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PREFACE

This volume reports the proceedings of a workshop held to report recent results obtained by participants in the regional bean research and training network in Southern Africa. The SADC Bean Research Network is the bean component of the Grain Legume Improvement Programme of the Centre for Cooperation in Agricultural Research and Training (SACCAR). This Network was initiated in 1987 under a grant from the Canadian International Development Agency (CISA) to CIAT, which ended in 1992.

Much of the research reported here has been supported directly by funds from the National Agricultural Research Systems of SADC member countries; this demonstrates a commitment by members to sustain the Network. Valuable additional support was provided from the Overseas Development Administration (ODA) of the United Kingdom in the case of Malawi, and from CIDA and the United States Agency for International Development (USAID) as donors to the Eastern African Bean Research Network, which sponsors part of the research reported from Tanzania.

The SADC Bean Network continues to part of a larger network of interdependent regional bean groupings in Africa, in which CIAT also collaborates. Further information on regional research activities on the common bean in the SADC region and in Africa generally is available from:

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

Germplasm Coordinator, SADC Bean Network, Chitedze Research Station, P.O. Box 158, Lilongwe, Malawi.

Coordinator Regional, Reseau pour l'Amelioration du Haricot (Phaseolae) dans la region de l'Afrique Centrale (RESAPAC), c/o P.O. Box 2704, Arusha, Tanzania.

Coordinator, Eastern Africa Bean Research Network, P.O. Box 6247, Kampala, Uganda.

Pan-Africa Coordinator, CIAT, P.O. Box 23294, Dar es Salaam, Tanzania.

PUBLICATIONS OF THE NETWORK ON BEAN RESEARCH IN AFRICA

Workshop Series

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No. 2. Bean Research in Eastern Africa, Mukono, Uganda, 22-25 June 1986.

No. 3. Soil Fertility Research for Bean Cropping Systems in Africa, Addis Ababa, Ethiopia, 5-9 September 1988.

No. 4. Bean Varietal Improvement in Africa, Maseru, Lesotho, 30 January-2 February 1989.

No. 5. Troisieme Seminaire Regional sur L'Amelioration du Haricot dans la Region des Grands Lacs, Kigali, Rwanda, 18-21 Novembre 1987.

No. 6. First SADCC Regional Bean Research Workshop, Mbabane, Swaziland, 4-7 October 1989.

No. 7. Second Workshop on Bean Research in Eastern Africa, Nairobi, 5-8 March 1990.

No. 8. Atelier sur la Fixation Biologique d'Azote du Haricot en Afrique, Rubona, Rwanda, 27-29 October 1988.

No. 9. Quatrieme Seminaire Regional sur L'Amelioration du Haricot dans la Region des Grands Lacs, Bukavu, Zaire, 21-25 Novembre 1988.

No. 10. National Research Planning for Bean Production in Uganda, Kampala, Uganda, 28 January-1 February 1991.

No. 11. First Meeting of the Pan-African Working Group on Bean Entomology, Nairobi, Kenya, 6-9 August, 1989.

No. 12. African Bean Research Workshop, Morogoro, Tanzania, 17-22 September, 1990.

No. 13. Virus Diseases of Beans and Cowpea in Africa, Kampala, Uganda, January 17-21, 1990

No. 14. First Meeting of the SADCC/CIAT Working Group on Drought in Beans, Harare, Zimbabwe, May 9-11, 1988.

No. 15. First Pan-African Working Grop Meeting on Anthracnose of Beans, Ambo, Ethiopia, February 17-23, 1991.

No. 16. Cinquieme Seminaire Regional sur l'Amelioration du Haricot dans la Region des Grands Lacs, Bujumbura, Burundi, 13-18 Novembre, 1989.

No. 17. Sixieme Seminaire Regional sur l'Amelioration du Haricot dans la Region des Grands lacs, 21-25 Janvier 1991.

No. 18. Conference sur le Lancement des Varietes, la Production et la Distribution de Semaines de Haricot dans la Region des Grands Lacs, Goma, Zaire, 2-4 Novembre 1989.

No. 19. Recommendations of Working Groups on Cropping Systems and Soil Fertility Research for Bean Production Systems, Nairobi, Kenya, 12-14 February 1990.

No. 20. First African Bean Pathology Workshop, Kigali, Rwanda, 14-16 November, 1987.

No. 21. Soil Fertility Research for Maize and Bean Production Systems of the Eastern Africa Highlands - Proceedings of a Working Group Meeting, Thika, Kenya, 1-4 September 1992.

No. 22. Atelier sur les Strategies de Selection Varietale dans la Region des Grands Lacs, Kigali, Rwanda, 17-20 Janvier 1991.

No. 23. Pan-African Pathology Working Group Meeting, Thika, Kenya, 26-30 May 1992.

No. 24. Bean Research Planning in Tanzania: Uyole Research Centre, 18-24 May 1992.

No. 25. Second Meeting of the Pan-African Working Group on Bean Entomology, Harare, 19-22 September 1993.

No. 26. Bean Improvement for Low Fertility Soils in Africa: Proceedings of a Working Group Meeting, Kampala, Uganda, 23-26 May 1994.

No. 27. Third SADC/CIAT Bean Research Workshop, Mbabane, Swaziland, 5-7 October 1992.

No. 28. Third Multidisciplinary Workshop on Bean Research in Eastern Africa, Thika, Kenya, 19-22 April 1993.

No. 29. SADC Working Group Meeting of Bean Breeders, Lilongwe, Malawi, 26-29 September 1994.

No. 30. Regional Planning of the Bean Research Network in Southern Africa, Mangochi, Malawi, 6-8 March, 1991.

No. 31. Fourth SADC Regional Bean Research Workshop, Potchefstroom, South Africa, 2-4 October 1995.

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Reprint Series

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OPENING ADDRESS AT THE SADC REGIONAL DRY BEAN RESEARCH WORKSHOP, POTCHEFSTROOM-02/10/1995 BY MATOME waga MAPONYA PRESIDENT - NAFU

INTRODUCTION

Chairperson, I would like to commence my talk by stating that dry beans are one of the nutritious natural crop commodities so underestimated in our society, to the detriment of the nation's health and nutritious status.

In traditional African Society, dry beans were regarded as perfect substitutes for animal protein, that is "meat". To that effect different types of beans, eg; Ditlhodi, Ditloo - Marapo are regarded as top protein sources.

I scanned the Corporate Mission of the Dry Bean Producers' Organisation and found that their ideal is understandable. However, there is something pivotal missing in their strategies aimed at attaining their main objective. The missing link is that there appears to be no mention of on-farm research into the traditional types, role and economic significance of indigenous beans. However, I hope this is not an oversight and the necessary follow-up and linkages with emerging African farmers, will reveal useful hints.

Chairperson, allow me to present a brief review of the dry bean industry before I share my views on the importance of research into dry beans.

According to the Annual Report for the DPO up to 31 March 1995, the production of beans has seen two major fluctuations, production of major beans dropped in 1992 to about 25 metric tons. In 1991, production was about 98 metric tons. A 73% drop. However, in 1993, production picked to about 55 metric tons. The persistent drought and untimely planting can be ascribed to the 1992 production decline. For 1994 and 1995, production has been around 52 and 45 metric tons, respectively.

On the consumption side the demand for both canned and dry beans has seen an average of 90 metric tons between 1990 and 1994. This clearly shows that our production has not addressed the domestic demand. This provides a golden opportunity for other farmers - particularly emerging ones, to fill the gap and produce varieties which are in great demand. South Africa has since been forced to import dry beans from China and the USA. Is this a healthy state of affairs, while we have emerging farmers who have been complaining about market rigidity and inaccessibility?

While the DPO Report prints a glossy picture-albeit-exclusively-about dry bean industry in South Africa, I would like to share with you some of emerging farmers needs in the sector.

These are:

* Information
* Technical production and research
* Market and Marketing opportunities
* Representation on Commodity Organizations

The importance of relevant information at the correct time is critical for farmers to make decisions. While information can be available inside the high-risk double-storey buildings, such as DPO's offices, it may not be accessible to farmers especially emerging to get themselves informed.

This may mean lack of dissemination vision or strategy. Because some information is vital, a price is often attached to its acquisition. Whilst this may be acceptable, however, the necessary interaction with farmer organizations can be a useful communication strategy.

Market and marketing information is viewed by farmers as the barometer of their production plans. If market and marketing temperatures are low, then farmers will know how and when not to act. However, if one is not exposed to market or marketing information, it becomes difficult to plan production based on market demand. Again, the dissemination of such information at the right time is always critical for farmers. The DPO can play a pivotal role in re-vitalizing the production of bean varieties in short supply by emerging farmers in South Africa.

Technical production back-up and farm-based-farmer-driven research is what can encourage emerging farmers to consider increased participation in bean production. It is common knowledge that bean production can be quite tricky. This then, calls for better back-up services to ensure that farmers or at least "master farmers, grasp the technology production side. Research into qualities such as drought resistance, increased productivity per production unit, resistance to common diseases, both soil borne and transmissible, is important in the emerging sector. The current research approach, done and documented in research stations, hundreds of kilometers away from farmers does not help them to comprehend any technical innovation or advantage achieved.

I propose that research must be taken to farmers who need it most. On-farm demonstration trial in collaboration with extension services, nutrition and community development groups as well as non-governmental organisations involved in rural development could be the starting point for seed multiplication and distribution. Let their farms be experimental stations where they can observe, manage and absorb the results of the process, only then will emerging farmers appreciate and support technical improvements.

Ditloo-Marapo and Dihlodi which are so popular among African household are gradually disappearing. It is not easy to get seed of these commodities and their market lies right here. It is in these areas I feel cultivar development should be concentrated on.

The bean leaf is another aspect that I feel the commercial farmers, especially, are losing a lot of revenue on. When cooked fresh and dried or when dried uncooked the bean leaves make a nice and nutritious Morog called MOKHUSHA. It becomes even more palatable when crushed groundnuts is added on to it. More research is required into better and effective methods of preservation.

The plucking of these leaves alone can generate jobs that this Country has never seen before. Above all, this is African innovation that must be preserved and promoted.

Some beans are called Cowpeas. This may be an internationally accepted name but one does feel quite conscious when eating such as the name suggest. I further feel that research should further look into the proper re-naming of these products like we no longer have Kaffir beans.

Secondly the research should focus on the real issues to which farmers, especially emerging farmers want answers. More attention should now be given to indigenous germplasm for characteristics that could contribute to grain legume improvement.

Many organisations in South Africa make mistakes of wanting to be exclusive. One is impressed to note that there are about 80 African bean producers in the QwaQwa region who are members of the Dry Bean Producers Organisation. It is hoped that the DPO will stretch its wings Countrywide to accommodate or be in communication with all the farmers of the land who are committed to the production of dry beans. An effective representative DPO can achieve far more than what is currently experienced.

The larger SADC region can greatly benefit from any research program when the needs of not only so-called commercial farmers are addressed. Dry beans are both profitable and less vulnerable than other grains. Thus smallholder can be better-off if farm-based-farmer-driven research can be conducted on their fields. It is only when those involved are convinced that the process hold some keys for future prosperity that researchers will find it less difficult to have their results accepted and their recommendation implemented.

Chairperson, ladies and gentlemen, I declare this workshop officially opened. Enjoy the remaining sessions of the day.

CONTENTS

SESSION 1

PLANT PROTECTION

CHAIRMAN : D.E. MALAN

ADVANCES IN THE ESTABLISHMENT OF THE PAN-AFRICAN BEAN COMMON MOSAIC VIRUS DISEASE RESISTANCE NURSERIES IN THE EASTERN AND SOUTHERN AFRICA[1,2]

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ABSTRACT

Bean Common Mosaic Virus (BCMV) disease has disastrous effects on bean crop yield wherever bean (Phaseolus vulgaris L.) is grown in Africa. A project to establish the Pan-African BCMV disease resistance nurseries in the countries of the Eastern and Southern Africa was initiated in 1989 under the CIAT/SADC bean Regional Programmes in Africa. The objectives of this project include: a) Survey and identify BCMV strains in Ethiopia, Tanzania, Uganda, Zambia and Zimbabwe; b) Evaluate/screengermplasm collections in each of these countries against the predominant strains at designated "hot spots" in each country; c) Conduct comparative studies of pathotypes against promising materials within each region and; d) Identify possible existing BCMV strains in alternative leguminous hosts.

Studies carried out so far and, in close and effective collaboration with several developed laboratories in Europe and the USA, indicate that; i) with the exception of Ethiopia, the black root strain (BCMV-NL3) is the predominant and the most important strain in these countries and that, based on this strain identification, geographical and ecological mapping of strain distribution seems not only desirable to guide the seed movement and development of beans within and outside Africa, such mapping may also assist breeders to determine where the I-gene can be used on its own or where it can be further protected by recessive genes bc2² and bc3; ii) strains of BCMV exist in wild leguminous hosts and; iii) certain bean materials have been identified to show resistance against these strains. The implication of these findings is discussed in relation to the epidemiology of the disease, plant quarantine, questionable origin of BCMV in Africa, and the need for continued monitoring of the dynamics of strain distribution using molecular diagnostic tools in the field. A strong need to have intercontinental and interdisciplinary approaches to this complex problem is advocated.

[1] Keynote address presented on behalf of the PAN-AFRICAN/CIAT/SADC BCMV subproject teams in Eastern and Southern Africa at the 7th SADC Bean Research Workshop in Potchefstroom, South Africa: 1-5 October 1995.

