for Renewed growth with which I believe some of you are quite familiar The first of these papers mainly revolves around production of sufficient food and generation of employment to cater for our rapid growth of population presently estimated to be over 22 million people and expected to jump to over 35 million people by the turn of the century Beans as a food crop plays an important role in meeting these challenges particularly in the area of nutrition employment foreign exchange earning and income generation

Although food and snap beans are important in this country they are not without problems There are those problems related to production which involve quality in snap beans and poor yields in food beans To a large extent these affect the level of production and the quality of produce It must be clearly understood that use of sub standard inputs by farmers may not only result in reduced yields but may in the long run result in increased build up of diseases and pests which can be a threat to future production We must also encourage effective feedback from farmers as they also have their own experiences which could be useful when integrated with research findings

Finally I must point out that the knowledge gathered from this workshop will serve no useful purpose unless it reaches the farmer in the manner he can understand so that he will be able to improve his farming practices I therefore trust that you will disseminate the information acquired to the farmers With these few remarks it is my pleasure to declare this workshop officially closed

Thank you

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[1]Presented by Mr D O Michieka Director KARI National Horticultural Research Station Thika

PARTICIPANTS LIST

Name	Discipline	Address
Canada		
George Weber	Agricultural Officer	CIDA 200 Promenade du Portage Hull Quebec KIA 0G4 Tel 819 994 4106
Ethiopia		
Habtamu Admassu	Agronomist	Institute of Agricultural Research (IAR)
Melaku Ayele	Plant Breeder	Nazreth Research Center
Aberra Deressa	Research/Extension Liaison	P O Box 436 Nazreth
Teshome Girma	National Bean Coordinator	Tel 251 2 112186/110045 Fax 251 1 611222
Alelign Kefyalew	Agricultural Economist	
Senait Regassa	Agricultural Economist	
Senayit Yetneberk	Food Scientist	
Tesfaye Beshir	Plant Pathologist	Plant Protection Research Centre P O Box 37 Ambo Tel 251 1 115912 Tlx 21568
Getachew Kassaye Gome	Agronomist	IAR Awassa Research Center
Tenaw Workayehu	Agronomist	P O Box 6 Awassa Sidamo Tel 251 6 200224/200045
Mitiku Haile	Soil Scientist	Alemaya University of Agriculture P O Box 138 Dire Dawa Tel 251 5 112374 Fax 251 5 112515
Kenya		
J J Anyango	Microbiologist	Kenya Agricultural Research Institute (KARI) National Agricultural Laboratories P O Box 14733 Nairobi Tel 254 2 444144 Fax 254 2 444144
Wilson K Rono	Plant Breeder	KARI National Dryland Farming Research Centre
Wilson Songa	Plant Pathologist	Katumani P O Box 340 Machakos Tel 254 145 30624 Fax 254 145 30186
J K Kamau	Plant Breeder (Beans)	KARI National Horticultural Research Centre
S I Kanyagia	Coordinator Bean Programme	Thika P O Box 220 Thika
Agnes M M Ndegwa	Agronomist	Tel 254 151 21281/2/3/4/5
Susan M W Munene	Agricultural Economist	
David O Micheika	Centre Director	
Mercy W Wanjiru	Agricultural Economist	
Ngari Macharia	Agronomist	KARI Regional Research Centre Embu
John G N Muthamia	Agronomist	P O Box 27 Embu Tel 254 161 20116

PARTICIPANTS LIST (continued)