[2] Dedicated to Dr (Mrs) Jeanne Dijkstra of the Wageningen Agricultural University, the Netherlands on the occasion of her retirement and in recognition of her contribution to our knowledge and understanding of the bean common mosaic virus.

INTRODUCTION

Bean Common Mosaic Virus (BCMV) disease is one of the five most important diseases that limit bean (*Phaseolus vulgaris* L.) yield wherever bean is grown and by far, the most important virus isolated in beans in Africa. Infection by this virus may reach 100% and damage to the bean crop yield and produce may range between 35-95% (14). Currently, about seventeen strains of BCMV have been identified (1, 18) and these have been differentiated into VII pathogenicity groups based on group virus reactions to specific cultivars used for virus differentiation. Unlike the situation with fungal and bacterial diseases where an array of chemicals may be used to control for further control of BCMV or any other virus. the respective diseases, no chemical has been found. Consequently breeding for resistance is the only feasible way to control BCMV. However, resistance breeding to BCMV is a little complex as it has been discovered that resistance breeding to BCMV is a little complex as it has been discovered that resistance to BCMV is effected by recessive strain specific genes or by the dominant I-gene (1). Yet, in the African Context, where most of the bean is being produced by the small holder farmers, host plant resistance certainly seems to be the most probable answer to the BCMV problem as it is sustainable, costs farmers less and fits very well into farmers' schemes.

In an effort to making resistant varieties available to the bean growers in different countries within Eastern and Southern Africa, a study was initiated in 1989 under the funding of the Regional Programmes in Africa of the Centro International de Agricultura Tropical (CIAT). The objectives of this study included: a) survey and identify BCMV strains in Ethiopia, Tanzania, Uganda, Zambia and Zimbabwe; b) evaluate germplasm collections against prevalent (most common) strains of BCMV at the "hot-spots" within the participating countries of the two regions; c) conduct comparable studies of pathotypes against promising materials within the two regions; and d) identify possible existing BCMV strains in alternative leguminous hosts that may be serving as BCMV reservoirs. A progress report on this endeavour over a five-year period is presented in accordance with the action plan laid down by the Working Group meeting on Viruses of Beans and Cowpeas in Africa during their deliberations in Kampala, Uganda in 1990 (2,4,6).

MATERIALS AND METHODS

Survey and BCMV strain identification

Fresh leaves and occasional seed samples of the virus and virus-like infected bean seedlings were collected in several bean growing localities in each of the participating countries of Ethiopia, Tanzania, Uganda, Zambia and Zimbabwe between 1989 and December, 1994. Each sample collected was labelled with date, location and an assigned number. Furthermore, all samples collected from each location received the same treatments - some were collected and stored in poly-ethylene bags, and put in a freezer, some were put in vials containing calcium chloride, while some, depending on the distance between collecting sites and the laboratory were tested fresh in the field. Testing for strain identification was essentially by mechanical inoculation of infected sap on-to healthy bean differentials and by use of either or both monoclonal or polyclonal antisera in direct and/or indirect enzyme linked immunoabsorbent assay (ELISA). Some of these samples were sent or carried in vials containing calcium chloride to developed laboratories in Europe and the USA for conclusive tests.

Screening for resistance

Based on the results of above strain identification test, healthy seedlings of hundreds of bean lines or cultivars in each location strain were inoculated in the screen houses or in the fields ("hot spots") where ELISA and mechanical inoculations on BCMV differentials were conducted. It is important to point out at this juncture that the material used were varied in origin - they included landraces, CIAT lines and some promising materials from each of the participating countries (2,8,9,11,13). It is also relevant to mention that scientists involved in this study exchanged germplasm collection for screening in this exercise at their respective designated "hot-spots" in each of the participating countries.

Identification of wild leguminous hosts of BCMV strains

Various wild leguminous hosts were collected from various bean and non-bean growing areas in each country. Majority of samples collected showed some foliar symptoms while a few were symptomless. Seeds of some of these were also collected. In areas where bean croppings exist in close proximity with the wild legumes, bean leaf samples were also collected to determine whether or not there was any correlation in strains found in the bean croppings *vis-a-vis* those found in the near by wild legumes. In all testings, strain identification was carried out by reaction on Drifjhout differentials, ELISA and immunosorbent electronmicroscopy (ISSEM)

(2,12,14,17,18). Only the Ugandan and Zambian groups used different aphids species as part of their identification procedure (14,16).

RESULTS AND DISCUSSION

The results of the 5 year collaborative investigation are summarised in Table I. Details of findings from each participating country of Ethiopia, Tanzania, Uganda, Zambia and Zimbabwe can be found in relevant country reports published or presented in different media (8,9,11,14,16). Suffice to say that a total of 3672 seedlings were collected and tested from 72 locations in the five participating countries. Some of those samples were tested in developed laboratories outside the participating countries. Some samples from Uganda, in addition to being tested in the laboratories of the Namulonge Research Station in Uganda, were also tested in the plant virus laboratories of the Horticultural International in Wellesbourne and of the Sokoine University of Agriculture in Tanzania and at the CIAT headquarters in Colombia. During the early stages of this investigation, some samples from Ethiopia and Sudan were tested in the Crop Science laboratories of the Makerere University in Uganda as Well as the Plant Virus Institute in Braunwieg, Germany. Collections from Zimbabwe were identified in Harare and at the International Institute of Tropical Agriculture (IITA) Nigeria while the Zambian samples were tested and identified using differential hosts at that country's research stations. In Tanzania, besides the samples collected by the local team, a two man team from Washington State University, Pullman/Prosser USA had contributed tremendously on our knowledge on strain identification and distribution in Tanzania as the American team had initiated this study as early as in 1984 and, except that the local team had collected more samples, the results were not significantly different from those of the US team. The samples collected by the Tanzanian team were analysed in Stuttgart, Germany, in Wageningen, the Netherlands and in Prosser, Washington, USA. Based on these results, BCMV strains NL1, NL3, NL5, NL5, NL8 and NL15 occur in bean fields in the two regions and with exeption of Ethiopia, the BCMV-NL3 (necrotic strain) is the most predominant strain which causes devastating losses.

Breeding studies indicate that lack of resistant genes to BCMV strains in African bean germplasms may be a possible indication that these viruses and their strains may have evolved differently/or separately from their hosts. While it has been discovered that resistance to BCMV is imposed by recessive strain specific genes or by dominant I-gene and that the deployment of the latter has been successful in Latin America, temperature insensitive or black root strains of BCMV have overcome the I-gene resistance and induced systemic necrosis.

Fortunately, it has been discovered that cultivars with I-gene are not killed by the necrotic strains if either of the genes $bc2^2$ or bc3 or both are incorporated to protect the I-gene. For five years, hundreds of bean accessions were screened in different locations against the predominant strains in each locality. The results of these screenings are found in Table I in which resistant materials have been identified against these predominant strains. In Zambia, Zimbabwe and Uganda, the resistant materials are mostly the outcome of crosses from CIAT MCM 5001 and MCM6 series. In Tanzania, cultivar "SUA 90" which is an improved line from one of the Uyole accessions, has been identified and released for use by the farmers as being resistant to BCMV strains and as having many attributes of yield, flavour and acceptability. All resistant materials have been tested in different agro-ecological zones and in some areas, some resistant varieties have been found to be specific to locations or altitudes. Our investigation confirms that BCMV strains exist in wild legumes in Tanzania and Uganda and studies in Zambia and Zimbabwe are currently inconclusive. BCMV strains NL1, NL2, and NL8 have been isolated from leaf samples of one or more of the following wild legumes - *Cassia bicapsulavis* (Tanzania); *Centrosema puberces* (Tanzania and Uganda); *Crotolaria incana* (Tanzania); *Crotolaria* spp (unidentified) (Uganda); *Sena hirsuta* (Uganda); *Rymochosia zernyl* (Tanzania); *Indigoferai* spp (Tanzania and Uganda) and *Vigna* species (Tanzania and Uganda).

The results presented above raise many issues which warrant clarification and discussion. Knowledge of the strain distribution in each locality should be considered valuable as this helps the breeders to

Table I: **Predominance of BCMV strains found in bean crops and wild legumes in Eastern and Southern Africa with available resistant materials.**

Country	Strains	Bean Resistance Materials	Wild Resevoirs of BCMV
Tanzania	NL 1, 3, 5, 6, 8, 15	Uyole 84 SUA 90 Lyamungu 85 Ep.4 Series 94	*Cassia* Spp *Oxalis* Spp *Centrosema* Spp *Crotolaria* Spp *Vigna* Spp *Rynochosia* Spp
Zambia	NL 3, 6, NY15	Mostly from CIAT lines	?
Uganda	NL 1, 3, 6, 8	G42 Rubone 42 GLP 582 and GLP 585 (Bukalasa) Landraces 52	*Cassia* Spp *Centrosema* Spp *Sennahirsuta* *Crotolaria* Spp
Zimbabwe	NL 3, 6, 8	MCM6 (CIAT lines)	?

determine where I-gene can be used on it's own or where it should be protected by recessive genes. Furthermore, with the predominance of the necrotic strains in the countries of the two regions, it will seem risky at this point for several of these countries release genotypes with bc3 genes alone. Instead, the use of both $bc2^2$ and bc3 should be encouraged. A geographical map indicating the locations of each strain in each country will also help the breeders as continued monitoring of these strains will promote the opportunity of becoming aware of emergence of new recessive genes particularly if field testing are carried out in "hot spots".

Nobody knows why the necrotic strain is absent in Ethiopia. For now, it is suggested that scientists in that country should not receive any materials from any of the African nurseries in order to keep Ethiopia free from any of the devastating strain. The revelation that BCMV strains exist in wild legumes has epidemiological consequences. Such information will help breeders in the efficiency of screening in nurseries and to identify hot spots as well as unknown strains in these reservoirs which may be transmitted by aphid vector species. It is also advised that materials with I-gene should be properly protected by national bean programmes before release.

This study is an example of an effective and productive collaboration between scientists within the regions which should continue as it serves as a foundation for successful networking in future studies. Collaboration with scientists in developed laboratories should be strengthened as there are materials or technologies which are being developed that can be useful for the two regions. It is envisaged that the availability of molecular diagnostic tools to regional scientists will help to hasten diagnosis, testing and clearance of germplasm demand by national programmes at the plant quarantine stations or offices. Diseases such as bean common mosaic, common bacterial blight and halo blight are complex diseases which require not just multinational or regional approaches but also intercontinental approaches if a lasting solution is to evolve.

ACKNOWLEDGEMENT

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supported most of the studies in Ethiopia, Tanzania, Uganda, Zambia and Zimbabwe. The Natural Resource Institute (UK) and the Rockfeller Foundation provided additional funds that allowed some indepth studies on the Ugandan component to be carried out in Wellebourne, UK. Similarly the Directorate of Research and Postgraduate Studies of the Sokoine University of Agriculture (SUA) in Tanzania, the EU Counterpart Food Aid Project, the DAAD Fellowship Programme for Senior Scientists in Africa (Germany), the ZWO of the Netherlands and USAID - CRSP Bean Project (USAID) made financial contributions that made intense study of this disease also possible in Tanzania. The hospitality of the host scientists in laboratories in Braunswieg, Cambridge, Ibadan, Stuttgart, Wageningen and Wellesbourne is deeply appreciated.

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THE VIRUSES OF *PHASEOLUS VULGARIS* IN SOUTH AFRICA

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ABSTRACT

Very little information is available on the virus status of Phaseolus vulgaris in South Africa. During a survey conducted in 1993, all previously documented viruses (bean common mosaic virus (BCMV), bean yellow mosaic virus, peanut mottle virus, alfalfa mosaic virus, and cucumber mosaic virus) as well as two unidentified potyviruses and a geminivirus were found. The potyviruses were designated isolates 93/1 and 93/65. Using IEM, it was shown that isolate 93/1 has epitopes in common with clover yellow vein virus and isolate 93/65 with blackeye cowpea mosaic virus. Due to the complex serological interrelationships of potyviruses, serology alone is insufficient to confirm the identity of a new virus, and comparisons of nucleic acid sequence data with that of other potyviruses is essential. Part of the coat protein as well as the 3' untranslated regions were amplified with immunocapture reverse transcription polymerase chain reaction (IC-RT-PCR). The PCR products were cloned into pBluescript KS+ and sequenced with DIG cycle sequencing. Preliminary results confirm that 93/1 and 93/65 are related to ClYVV (clover yellow vein virus) and BlCMV (blackeye cowpea mosaic virus) respectively, but that both viruses may be new strains.

The geminivirus causes severe yield loss (approximately 90% per plant) in the seed production areas. IEM and nucleic acid sequence data have shown that the virus is related to, but not identical to tobacco yellow dwarf virus (TYDV). Nucleic acid sequence data suggests that it may be considered a new virus. The virus was purified from field collected material and an antiserum prepared. This antiserum was used to detect the virus by IEM and immunocapture PCR. These techniques will be used to determine the host range and vector of the virus.

HOST PLANT RESISTANCE, CULTURAL PRACTICES AND BOTANICAL PESTICIDES FOR THE MANAGEMENT OF BEAN STEM MAGGOT IN SMALL SCALE FARMER SYSTEMS

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ABSTRACT

In our efforts to develop strategies for the management of bean stem maggots (bean fly) (Ophiomyia spp.; Diptera: Agromyzidae) in small scale farmers' systems, we focus on options that are available and sustainable within the farming environment. These include host plant resistance, cultural practices and botanical pesticides. For host plant resistance, we identified various sources of resistance from the CIAT Phaseolus vulgaris core collections as well as materials held in the Tanzania bean germplasm collections. Some of these sources are now in use to transfer resistance to adapted lines as well as elite breeding lines. With cultural practices, we observed previously that mulches reduced plant damage resulting from BSM attack and we set up further trials to gain a greater understanding of the mechanism of grass mulches in promoting plant vigour and tolerance to BSM infestation. We observed that grass mulches preserved soil moisture and stabilized soil temperature at a lower level below the ambient temperature and the non-mulched treatments. This was reflected in adventitious root development and plant survival. Botanical pesticides such as aqueous extracts of neem and Persian lilac seed powder and Tephrosia leaves also reduced BSM infestation and damage. These practices could be used in the development of IPM strategies for small scale farmers' systems to reduce BSM pressure and increase bean yields.

Key words: Bean stem maggots, beanfly, Ophiomyia spp., host plant resistance, cultural methods, mulch, botanical pestsicides, neem

INTRODUCTION

Over 80 insect species are recorded on beans in Africa but bean stem maggots, bruchids, foliage beetles, aphids, pod borers and pod bugs are considered as the key pests that constrain productivity in the region (Ampofo, 1993). Three bean stem maggot (BSM) species: *O. phaseoli*, *O. spencerella* and *O. centrosematis* attack the crop and cause damage wherever beans are grown in Africa. Recent studies by Autrique (1989) and Oree et al. (1990) suggest that *O. spencerella* dominates in cool high altitude environments while *O. phaseoli* dominates in warm lowland areas and that strong reversals in species dominance occur wherever two or more species occur together.

BSM damage is caused by the maggot feeding in the medullary tissue of stems and roots of bean plants. Extensive damage to seedlings may result in the root and stem epidermis drying, reduction in lateral root formation and subsequent plant mortality. In older plants the stems crack and adventitious roots may develop: under favorable conditions the crop may survive but such plants are usually stunted and yield is reduced. In late infestations the larvae may girdle the stem near ground level. This results in canker formation and lodging under windy conditions or if pod load is heavy.

The growth in importance of BSM in many farming situations is magnified by some of the following factors:

* Shortage of land leading to poor rotation or reduced fallowing. This, coupled with the extended duration of favorable temperatures and rainy periods that allow continuous cropping lead to rapid multiplication and development of several generations of the pest.

* Changing cultural practices that favor pest population build up: these include the shift from intercropping to monocropping coupled with reliance on chemical pesticides that often disturb the pest/natural enemy equilibrium adversely.

* Synergistic interactions between the pest attack and diseases that lead to increased crop damage.

* Planting of 'tasty', high yielding exotic varieties that have no tolerance to BSM.

* Lack of farmer education: often the farmer is aware of a 'problem' but may lack knowledge of the factors that lead to it or of the causative organism and therefore fail to take appropriate action.

Yield losses attributed to BSM infestations vary with location and season and range from 33% to total crop failure (Greathead 1969; de Lima 1983; Autrique 1985). Various tactics have been employed for BSM control but none has proved adequate alone. A multifaceted approach that relies on the principles of integrated pest management may be more appropriate. Important components in such an approach include: host plant resistance, suitable cultural practices such as soil fertility improvement and maintenance and the control of root diseases that aggravate BSM damage. In this paper we report on progress made in the last few years on the development of resistant cultivars, evaluation of cultural practices and botanical pesticides for the management of BSM in small scale farmers' systems.

BREEDING FOR RESISTANCE TO BEAN STEM MAGGOTS (*OPHIOMYIA* SPP).

Evaluation of germplasm accessions for sources of resistance.

During the period between 1990 and 1995 several thousand germplasm lines in sets ranging from 500 to over 1000 were screened for resistance to BSM. This was done at different locations and planting was timed to take advantage of suitably high pressures of the pest. An augmented design with a susceptible variety protected (with insecticide seed dressing) designated as the "resistant" check and the same variety (without the insecticide protection) as the susceptible check: The resistant and susceptible checks were repeated after every five test entries to map out the distribution of the pest in the field and make the necessary adjustments for resistance selection. All seeds were treated with fungicides Benomyl[R] and Ridomil[R] before sowing to minimize fungal disease infection that may confound BSM induced damage. Plot size was a single row of 5 m spaced at 0.5 m apart, plants within rows were spaced at 15 cm. Apart from the protected check, no insecticide was applied before flowering, but all plots were protected after flowering to reduce damage by post -flowering pests. All dead plants were removed and analyzed for causes of mortality and categorized accordingly. Dead plants from the check plots were dissected to determine the level of BSM infestation that was causing the mortalities. Resistance parameters, such as percent plant survival and yield under the BSM pressure, derived from the checks were used to sort susceptible from the resistant entries among the test material. Entries combining moderate levels of resistance and high yield were also selected.

Resistant selections based on the statistics of the mean and 5% confidence limits around the protected check, were retested in replicated trials for confirmation of the observed resistance and to weed out possible escapes. This methodology was used to evaluate the germplasm accessions held by the Tanzania Bean Programme and parts of the CIAT's *Phaseolus vulgaris* "Core Collection" as well as breeding lines.

Six hundred and ninety-five accessions from the core collections were evaluated in Feb - May 1995 at Mabughai, Lushoto District, Tanzania and their performance in terms of plant survival under BSM pressure is illustrated in figure 1. Table 1 shows the performance of the resistant and susceptible checks in terms of plant survival and yield under BSM pressure. Infestation was generally high and with significant differences between the checks in all the damage parameters measured. Several entries showed high levels of tolerance and suffered no plant loss but some of these entries were unadapted and produced no yield. Of the 106 entries selected from the core collection as showing moderate to high levels of resistance under the prevailing BSM pressure, 50 % (55 entries) are of Mexican origin, 11 % (12 entries) are of Peruvian origin, 7.% (8 entries) are from the secondary center of Rwanda/Burundi (Figure 2), and the rest are from other centres mostly within the middle-America region. These results confirm earlier observations that germplasm accessions of middle-American origin are more likely to yield sources with higher levels of tolerance to BSM.

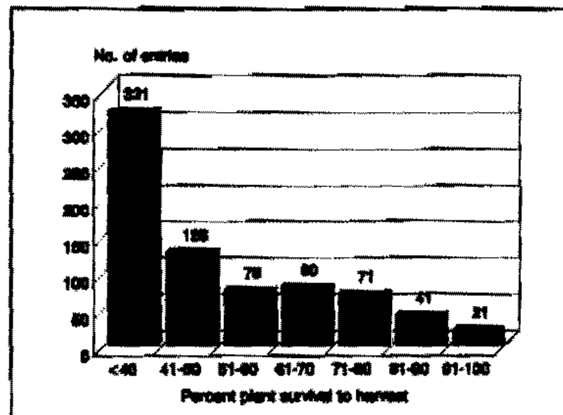

Figure 1. Resistance performance of entries from the first set of "core collections".

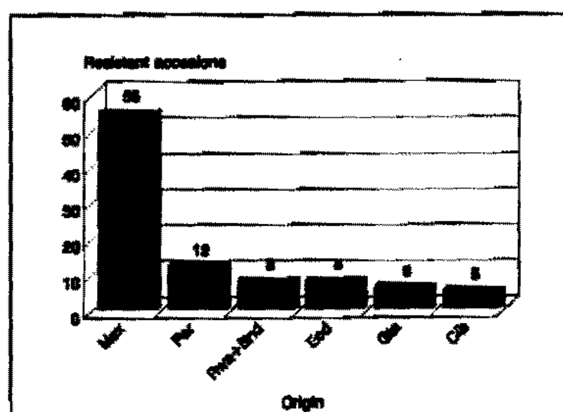

Figure 2. Frequency of resistant selections from different regions.

BSM Confirmatory Nursery

A set of material that had shown resistance in earlier germplasm evaluations in northern Tanzania plus contributions of putative sources of resistance from scientists within the network were put together for evaluation at Mabughai (Tanzania) in January 1995. The parameters used for the evaluation were: plant survival, and yield under infestation as described in Table 1. Mean infestation was high, 80% of all plants, were infested and the mean infestation per plant at 4 WAE (from a random sample of apparently healthy plants) was 2 insects per plant. Mean

Table 1: **Performance of resistant and susceptible checks in the evaluation of the core collections**

Treatment	Plant Stand at emergence	% Plant Survival at: Flowering	Harvest	Grain yield g/plot
"Resistant"	20.7 ± 3.1	94.3 ± 11.1	93.6 ± 11.8	79.9 ± 37.9
"Susceptible"	21.3 ± 2.9	51.7 ± 24.3	32.9 ± 25.0	25.0 ± 21.1

Plot size - 1 row 4 m long (27 plants)

Table 2: **Resistance performance of certain entries in the confirmatory nursery.**

Entry name	BSM infestation at 4 WAE: Random sample (5 plts/plot)		Plant survival at harvest	Yield in g/plot
	Infested plts	BSM/plant infested		
Mlama 49	4.3	7.5	23.3 (45.7)[1]	102.1
Mlama 127	4.0	6.2	17.7 (32.2)	79.2
G 22258	5.0	5.4	16.7 (32.7)	69.6
G 22501	4.3	6.2	17.0 (32.7)	67.1
G 11746	5.0	8.4	16.0 (30.2)	30.5
Checks				
Lyamungu 90 treated "P"[2]	2.3	7.0	35.3 (84.5)	159.7
Lyamungu 90 untreated "S"	5.0	7.6	1.7 (3.8)	9.7
ZPv 292 tolerant check	5.0	6.5	17.7 (35.4)	53.1
Mean	4.5	7.4	11.0 (22.9)	41.9

1 Means in parentheses are percentages
2 "P" = protected check, "S" = susceptible check.

infestation per dead plant was 11 insects. Plant mortality was very high and in some entries nearly all plants died from BSM attack or related causes. Out of the 25 test entries Mlama 49, Mlama 127, G 22258, G 22501 and G 11746 were the best under the prevailing pressure, with plant survival values ranging from 45 to 30 percent compared with the 3.8 % for the susceptible check and 35.4 % and 84.5 % for the tolerant and protected checks respectively (Table 2). It is interesting to note here also that G 22501 and G 22258 originated from the secondary center of Burundi while G 11746 is of Peruvian origin. Mlama 49, Mlama 127, G 22258, G 11746 and G 22501 will be distributed to interested scientists through the Bean

Stem Maggot Resistance Nursery - 4 for further evaluation and deployment in breeding programmes as they may wish to.

Cultural control methods and plant tolerance to BSM attack.

Field studies were conducted in the 1992 and 1993 short growing seasons at two locations in Northern Tanzania: Sinon in Arusha District and Mabughai in Lushoto District. These sites contrast in soil fertility, a parameter which also affects plant ability to tolerate BSM damage.

Cultural methods tested were:

1. Enhanced soil fertility (F): additional organic fertilizer applied at sowing and side dressing at 30 kg P_2O_5 and 60 kg N per ha.

2. Mulches (M): the spreading of dry banana leaves (in Sinon) or dry bracken fern leaves (at Mabughai) to a layer ca. 4 cm thick over the plots after sowing.
3. Endosulfan seed dressing (E) at 5g of Endosulfan 47% mixed in a slurry with 1 kg of wetted seed before sowing.
4. Control (C) (seeds sown on the flat without the application of any of the above)

5-8: Various combinations (M+F, M+SD, F+SD and M+F+SD) of the individual treatments were applied.

Common bean variety "Lyamungu 85" was used in these trials. Among individual non-Endosulfan treatments, mulch and fertiliser reduced plant mortality significantly below that of the control at Mabughai. Mulch also delayed mortality but did not reduce BSM infestation. However, all the treatment combinations (including M+F) reduced plant mortality further below that of Endosulfan alone at Sinon. Plant mortality was significantly correlated with BSM infestation at 3 WAE (r^2 = 0.47, p = 0.006) (Ampofo and Massomo unpublished).

Further trials were set up this year to investigate the effects of some cultural control methods on the mechanism of plant tolerance to BSM attack. The treatments investigated were: mulches (with rice straw), addition of farmyard manure and earthing up, in comparison with chemical seed dressing and a standard practice -- planting on the flat without any additional input. Two levels of moisture stress were superimposed on these. Special focus was on the micro-environment within the root zone, and measurements of soil temperature, soil moisture as well as root development were made. The mulches reduced soil temperature in comparison with the control at all times of the day and soil temperature under the mulch was more stable (in relation to the ambient temperature) than the control (Figure 3). The mulch treatment also conserved moisture (Figure 4) and enhanced adventitious root development in terms of numbers, length and biomass (Table 4) but had no apparent effect on lateral root development. These differences help explain the observed tolerance to BSM attack associated with mulched plots. The mulch technology is currently being evaluated with farmers in Usa River and Valesca farming communities in northern Tanzania within an overall IPM strategy.

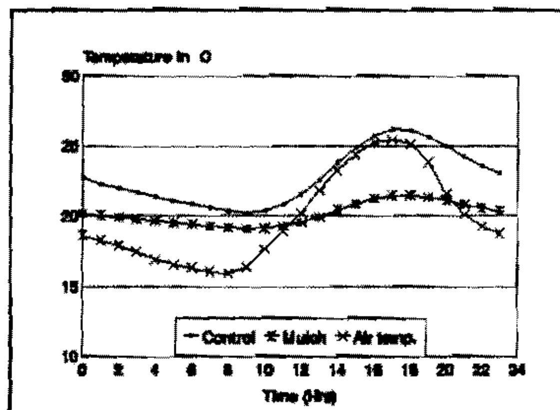

Figure 3. Effect of mulch on soil temperature fluctuations in relation to time.