Name	Discipline	Address
Kenya		
Sammy Ajanga	Plant Pathologist	KARI Regional Research Centre Kakamega
R M Otsyula	Plant Breeder	P O Box 169 Kakamega
Gedion O Rachier	Agronomist	Tel 254 331 30031/30039
Felister Makini	Plant Pathologist	Kenya Agricultural Research Institute Regional Research Centre Kisii P O Box 523 Kisii Tel 254 381 20527
Isaac Mulagoli	Senior Agricultural Officer	Ministry of Agriculture P O Box 30028 Nairobi Tel 254 2 718870
R I Jasdanwala	Senior Lecturer	Moi University Department of Botany P O Box 3900 Eldoret
Paul M Kimani	Senior Lecturer/Breeder	Department of Crop Science University of Nairobi
Isanda George Omwenga	Student	P O Box 29053 Nairobi
Agnes W Mwang ombe	Senior Lecturer/Pathologist	Tel 254 2 632211/632141/632175
John H Nderitu	Senior Lecturer/Entomologist	
Beatrice Anyango		Department of Botany University of Nairobi P O Box 30197 Nairobi
A F F Palmer	Project Coordinator	CMRT Project/CIMMYT P O Box 677 Njoro Tel 254 37 61456 Fax 254 37 61145 Tlx 30375
Hudson J Masambu	Program Specialist	USAID/REDSO/ESA P O Box 30261 Nairobi
David Martella	Regional Agricultural Advisor	Tel 254 2 331160
Madagascar		
Aimee Rabakoarihanta	Plant Breeder	FOFIFA/DRA B P 1444 Antananarivo 101
Lea Randriambolanoro	National Coordinator	Tel 261 2 40278 Fax 261 2 25926
Bodovololona Rabary	Agronomist	
Georges Rakotomalala	Plant Pathologist	
Mauritius		
Noel Govinden	Senior Scientific Officer	Mauritius Sugar Industry Research Institute Reduit Tel 230 4541061 Fax 230 4541971 Tlx 4899 MSIRI IW
Sudan		
Salih H Salih	National Bean Coordinator	Agricultural Research Corporation Shendi Research Station P O Box 33 Shendi Tlx 50009 TXBOWD SD

PARTICIPANTS LIST (continued)

Name	Discipline	Address
Tanzania		
Clemence S Mushi	National Coordinator	Selian Agricultural Research Institute P O Box 6024 Arusha Tel 255 57 2268/3883 Fax 255 57 8557/8264 Tlx 42106 CANWIH AT TZ
Roger A Kirkby	Coordinator	CIAT Regional Programme on Beans in Eastern Africa P O Box 23294 Dar es Salaam Tel 255 51 72714 Fax 255 51 75600/30966 Tlx 41529 SEC SER
J K O Ampofo Wayne Youngquist	Entomologist Plant Breeder	SADC/CIAT Regional Programme on Beans in Southern Africa Selian Agricultural Research Institute P O Box 2704 Arusha Tel 255 57 2268 Fax 255 57 8557/8264 Tlx 42106 CANWIH AT TZ
Rwanda		
Robin Buruchara Urs Scheidegger Louise Sperling	Plant Pathologist Coordinator Anthropologist	CIAT Regional Programme on Beans in the Great Lakes Region B P 259 Butare Tel 250 30446 Fax 250 30599 Tlx 22604
Uganda		
Victor A Ochwoh	Senior Lecturer	Department of Soil Science Makerere University P O Box 7062 Kampala
Theresa Sengooba	Plant Pathologist	National Agricultural Research Organization (NARO) Namulonge Agricultural Research Institute P O Box 7084 Kampala
Asinasi Lina Opio Patrick K Jjemba Michael Ugen A Sophy Musaana Beatrice Male Kayiwa M Silim Nahdy	Plant Pathologist Soil Scientist/Microbiologist Research Officer/Agronomist Plant Geneticist Plant Geneticist Storage Entomologist	NARO Kawanda Agricultural Research Institute P O Box 7065 Kampala
Howard Gridley Charles Wortmann Fischler Martin	Plant Breeder Agronomist Agronomist	CIAT Kawanda Agricultural Research Institute P O Box 6247 Kampala Tel 256 41 567670/74 Fax 256 41 567635
U S A		
Edward Rice	Agricultural Research Specialist	Winrock International Suite 600 1611 North Kent St Arlington Va 22209 Tel 1 703 5259430 Fax 1 703 5251744

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