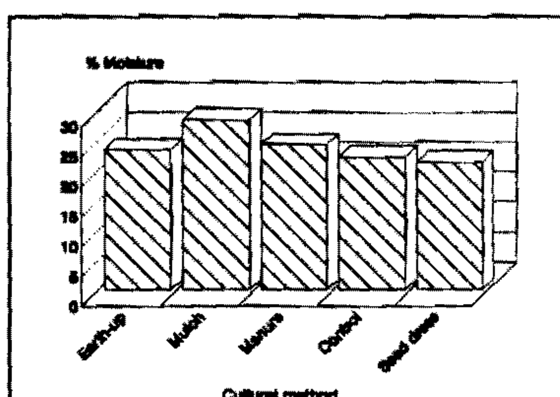

Figure 4. Effect of cultural method on soil moisture conservation.

Effectiveness of certain botanical pesticides for the control of BSM

We continued the search for alternative methods for BSM management; our focus still being on strategies that are sustainable within the small scale farmers environment. Three plant products: 1. neem (*Azaderachta indica*) seed powder, 2. Persian lilac (*Melia azaderach*) seed powder, and 3. ground *Tephrosia vogelii* leaves, were infused in water and sprayed over bean plants at a concentration of 5 % and at different times during the first 10 days after emergence (the period of growth that is most susceptible to BSM infestation). These treatments were evaluated alongside a chemical seed treatment of imildacropid at 5 g. of the product per 1 kg of seed applied in a slurry. While all three extracts reduced the levels of BSM infestation and subsequent plant mortality below the control, only the NSE applied at emergence, and at 3, 5 and 10 DAE was significantly effective in reducing the percentage of plants infested. This treatment also doubled grain yield over the control (Table 5). The use of botanical pesticides offers a suitable option for use in small scale farmers' IPM strategies especially in combination with moderately resistant cultivars and appropriate cultural methods.

DISCUSSION

In many parts of Africa the bulk bean production is carried out by small scale farmers. They cultivate their crops in a complex array of cropping systems including multiple cropping, crop rotation, continuous cropping etc. Their production is mostly for subsistence and although there is a desire for increased productivity and marketing of surpluses, the use of purchased inputs such as fertilizers, pesticides etc. is quite uncommon. Soil infertility, moisture stress, diseases and pests are the principal agronomic constraints that limit bean productivity in the African small scale farmers' cropping systems.

Our approach is to develop components that could be used in IPM strategies for BSM in the small scale farmers' systems. We consider host plant resistance as ideal; it comes as a control package in the seed and is compatible with most control practices. We have identified several sources of resistance that could be used in the transfer of resistance to adapted and elite lines with good agronomic characters and work in this area is already in progress (see Mushi and Slumpa in this publication). It is interesting to note from the evaluation of both the core collection and the confirmatory nursery that several middle American materials, especially accessions from Mexico had good levels of tolerance to BSM. The high proportion of African materials (land races), especially from Rwanda and Burundi showing resistance to the pest is quite promising, as the number of entries from this group in the core collection is relatively low compared with entries from the primary centres of origin (middle America and the Andean regions) and suggests that more resistant materials may be obtained from this group. The shift from such local land races to introduced germplasm with high yielding potential and no tolerance to the pest contributes to the growing importance of the BSM problem. While the African material may have had a long exposure to a selection pressure against the pest, the middle American accessions have had no previous contact with the pest as BSM does not exist continental America. It is hypothesised that these materials may have developed tolerance mechanisms to some stress(es) that allow them also to tolerate BSM attack better. Knowledge of such a relationship will be useful in the identification of further sources of resistance.

The observed levels of resistance in the currently available cultivars and germplasm are low and often succumb under severe pressure from BSM. It is therefore necessary that HPR is deployed in combination with other control options for greater stability of the management strategy.The use of cultural methods and botanical pesticides provides a sustainable support to HPR in this strategy. In our previous trials (Ampofo and Massomo unpublished), we observed that mulches, while enhancing plant tolerance to BSM infestations, did not reduce BSM infestation per se, but Litsinger and Ruhendi (1984) suggested that rice straw mulches could interfere with visual cues used by certain insects including the BSM in host location. In our trials the effect of mulches on plant vigour and tolerance to infestation was greater. The ease of applying the mulch strategy may vary

Table 4: **The effect of cultural method on adventitious root development.**

Cultural methods	Adventitious root development	
	Number	Length in cm.
Earthing up	11.8 ab	9.6 b
Mulch	11.6 ab	14.4 a
Manure	5.4 c	8.8 b
Control	8.8 bc	9.0 b
Seed dressing	13.5 a	8.5 b

Means within a column followed by the same letter are not significantly different according to the SNK test.

Table 5: **Effect of certain botanical pesticides on BSM infestation and damage to bean plants (Neem, *Azadirachta indica*)**

Treatment	% plants infested	BSM /plant infested	BSM induced plant mort.	Yield in g/plot
Control	93.5 c	5.5 b	80.8 c	439.2 b
Neem at 1 DAE	93.4 c	4.9 b	80.5 c	505.0 b
1, 3, DAE	83.4 c	4.9 b	69.2 bc	717.5 b
1,3,5 DAE	90.0 c	4.0 b	69.2 bc	741.2 b
1,3,5,10 DAE	63.3 b	2.8 b	57.0 b	987.5 b
Seed dressing	0.0 a	0.0 a	1.2 a	1912.5 a
CV	16.8	35.2	26.1	34.9

Means within a column followed by the same letter are not significantly different according to the SNK test.

with location and availability of materials for mulching. In the rice growing areas of northern Tanzania, this does not seem to be a problem while in other areas the may be competition for the use of possible mulch materials for animal feed.

Our other trial with the botanical pesticides suggest that even though the materials used did not give statistically significant differences in grain yield, there were significant trends in BSM infestation levels, BSM induced plant mortality and grain yield associated with the use of all three botanicals tested. The plant species however, tend to be adapted to different environments: for instance neem is adapted to warm lowland areas while Persian lilac and *Tephrosia* spp. are adapted to medium altitudes. This may limit the scope of adoption of neem on a greater scale. More work needs to be done to identify alternative species with suitable potential for use in different environments. More work needs also to be done in refining the strategy to reduce the number of applications to one or two only without losing the efficacy.

Requirements for IPM often tend to be location specific and therefore components and strategies also tend to vary accordingly. In this paper we have demonstrated some of the possible options that could be deployed in an overall IPM for BSM in small scale farmers' situations in eastern Africa.

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EFFECT OF INTERCROPPING BEANS AND MAIZE ON BEAN STEM MAGGOT (Ophiomyia spp) INFESTATION AND DAMAGE: A CULTURAL CONTROL OPTION

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ASTRACT

Field studies to investigate the effect of intercropping beans and maize on bean stem maggot (Ophiomyia spp.) infestation and damage as a cultural control option were conducted at RRC-Embu Kenya. Results indicated that, oviposition and establishment of BSM remained significantly (P = 0.05) low in all the plots where beans were planted under maize than when in pure stands. Similarly the number of maggots migrating to the base of the bean plant to feed and subsequent pupation remained very low in all the plots where beans were planted together with the maize and not sprayed and in those plots that were sprayed with insecticides. This led to the conclusion that under small scale farming systems where intercropping is practiced there is no need to use insecticide to control BSM. This means that intercropping is a lot better than monoculture in reducing pest damage.

INTRODUCTION

Low build up of insect pest population is believed to be one of the many advantages realized from intercropping due to provision of a less favorable habitat for some of the pests than when the same crops are grown in pure stands (Nangju, 1976). Mixed cropping prevents the spread of some pests to other areas due to creation of physical barriers by the taller plants (Juarez *et al.*, 1982).

Some studies on insect buildup in mixtures have been reported by many workers (IRRI, 1974; Kayumbo,1976; Karel and Mueke, 1978; Gethi and Khaemba, 1985, and Gethi *et al.*, 1993). Moreover evidences from field results have yielded conflicting results as regards to the above suggestions. But there is evidence to show that reduction of insect pest in an intercropping ecosystem is due to the confusing olfactory and visual cues received from host and non-host plants leading to the disruption of normal mating and feeding behaviors (Saxena 1985; Gethi *et al.*, 1993).

Bean growers in Kenya consist mainly of small scale farmers, who obtain yields of about 300 - 750 kg/ha when the crop is planted as a pure stand, and about 200 - 375 kg/ha when it is planted as a mixed crop (Anon, 1978). Except where beans are grown commercially under pure stands, most of it is grown in combination (intercropped) with cereals such as maize. Low yields of beans are attributed to severe damage by insect pest and diseases. Among the major insect pests are the bean stem maggot (BSM) - commonly known as the beanfly (*Ophiomyia* spp) which is composed of two major species *O. phaseoli* and *O. spencerella*, and the black Aphid (*Aphis fabae* Scopoli) (Karel et al 1980). Cereal legume combination has been identified as a good combination in terms of legume pest reduction (mainly on cowpeas). However very little is known about the population dynamics and behavior of bean pest in an intercropped agro-ecosystem. It was therefore found necessary to investigate the effect of intercropping beans and maize on the population build up and damage by bean stem maggot.

MATERIALS AND METHODS

Field experiments were conducted at RRC-Embu during the minor and the major cropping seasons of 1991/92. The station is at an altitude of 1460m above sea level and experiencing a bimodal type of rainfall which varies from year to year.

CROP ESTABLISHMENT

The bean crop was planted using an additional model of intercropping. This was by adding beans to maize crop thus ensuring that plant population pressure of beans is both pure and intercropped stands were constant.

Bean variety GLP 24 (Canadian wonder) and maize H 511 were used in the experiments. Both crops were planted at the same time at the onset of effective rainfall at the rate of two seeds per hole. This was later thinned to one plant per hole approximately 2 weeks after germination.

DESIGN

Randomized complete block design was used during planting and the treatment were replicated three times. Treatments were then allocated at random to plots measuring 10.5 x 10m. Bean monocrop and intercrop had approximately 133333 plants per ha at a spacing of 75 x 10 cm while the maize was at a spacing of 75 x 25 cm (53,333 plant/ha).

The treatments were:

- Beans pure stand -unsprayed
- Beans pure stand -sprayed
- Beans/maize - unsprayed
- Beans/maize -sprayed.

Spraying was done by a hand -operated Knapsack sprayer. The insecticide applied was Endosulfan 35 EC at the rate of 0.15 % litre/ha at weekly intervals starting one week after germination. This continued for about four weeks when the bean stem maggot was expected to lay no more eggs. Polythene screens were installed during chemical application to minimize drifts to the unsprayed plots. The other control treatment were sprayed with water.

Each respective plot in the field was subdivided into 36 equal cells measuring 2.0 m x 2.1 m using a manilla twine. The cells bordering the edges of the plots were considered as guard cells and were not included in the sampling or harvesting to avoid edge effect. Six of 16 remaining cells were randomly selected and marked on harvesting cells. The remaining 10 cells were each sampled once.

SAMPLING

To assess the effect of mixed cropping and insecticide treatment in BSM, samples of bean plants from both pure and intercropped stands were taken. Beginning one week after crop emergence (WAE) every bean plant in the middle row of the sampling cell was uprooted, labelled and taken to the laboratory.

Each batch was examined for BSM injury (Ovipunctures and mines on the stem). Thereafter the stems were dissected to count the number of larvae and pupae present. The data obtained was used to determine the incidence and population buildup of BSM in the treatments.

RESULT

The data on the incidence and damage by BSM when beans were planted in pure stand and when intercropped with maize indicated that the oviposition was influenced greatly by the cropping systems. This is evident from the data presented in figure 1. From the figure, it is clear that the oviposition was highest during the second week of sampling on pure plots of beans and on intercropped beans that were not sprayed. However, oviposition reached the peak in the 4th weak (1 month later) after planting and was highest on monocropped beans that were not sprayed.

Oviposition remained lowest throughout the sampling period on plots where beans were planted together with maize and no chemical was applied (figure 1).

Figure 1. No. of ovipuncture per plant

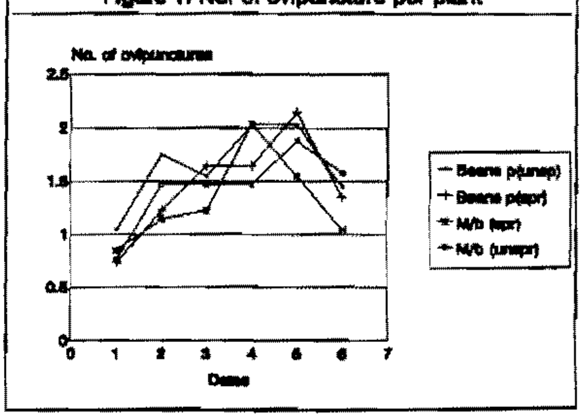


TABLE 1: **Mean number of BSM ovipunctures/plant recorded on bean plants when in pure stand and when intercropped with maize.**

Cropping System	Ovipunctures/Plant	Pooled Mean
Beans Pure (Unsprayed)	1.39 b	
		1.52 $\pm$ 0.18
Bean pure (Sprayed)	1.65 a	
Maize/beans (Sprayed)	1.33 b	
		1.39 $\pm$ 0.08
Maize/Beans (Unsprayed)	1.45 ab	
LSD	0.20	
CV %	20.58	

TABLE 2: **Mean number of bean plants with BSM mines on the stem when in pure stand and intercropped with maize.**

Cropping System	No. of Plants	Pooled Mean
Beans pure (Unsprayed)	0.88 a	
		0.81 $\pm$ 0.09
Bean pure (sprayed)	0.74 a	
Maize/beans (sprayed)	1.22 a	
		1.27 $\pm$ 0.06
Maize/beans (Unsprayed)	1.31a	
LSD	0.25	
CV %	35.96	

TABLE 3: **Mean number of *O. phaseoli* pupae per plant when beans were in pure stand and when intercropped with maize.**

Cropping System	No. of BSM		Pooled Mean
Beans pure (Unsprayed)	0.94 ab		
		0.84 $\pm$ 0.14	
Beans pure (sprayed)	0.74 b		
Maize/beans (Sprayed)	1.05 a		
		0.92 $\pm$ 0.18	
Maize/beans (Unsprayed)	0.79 b		
LSD	0.21		
CV %	35.31		

Fig. 2. No. of plants with BSM mines

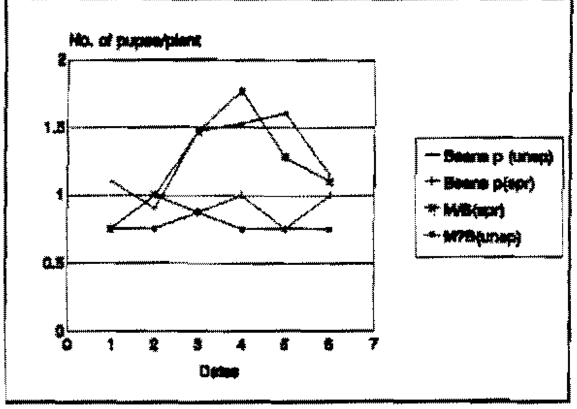
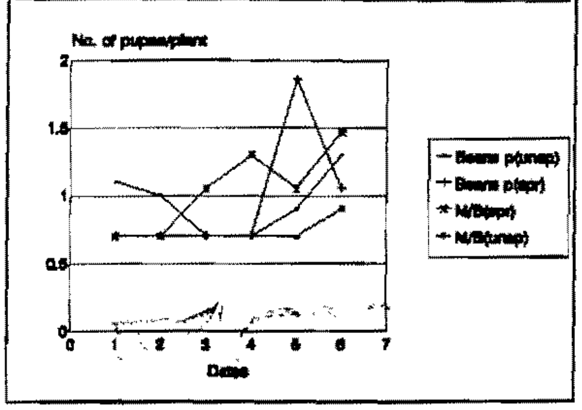


Fig. 3. No. of BSM pupae per plant



Similarly, Table 1 shows that the mean number of ovipunctures were significantly (P = 0.05) more on monocropped beans even when they were sprayed than when beans were intercropped with maize and not sprayed. Oviposition on intercropped plots(unsprayed) was reduced as on pure bean plots that were sprayed. This indicated that intercropping lowered oviposition significantly (P=0.05).

Figure 2 similarly indicates that mining on bean stemsand symptoms that the maggot were moving toward the base of the plant remained low on plots where beans were planted together with maize and when beans planted as a monocrop was sprayed with insecticides. Mining on plants reached the peak 4 weeks after germination in bean plants that were intercropped with maize and sprayed and on fifth week when in pure stands and not sprayed. Table 2 shows that there were no significant (p=0.05) differences between treatments in the symptoms of mining. However, the number of BSM that reached and entered the base of the bean plant, damaged and pupated were lowest in plots where beans were intercropped with maize (Figure 3) showing that not all maggot that managed to go down were able to damage the plant. This was also evident when the number of pupae were counted as shown in table 3. There are indication that there were no significant (P = 0.05) differences in the number of *O. phaseoli* recovered per plant between plots where beans were intercropped with maize and when in pure stands. This is a clear indication that intercropping even without insecticide treatment lowers damage considerably. Only a few of *O.spencerella* were recovered during the course of the experiment.

DISCUSSION

The data on BSM oviposition (No. of ovipunctures) and damage (number of mines and pupae recovered on damaged plants) tended to show that initially oviposition was uniform in all the treatments. However, when maize got taller and started covering the beans, oviposition was reduced in all intercropped plots.

This observation reveals that initial colonization by *O. phaseoli* adults was not affected by the cropping. However, as the season progressed, oviposition was reduced in all intercropped plots, an indication that adult movement was hampered by maize. Gethi and Khaemba (1985) working on pest of cowpea found that *Maruca testulalis* Geyer damage symptoms were higher at the edge than at the center of the plots, an indication of the pest not being able to penetrate to the centre. It is also clear from the data that application of the insecticide reduced the number of maggots migrating after hatching. Similarly migration as evidenced by the number of mines was also very low in all the plots where beans were intercropped with maize. This indicated that intercropping reduces the number of eggs laid and subsequent maggot survival.

It is presumed that other than barriers to the adults of the bean fly, other factors like shading effects of maize never favored the establishment and larvae survival in bean plants. It is also most probable that the distribution and establishment activities of BSM in the intercropped plots were also influenced by other factors suggested by Nangju (1975). Nevertheless, these findings suggest that intercropping beans with maize resulted in fewer number of BSM damaging the crop. These findings are in the agreement with those of Kayumbo's (1977) work on cowpea.

The overall impression gained from the data presented indicated that intercropping played a very big role in reducing BSM population when the crop was planted together with maize.

CONCLUSIONS

It can be concluded that intercropping had specific effect on the *O. phaseoli* establishment and surviving on the bean plant. This can be attributed probably to microenvironments created within the intercrop (High RH and low temperatures). It is already known that BSM is more destructive in drier than cooler conditions (Nderitu and Kayumbo, 1990). Maize might have acted as a movement barrier within the intercrop.

The use of insecticide on pure bean stands is at times necessary to reduce BSM damage. If the insecticide protection is absent, intercropping beans with other crops, mainly maize, can be considered as a method of reducing damage by BSM.

This leads to a major conclusion that under small scale farming system with no insecticidal application to control BSM, intercropping is a lot better than monoculture.

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PRELIMINARY INVESTIGATIONS INTO THE INCIDENCE OF BEAN FLIES, (*OPHIOMAYIA* SPP), AND THEIR PARASITISM IN SELECTED GRAIN LEGUMES COMMONLY GROWN BY SMALHOLDER FARMERS IN MALAWI

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ABSTRACT

The incidence of bean flies ophiomyia spp in beans, Phaseolus vulgaris; cowpeas Vigna unguiculata; soya beans Glycine max and pigeonpeas Cajanus cajan was investigated in rain fed and irrigated trials at Bunda College of Agriculture in the 1993/94 season. Bean flies significantly preferred beans to cowpeas, soya beans and pigeon peas and their preference in cowpeas and soya beans was similar. Bean fly adults were the lowest in pigeon peas. No bean fly immatures were found in pigeon peas but they were significantly higher in beans than in cowpeas and soya beans. Immatures, suspected to be those of Agromyza sp. were only found in pigeon peas. Parasitoids suspected to be Sphegigaster spp and Eopelmus spp were found to parasotize bean fly in the rain fed crops only. Sphegogaster spp parasitism was 59, 27 and 14% whilethat of Eupelmus spp was 83,O and 17% on beans, cowpeas and soya beans respectively.

INTRODUCTION

In Malawi, pulses, beans (*Phaseolus vulgaris*); cowpeas (*Vigna unguitulata*), soya beans (*Glycine max*), and pigeon peas (*Cajanus cajan*) are among the important food legumes. However, beans are the most popular and widely grown.

Beans are a good and main source of protein in the diets of the rural and urban population. The are a good substitute for people living in areas where animal protein such as fish and livestock are inadequate. It is estimated that most families eat beans at least twice a week, Kapeya (1995). They are used as a side dish in schools, training institutions and hospitals. In addition beans are an important source of income to the rural population and an important foreign exchange earner for the country.

Beans are widely grown between 5OO-24OO metres above sea level Anonymous (1995), Kapeya (1995). The crop is grown as either an intercrop, mainly with maize or as a relay crop after the intercrop and as a dimba crop during the cold and hot months between April and November. The area cultivated to beans is estimated to be 116,268 hectares with an annual production of 38,755 metric tonnes, Kapeya (1995). The yield potential is 3000 kg/ha but actual yield is only about 2OO and 6OO kg/ha for the intercrop and sole crop respectively. The gap between the potential and actual yields being mainly due to poor management, poor soils, other factors and insect pests and diseases, Anonymous (1995), Mvula, (1995).

There are many insect pests of beans but several species of the bean fly (*Ophiomyia* spp) is generally considered to be the most destructive pest in tropical Africa including Malawi. The insect can cause damage up to 100% Kapeya, (1995) and losses of 50-100, Taylor (1959).

In the smallholder farming, systems, other leguminous crops, namely cowpeas, pigeon peas and soya beans are important alternative hosts of the bean fly, Kapeya (1995), ICRISAT (1989. However, it is generally felt that beans are the principal host crop Slumpa and Kabungo, (1989). In Malawi pigeon peas and cowpeas are commonly grown in the same fields or fields in proximity to those where beans are grown. Although soya beans have recently been introduced in the country, the crop is gaining popularity and is also grown in the same fields as beans or adjacent fields. These crops may therefore play an important role in the incidence of bean fly on beans and the survival of the insect at different periods during the year. The alternative crops may also affect the incidence and survival of the parasites of the bean fly.

Although the incidence of bean fly in alternative hosts both crops and wild plants has been widely recorded. there is limited or no such information specific to Malawi. Similarly such information is also lackinc on the parasitism of the bean fly on different crops.

The objective of these preliminary studies were therefore to establish the preferences of the bean fly between leguminous crops commonly grown by smallholder farmers, (namely beans, cowpeas, soya beans and pigeon peas) and to establish the level of parasitism on these crops.

MATERIALS AND METHODS

The trial was carried out at Bunda Students' Research Farm in the period 1993/94 growing season. A similar trial was repeated in the dry season at Bean/Cowpea Research Farm under irrigation. Beans (*Phaseolus vulgaris*) variety Nasaka; pigeonpeas (*Cajanus cajan*) variety ICP 9145; cow peas (*Vigna unguiculata*) variety IT 82E-16 and soya bean (*Glycine max*) variety Impala were grown in a completely randomized block design. Each treatment (Variety) was replicated five times. Each plot measured 6 ridges by 7 m and 6 ridges by 6 m in the rain fed and irrigated trials respectively. The ridges were spaced O.9 m apart. The blocks were separated by a path 0.5 m wide. The number of seeds per planting station and the within row spacing adopted were those currently recommended to farmers and are shown in Table 1. Planting was done on 21st December, 1993 and 23rd June, 1994 for the rain fed and irrigated trials respectively. Ridges 3 and 4 were reserved for yield data. Data collection was done once a week starting from the third week after seed germination. Adult bean flies were determined by pacing slowly for about 10 minutes in each plot and counting numbers observed in that particular plot and were sampled between 0700 and 1100 hrs. Pupae and larvae were determined by uprooting five plants showing damage symptoms at random from each plot. The plants were then thoroughly checked in all its parts (fresh pods, cotyledons and stem bases) for larvae and pupae presence. In pigeon peas, five pods were selected at random from the plants. The pupae sampled were stored until they emerged into adults in order to check for parasitism. The insect parasites found were identified by comparing them to the parasites that were once found on pupae sampled from beans being kept in the Entomology laboratory at Bunda.

RESULTS

Rain fed trial

The incidence of adults and immature bean fly are presented in Table 2. Beans had significantly higher incidence levels of all three stages than the rest of the crops. No immature stages were found on pigeon peas. On the other hand adults were found on all the four crops although levels were significantly lower in pigeon peas than the rest of the crops. It is interesting to note that although levels of adults were significantly different in cowpeas and soya beans, levels of immatures were similar.

In beans, soya beans and cowpeas the larvae and pupae were found in collars of infested plants. This infestation pattern was similarly true for the irrigated (Dry season) experiment. The insect that infested pigeon pea pods has not been identified, but is believed to be the Agromyza species. The infested pods had no external symptoms. However, larvae tunnelled through the seed consuming on the starchy food material in it. Pupation took place in the pods. The highest bean fly population in beans was found in February (Six to eight weeks from seedling emergence (Fig. 1a*). These results agree with those of Kantiki (1989) who reported that the bean fly occurrence in beans in Bunda is in mid-January peaking in mid-February, and Kapeya (1995) who found peaks between February and March at Makoka and Chancellor College in Southern Malawi. The bean fly larvae and pupae populations in both cowpeas and soya beans was in February peaking in early March when the beans had reached physiological maturity (Fig. 1b and c*).However, soya beans had a significantly ($P=0.01$) higher pupae count in March (nine to eleven weeks after seeddling emergence). Pigeon peas had the highest bean fly adult population in February (Fig. 1a*).

TABLE 1: **The number of seeds per planting station and the within row spacing for the treatments - Rain fed and Irrigared.**

Crop	Number of Seeds/Station	Number of Rows/Ridge	Between row spacing	Within row spacing
Beans	1	2	30	10
Soya Beans	1	2	30	5
Cowpeas	1	1	-	20
Pigeon peas	2	1	-	60

SOURCE: Malawi government 1992. Guide to Agricultural Production in Malawi 1992/93. Lilongwe : Extension Aids Branch, Ministry of Agriculture.

TABLE 2: **Mean incidence of bean flies (per plant for larvae and pupae, per 10 minutes for adults).**

Crop	Adults	Larvae	Pupae	Immature (L + P)
Beans	42.60	2.56	7.56	10.12
Cowpeas	19.40	0.64	1.12	1.56
Soya Beans	29.60	0.52	0.72	1.24
Pigeon peas	12.00	0.00	0.00	0.00
LSD (0,05)	5.609	0.621	2.456	2.435
CV %	15.72	51.24	63.85	54.70

TABLE 3: **Parasites identified in bean fly PU pupae.**

Parasite	Type of parasitism	Pest stage parasite recovered	Percentage parasitism		
			Beans	Cowpeas	Soya beans
Sphegigaster spp.	larval-pupal	pupae	59	27	14
Eupelmus spp.	larval-pupal	pupae	83	0	17

Pupae sampled from beans were the most heavily parasitized by both species of the parasites. Although identification has not been confirmed, the parasites are suspected to be *Eupelmus* spp.and *Sphegigaster* spp. and the levels of parasitism by each species are shown in Table 3. Crop yields and total immature beanfly infestations are indicated in Table 4. The yields are low and may also reflect the potential of each crop.

TABLE 4: **Grain yields and immature bean fly infestations per plant.**

Crop	Immatures	Yield (kg/ha)
Beans	10.120	286
Cowpeas	1.560	338
Soya Beans	1.240	424
Pigeon peas	0.000	170

TABLE 5: **Mean incidence of bean flies and pigeon peas (per plant) for larvae and pupae per 10 minutes for adults.**

Crop	Adults	Larvae	Pupae	Immature (L + P)
Beans	9.400	2.440	3.960	6.400
Cowpeas	3.200	1.160	0.240	1.400
Soya Beans	3.800	0.680	0.600	1.280
Pigeon peas	1.200	0.000	0.000	0.000
LSD (0,05)	2.750	0.595	0.694	0.995
CV %	45.36	40.38	41.97	31.81

TABLE 6: **Grain yields and immature bean fly infestations per plant.**

Crop	Immatures	Yield (kg/ha)
Beans	6.400	518
Cowpeas	1.400	519
Soya Beans	1.280	657
Pigeon peas	0.000	298
LSD (0.05)	2.435	211
CV %	31.81	30.76

Irrigated Trial

The results followed the same trends as the rain fed trial. But adults were similar between cowpeas, soya patterns are shown (Fig 2*). No parasitism was observed in the irrigated crops possibly because thetrial was close to a sprayed crop. Yields were generally higher than in the rain fed crops (Tabel 6).

DISCUSSION

These results have established that beans are preferred to other legumes although patterns of infestations are similar between beans, soya beans and cowpeas. The results are generally in agreement with those of Slumpa and Kabungo (1989) who found that beans were the principal host of *Ophiomyia* spp. The preference for and greater survival of bean fly on beans rules out or limits the use of cowpeas, soya beans and pigeon peas as trap crops in any control programme.

The incidence of high bean fly populations in soya beans and cowpeas in early March when the beans were physiologically mature could be because at this stage beans which are most preferred by bean flies had dry stems and much of its leaves were shed off the plants which form the oviposition sites for the insect. Thus cowpeas and soya beans whose stems and leaves were still fresh and the latter still intact on the plants became alternative hosts of the insect. This may have implications for pest survival after beans have been harvested and may be important more especially where the rainy season of these legumes is closely followed by an irrigated crop of susceptible legumes. Thus, if a bean variety that is resistant to bean fly infestation and having the same growth period as cowpeas and soya beans can be developed, the effect of bean flies on growth and development of susceptible cowpea and soya bean varieties can be reduced if the three crops are grown in association during the rainy season. Alternatively, breeding varieties of soya beans and cowpeas with short growth periods so that they mature at the same time as beans may reduce the survival of the bean fly in dry season when the bean crop is limited. Although the levels of parasitism were low on cowpeas and soya beans, those on cowpeas which are known to grow throughout the season may contribute to the rapid build up of parasites on the bean and other leguminous crops of the following season.

The low levels of bean fly populations in the dry season (irrigated crop) may be contrary to the findings of Swaine (1968) and Wallace (1939) who reported that bean fly infestations were more pronounced in the hotter, drier seasons than in cooler wetter seasons. However, the lower populations in the irrigated crop may be a result of dimethoate sprays which were applied to beans adjacent to the trial reported here. Similarly lack of parasitism may also be a result of drift from dimethoate sprays.

Lack of immature in pigeon peas is contrary to findings by other workers Reed, Lateef, Sithanantham and Pawar (1989). However, even if this finding is confirmed in later work, yield of pigeon peas would still be reduced by infestations of a suspected Agromyzidae found to damage pods Fig. 3*.

The mean percentage parasitism of 71 on beans is considered quite high and compares well with the findings of 53 and 68% at Makoka Research Station and Chancellor College in the Southern Region by Kapeya (1995).

Although the parasitism was high the poor control of *Ophiomyia* suggests that the parasitoids are inefficient. This may be because they arrive late on the scene. Therefore there is need to study how best to improve their efficiency.

The results of Kapeya and the work reported here suggests that there may be a wide diversity of parasitoics. Parasitioids found in the Southern Region were *Opius paseoli* and *Gronotoma* spp. Kapeya (1995) whereas those round at Bunda in the Central Region are *Sphegigaster* spp. and *Eupelmus* spp.

CONCLUSION

This work has established that *Ophiomyia* spp. prefer beans to cowpeas, soya beans and pigeon peas, and that the pest does not survive on pigeon peas which is attack by a suspected Agromyzidae. In beans infestations peaked in February, between 6 and 8 weeks after planting and in cowpeas and soya beans peaks were between February and March, 9-11 weeks after planting.

Populations of bean fly were relatively lower in the irrigated crops in the dry season and there was no parasitism. In the rain fed crop parasitism was significantly higher in the bean than on cowpeas and soya beans. The mean percentage parasitism were 71, 14 and 16% on beans, cowpeas and soya beans respectively. The unconfirmed identification of the parisites were *Sphegigaster* spp. and *Eupelmus* spp. There was no parasitism of bean fly by *Eupelmus* on cowpeas. There is need of further studies to improve the efficiency of parasitism on beans.

Although the results were in general agreement with other workers, there were areas which were contrary to other findings. There is need for further investigations.

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* Figures missing.

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AN INTEGRATED CONTROL PROGRAMME FOR BEAN STEM MAGGOT (BSM) FOR LOW EXTERNAL INPUT FARMERS ON THE NIASSA PLATEAU, MOZAMBIQUE.

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ABSTRACT

Research on bean stem maggot (BSM) is being carried out at Lichinga Research Station on the Niassa Plateau in northern Mozambique with the aim of determining the phenology and importance of the pest on common beans. The objective of the study has been to develop integrated control techniques for local farmers who have very limited access to external inputs (fertilizer, insecticide, etc.). The methods used included date of sowing trails in six consecutive seasons in order to determine infestation rates of BSM on beans with time during the main bean growing season (November- April) and to determine yield losses due to the pest. These trials were also used to evaluate insecticide treatments against BSM. At the same time a survey of parasites of the pest and parasitism rates was undertaken from pupa collected at each sowing date. Other work undertaken included a survey of local bean varieties for resistance to BSM in combination with the evaluation of varieties from the CIAT beanfly resistance reconfirmatory nursery as well, as an evaluation of the possible link between BSM infestation and the incidence of root rots. Using the results of this research it has been possible to formulate recommendations for integrated control of BSM under local farming conditions.

INTRODUCTION

Common beans (*Phaseolus vulgaris* L.) are an important crop for small scale subsistence farmers on the Niassa Plateau in northern Mozambique. The main cropping system is a maize-beans-Irish potato intercrop sown on ridges soon after the start of the rains in November. There are three principal bean growing seasons during the agricultural year; beans are sown in intercrop with maize in December, in relay crop with maize in March and in intercrop with maize or small areas of monoculture in valley bottoms with residual moisture from July. Beans are grown for their green leaves (plucked at 20- 25 days after emergence (dae)), green pods and dry grain.

There are various physical and biological constraints to bean production on the plateau depending on the growing season. Bean stem maggot (BSM) is the most prevalent insect pest on beans and is considered one of the most important limiting factors to bean production (Heemskirk 1988). In 1988 work was started to investigate the phenology and importance of BSM in the context of the local production system and as part of a general programme to improve research efforts on common beans at Lichinga Agricultural Research Station. The objective of the study has been to develop an integrated control programme for farmers in the region who have very limited access to external inputs (fertilizer, insecticides, etc.).

SUMMARY OF METHODS

Starting in December 1988 a series of trials was initiated at the research station. Only a brief description of the objectives and methods used are presented in this paper.

DATE OF SOWING TRIALS (1988- 1995)

Date of sowing trials were implemented in six consecutive seasons with the objective of rapidly obtaining basic information about BSM, including infestation rates with sowing date in the main (rainy) growing season and simple life cycle data including information on parasitism, damage levels and the efficacy of various insecticide treatments.

In each agricultural year bean trials were sown once a month throughout the rainy season. Each trial consisted of four treatments in a Latin square design. The treatments always included the local variety Manteiga, the local variety Encarnado without insecticide treatment, the same variety Encarnado with insecticide treatment and an improved variety from CIAT with suspected tolerance or resistance to BSM. A 417. The insecticide treatments varied depending on trial and season (see Fig. 2). BSM infestation was assessed from counts of larvae and pupae in 10 plants chosen at random 30 dae and the effects of BSM evaluated as a function of percentage plant loss and dry grain yield.

BEAN FLY RESISTANCE RECONFIRMATORY NURSERY

The bean fly resistance reconfirmatory nursery was sown in two seasons with the objectives of confirming the resistance or tolerance of four promising varieties to BSM and exploring a possible link between BSM and stem or root rots.

The trial was sown in a split-plot design with three replicates. In the first season the main plot consisted of insecticide treatment (diazinon as a seed dressing and a foliar spray 2 and 12 dae) and the sub-plots six different varieties (Ikinimba, ICA Pejão, ZPV 292, A 417, Manteiga and Encarnado). In the second season a fungicide treatment was added to the main plot treatments (benomil as seed treatment and foliar spray 12 and 20 dae). BSM infestation and plant mortality due to BSM and root rots was assessed at 20, 30 and 45 dae.

EVALUATION OF LOCAL VARIETIES FOR RESISTANCE TO BSM

Varieties of common beans collected locally were evaluated in four main seasons for resistance or tolerance to BSM. The observations were made as part of a larger trial to characterize local bean varieties.

The varieties were evaluated in a randomized complete block design in the two bean growing seasons (sown in December and March) within the main season. From the second year the local maize-bean cropping system was used. BSM larvae and pupae were counted in 5 plants at random 30 dae in each plot.

EVALUATION OF NATURAL PRODUCTS AGAINST BSM

Trials were run in three seasons to evaluate the performance of various natural products against BSM. The objective of the trial was to try and identify a low cost plant extracts available locally for use against BSM instead of imported insecticides.

The exact experimental design varied with season but five local products were evaluated as both seed treatment and as foliar sprays. These were tobacco (*Nicotiana tabacum*), garlic (*Allium sativum*), chilies (*Capsicum frutescens*), "mata-peixe" (*Tephrosia vogelii*) and basil (*Ocimum basilicum*). Recommended insecticide treatments (seed and foliar sprays) were used as treated control and a soap and water solution as the non-treated control. BSM infestation was assessed 30 dae in 10 plants chosen at random in each plot. Plant emergence was evaluated for possible phytotoxic effects.

SUMMARY AND DISCUSSION OF THE RESULTS

Date of sowing trial

BSM infestation with date of sowing

Levels of infestation of BSM on beans vary with date of sowing during the main cropping season (November-June) but are similar across seasons. In two local varieties (Manteiga and Encarnado) infestation is low at the start of each planting season (first planting season early to mid December, second season early to mid March) and rises with delay in sowing (Fig. 1), especially in the first planting season.

BSM infestation is low in off-season beans sown in 'baixas' (wet valley bottoms with residual moisture), but it is considered probable that these plantings are responsible for carry over between seasons, as no viable pupae have been found in bean residues, or emergence of adult beanfly observed later than 60 dae in sampled pupae (3.1.2.).

PHENOLOGY OF BSM

The principal species of BSM on the plateau in Niassa is *Ophiomyia spencerella* (normally 90% or more of pupae sampled) with a smaller percentage of *O. phaseoli* (typically 10% or less of sampled pupae) and *O. centrosematis* (less than 1%).

Peak emergence for BSM adults is 42 days after crop emergence (dae) and for parasites 48-58 dae (Fig. 2). *Eucloidea impartus* was the principal parasitoid found parasitizing BSM. Apart from *E. impartus*, the parasitoid *Opius melanagromyzidae* was found parasitizing BSM in significant numbers, and is possibly the reason for low numbers of *O. phaseoli* as it seems to be more efficient at parasitizing this species.

Rates of infestation have been linked significantly to the percentage parasitism by the parasitoid *Eucloidea impartus* in the preceding generation (Fig. 3), and it is probable that the reduced infestation rate of BSM on beans at the beginning of the second growing season is due to the increase in parasitism in the first season and the subsequent reduction in BSM population for the beginning of the second. It was not possible to link BSM infestation rates with abiotic factors such as amount of rainfall or temperature at oviposition times.

IMPORTANCE OF BSM

Percentage plant loss during the growing season and final yield of dry grain have been significantly linked to BSM infestation in all three untreated varieties (Figs. 4 and 5) though it has been more difficult to attribute the causes directly to BSM. The form of the yield response curve suggests that there are aggravating factors, which probably include a general weakening of the plants and the entry of root rots into the wounds caused by BSM which rapidly increase yield loss even with a small increase in infestation.

On average, for the variety Encarnado, 7.2% more plants were harvested in treated (5.9 BSM per 10 plants) over untreated (28.3 BSM per 10 plants) plots, and there is a yield advantage of 11.2% over the six seasons with treated plots. Analysing the data on the basis of the differences between the treated and untreated plots of the variety Encarnado an increase of one BSM per plant (or 10 BSM/10 plants) indicates a 6.5% increase in plant loss and a decrease of 27.7% in yield (Fig. 6) over normal losses in the absence of BSM, or about 11.5% plant loss and 17.6% yield decrease with an infestation of 1- 2 BSM per plant.

CONTROL WITH INSECTICIDES

Control of BSM has proved possible with a range of insecticides and application methods (Fig. 7). Cipermethrin (20 EC 1 ml/lt) applied as a foliar spray 2, 7 and 14 dae, diazinon (60 EC 2 ml/kg) as a seed treatment and endosulfan (50 EC 7.5 ml/kg) as a seed treatment have all proved effective though endosulfan provides most consistent protection against BSM throughout the season. Although the economic levels of attack depend on the price of beans and of insecticide the data indicate that currently in Lichinga this is 14 BSM per 10 plants at local production levels of 150- 200 kg/ha of dry grain (Fig. 8).

BEAN FLY RECONFIRMATORY NURSERY

The results of the bean fly reconfirmatory nursery are discussed in terms of the resistance or tolerance of the varieties evaluated in the trial and the interaction between BSM and root rots.

In general no significant differences were observed between the six varieties with respect to mortality due to BSM, root rots or BSM and root rots combined. Small but significant differences were seen in the numbers of BSM per dead plant between the varieties with the varieties Ikinimba and A 417 showing slightly less overall infestation. Ikinimba showed less overall plant mortality and higher yield than the other varieties, but this is probably due to better general resistance to foliar diseases (especially angular leaf spot).

Insecticide treatment suppressed BSM infestation on beans in the two years, whereas fungicide treatment in the second season appeared to have no effect on root rot. Inspecting plant mortality in the two seasons (Fig. 9) it can be seen that insecticide treatment, which suppresses BSM infestation and plant mortality due to BSM, also suppresses plant mortality due to BSM and root rot combined so that overall mortality is considerably reduced in the absence of BSM. These observations suggest an interaction between BSM infestation and root rots in the field and, it is possible that the wounds made by BSM at ground level on the bean plant stem facilitate the entry of root rots into the plant. Root rots identified in the field include *Fusarium oxysporum*, *Sclerotium rolfsii* and *Rhizoctonia solani*. Insecticide treatment also significantly increases grain yield (in all varieties), suggesting BSM infestation is strongly linked to final grain yield.

EVALUATION OF LOCAL VARIETIES

Across all eight seasons significant differences in BSM infestaion were observed between the 20 local varieties evaluated, especially in the second growing season. It appears that some varieties such as A 417, Nogolo, Kaela(r) and Manteiga II had lower infestation rates (Fig. 10). There were no significant differences in the percentage plant loss between the varieties across the seasons, although there was a tendency for a greater percentage loss with increase in BSM infestation (Fig. 11). In general across all seasons significant differences were observed between the varieties in terms of grain yield, and at the same time there is a tendency for the yield to decline with increase in BSM infestation, especially in the second growing season (Fig. 12).

EVALUATION OF NATURAL PRODUCTS

Plant emergence was not generally affected by seed treatment and the prepared natural products do not appear to have any phytotoxic effects. However in all seasons and with all natural products tested no significant difference was observed between the natural products and the untreated control (soap and water). The treated control (insecticide) was effective in controlling the infestation of BSM in all seasons (Fig. 13).

DISCUSSION OF INTEGRATED CONTROL OF BSM

Drawing from reviews made elsewhere (for example Gonzales (1986) and Ampofo (1991)), and on the basis of the results and observations made above, it has been possible to make recommendations for an integrated control programme against the BSM. It must be borne in mind however that there are other limiting factors to production, especially soil fertility and foliar diseases, which need to be addressed for yields to increase significantly for the subsistence farmer.

On the basis of the research undertaken, the following recommendations are being given to farmers, the emphasis being on cultural control of BSM which costs less.

1. Sow beans as early as possible in each sowing season (early December and early March in Niassa) to avoid periods of high infestation. Try to sow beans concurrently in any given area. The results from the date of sowing trial show that beans sown early in each growing season are less infested than beans sown at other times.

2. Observe good cultivation practises (prepare soil well, sow on ridges, fertilise at the optimum rate and on time) to ensure uniform emergence of seedlings. It is know healthy plants are less effected by infestation of BSM and root rots.

3. Earth up the plants 20-30 dae to encourage adventitious roots; the formation of secondary roots is a characteristic feature of BSM attack and infection by some root rots.

4. Bury (or destroy) the remains of the previous crop and try to leave as long an interval as possible between planting seasons, compatible with good husbandry (in the second planting season, for example, beans can suffer moisture stress if planted late). From observations made in Niassa it seems that most adult flies emerge within 60 dae of the crop and so although there is little carry over between seasons in crop remains seasons in the field. Destruction of plant it

is important not to overlap the crop remains is, however, beneficial for control of many foliar diseases.

5. Refrain from applying insecticide to the crop (or intercrop) between 40 and 70 dae, the main period of parasite emergence. If parasitism is disrupted in the first growing season it is probable that the population of BSM will be high at the beginning of the second season and from this point of view it would be better not to use insecticides in the first growing season when the expected yield is anyway low due to foliar diseases.

6. If infestation is expected to be high (late sowing in any planting season) or the field has a problem with root rots treat the seed with endosulfan (50 EC 5 ml/kg) or iazinon (60 EC 2 ml/kg) before sowing. It is best to avoid foliar applications of insecticide against BSM so as not to interfere with parasites. Due to the interaction between root rots and BSM infestation a treatment of insecticide or insecticide and fungicide is more effective in reducing incidence of root rots than fungicide alone.

Although some work has been initiated to test these recommendations in the local cropping system in on farm trials much more information is needed in this respect and the program will concentrate more on this aspect of the work in the coming seasons.

This work will aim not only to confirm the technical aspects of the recommendations but also to start building a better economic analysis of BSM infestation and the possible economic benefits of any control measures taken against the pest at farm level.

CONCLUSIONS

On the basis of a research programme carried out over six consecutive seasons it has been possible to gather basic information about the importance of BSM on common beans in Niassa. It has also been possible to use this information to suggest elements of an integrated control programme that can be adopted by farmers against this pest bearing in mind that their exist other constraints to bean production at this moment (foliar diseases and soil fertility). Future work will concentrate on testing these recomendations together with farmers to better evaluate their economic impact and to adapting the recommendations to fit in with the local cropping system.

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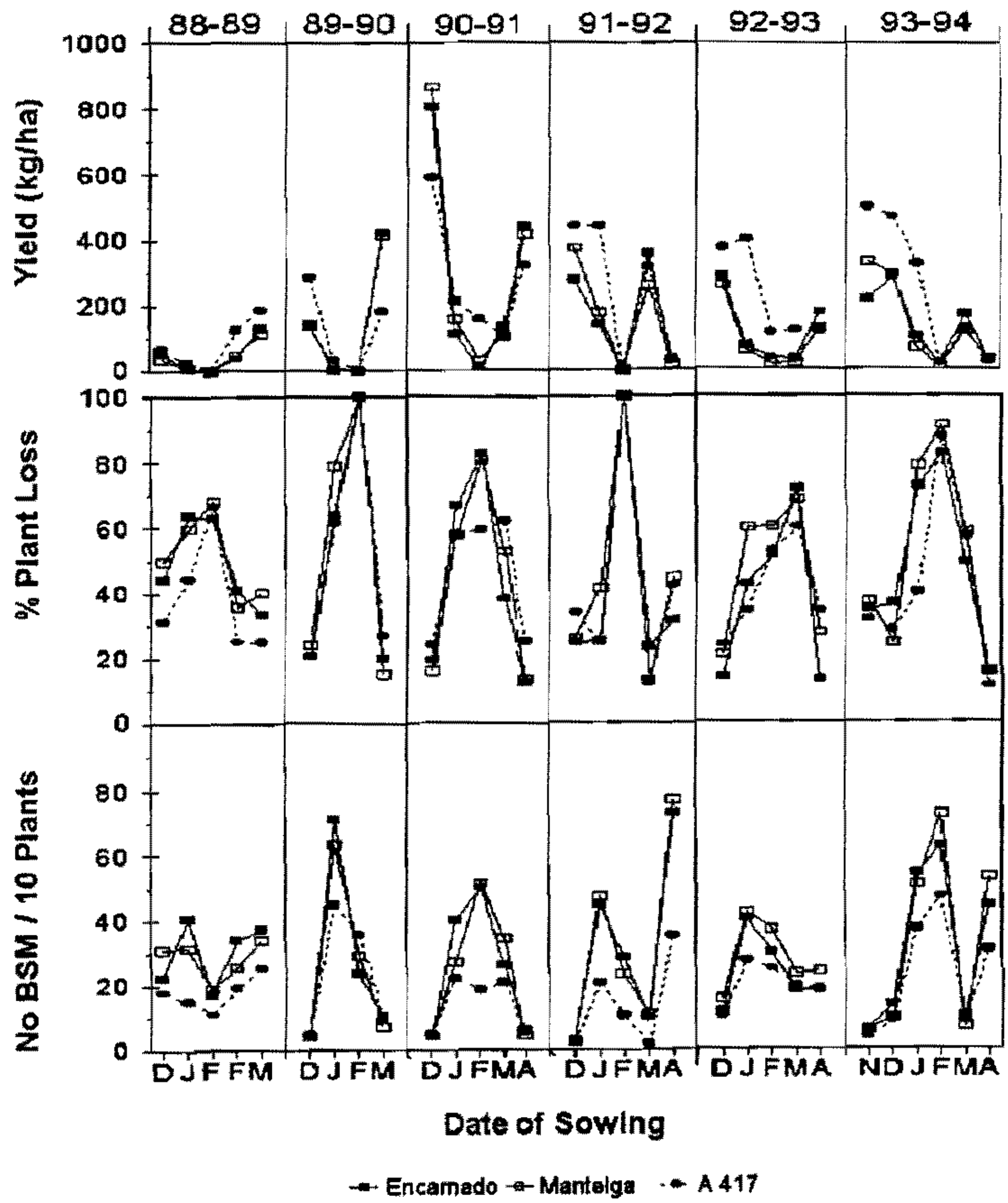
Figure 1: Numbers of BSM per 10 plants 30 d.a.e., percentage plant loss and yield (kg/ha) in three bean varieties over six main seasons, 1988- 94.



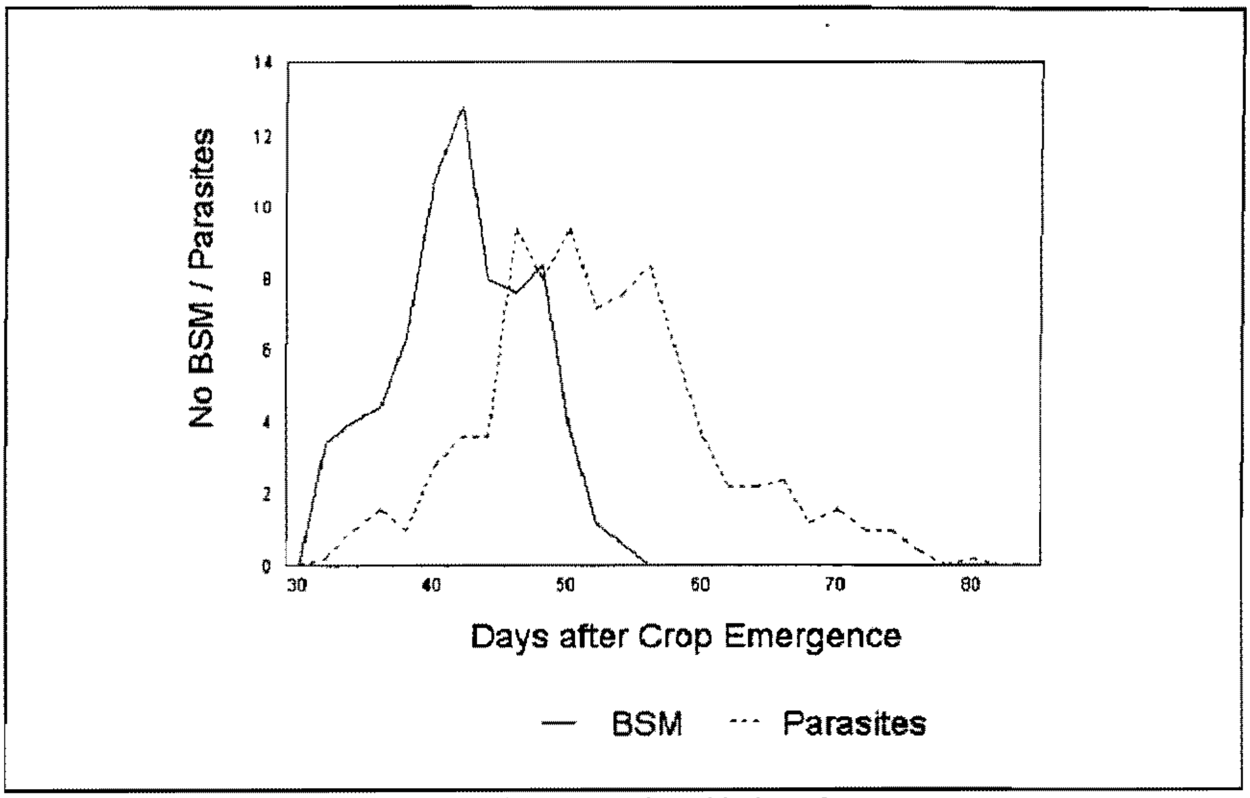


Figure 2: Number of BSM adults and parasitoids emerging with time after crop emergence.

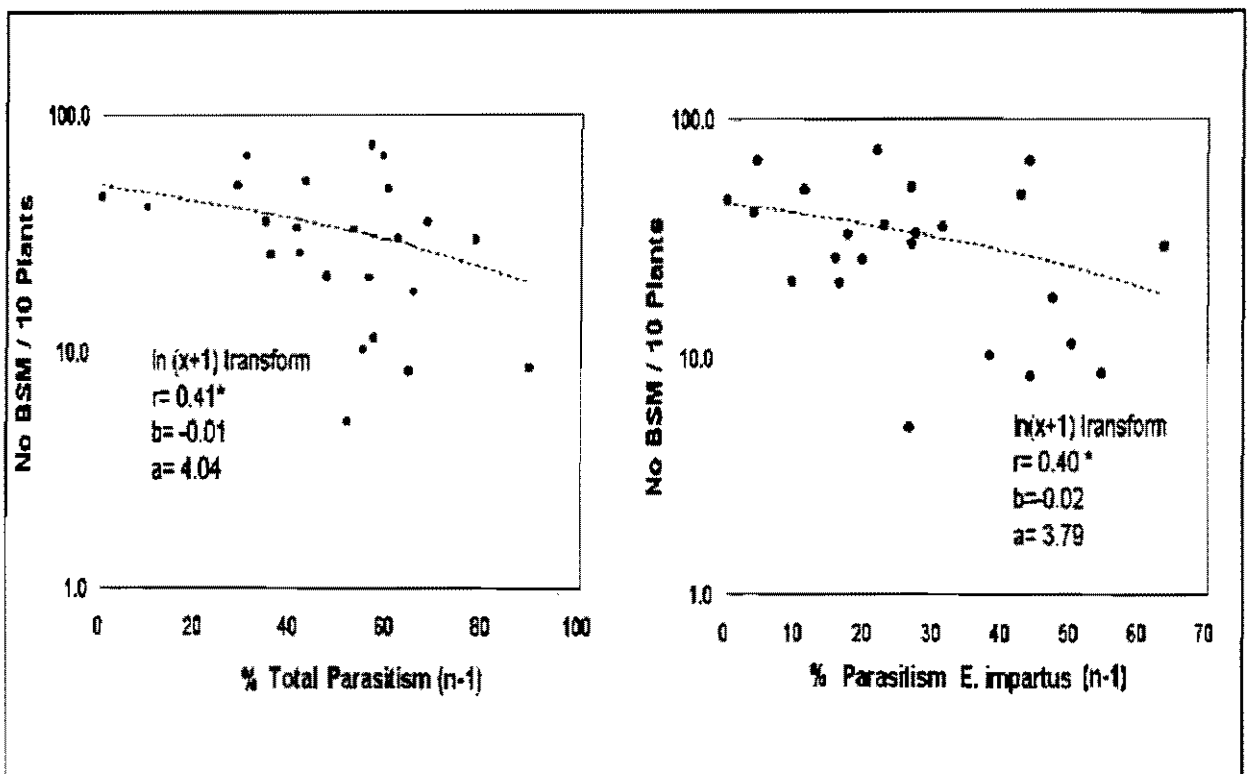


Figure 3 Number of BSM per 10 plants with a) total percentage parasitism and b) parasitism by *E. impartus* in the previous generation.

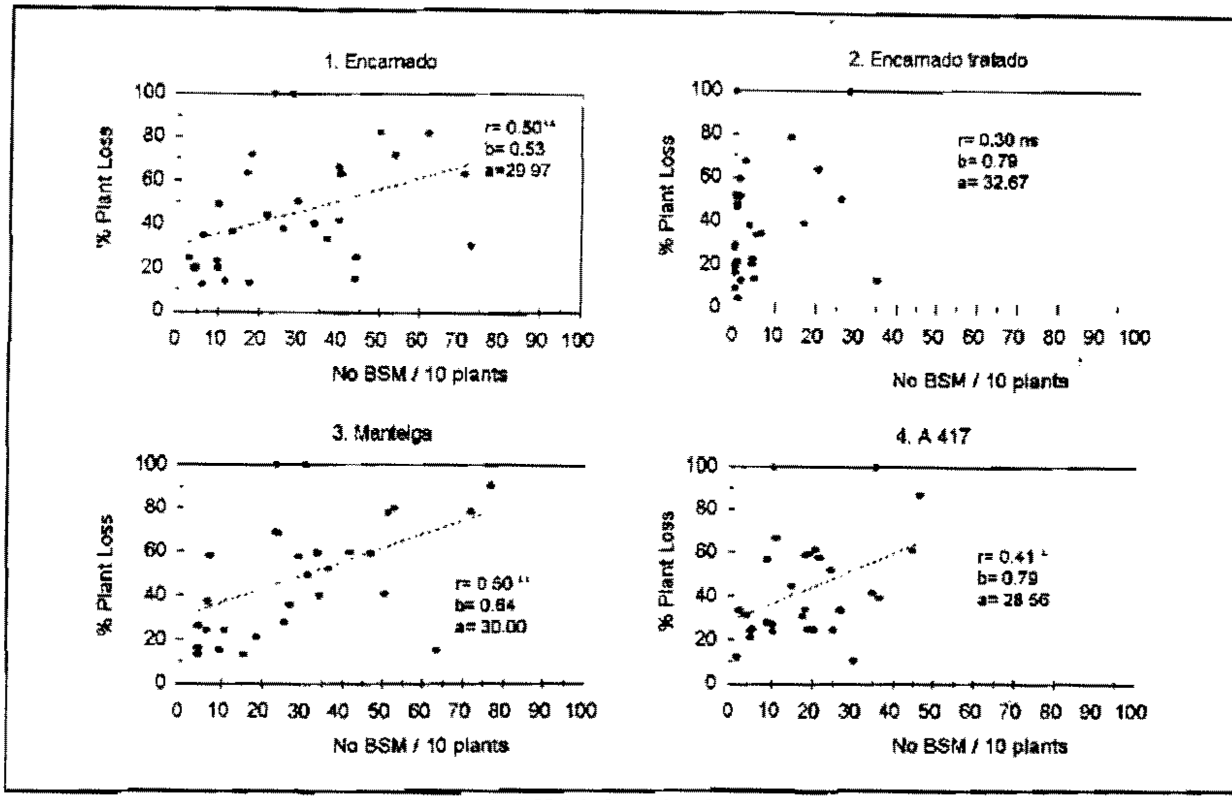


Figure 4 Percentage plant loss with BSM infestation in six seasons, 1988- 94.

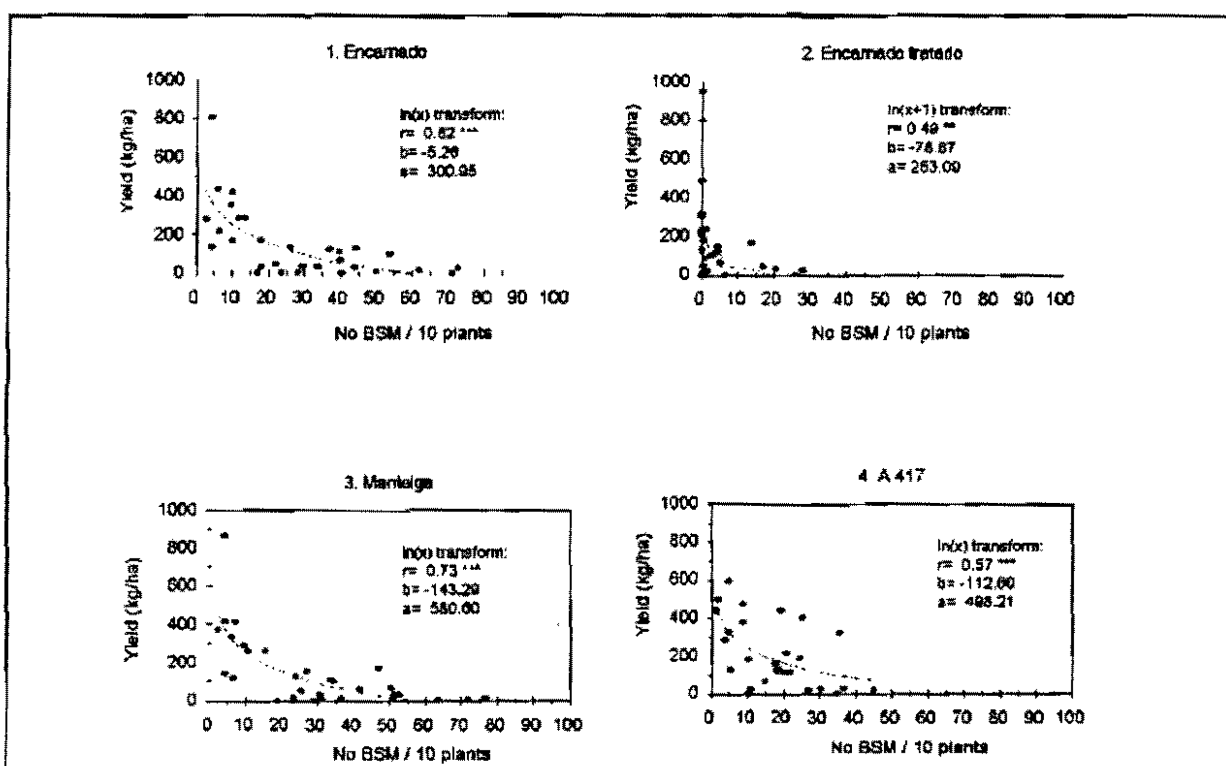


Figure 5 Yield (kg/ha) with BSM infestation in six seasons, 1988- 94.

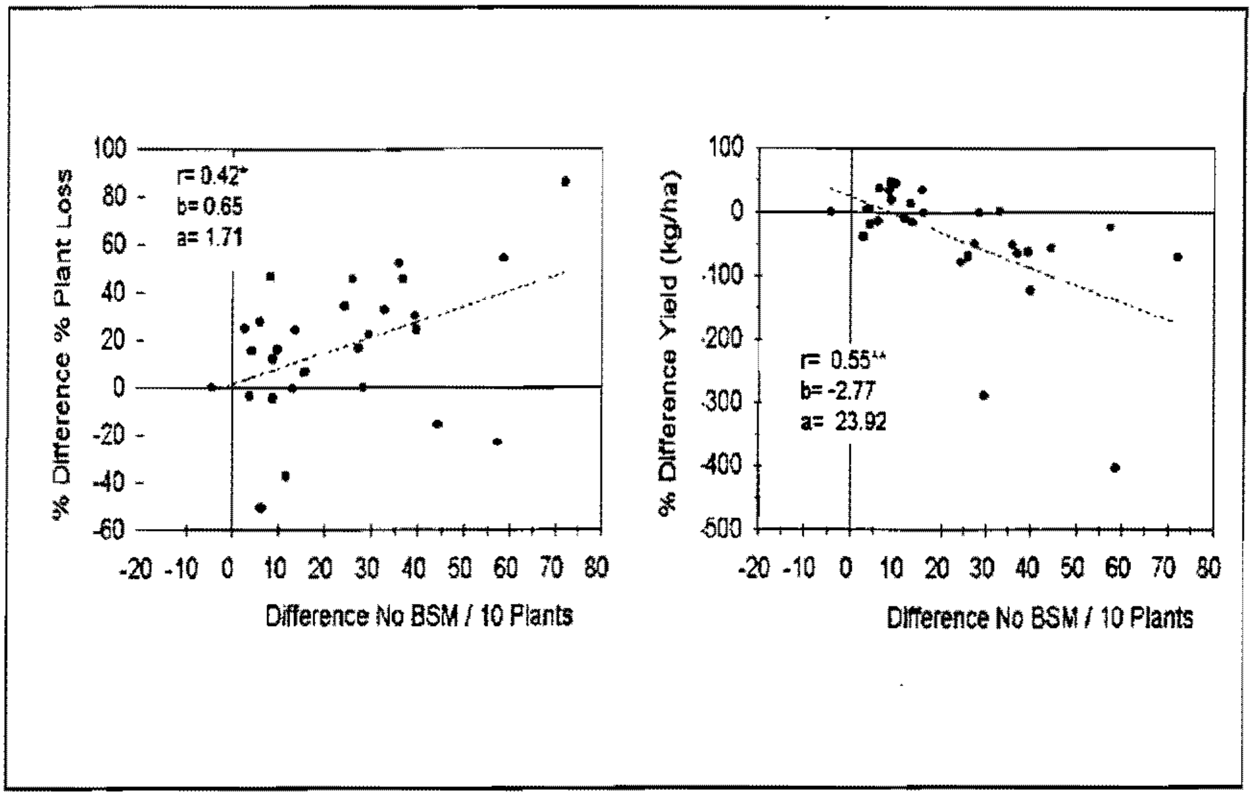


Figure 6 Percentage difference in plant loss and yield with difference in BSM infestation in treated and untreated plots of the local variety Encarnado, 1988- 95.

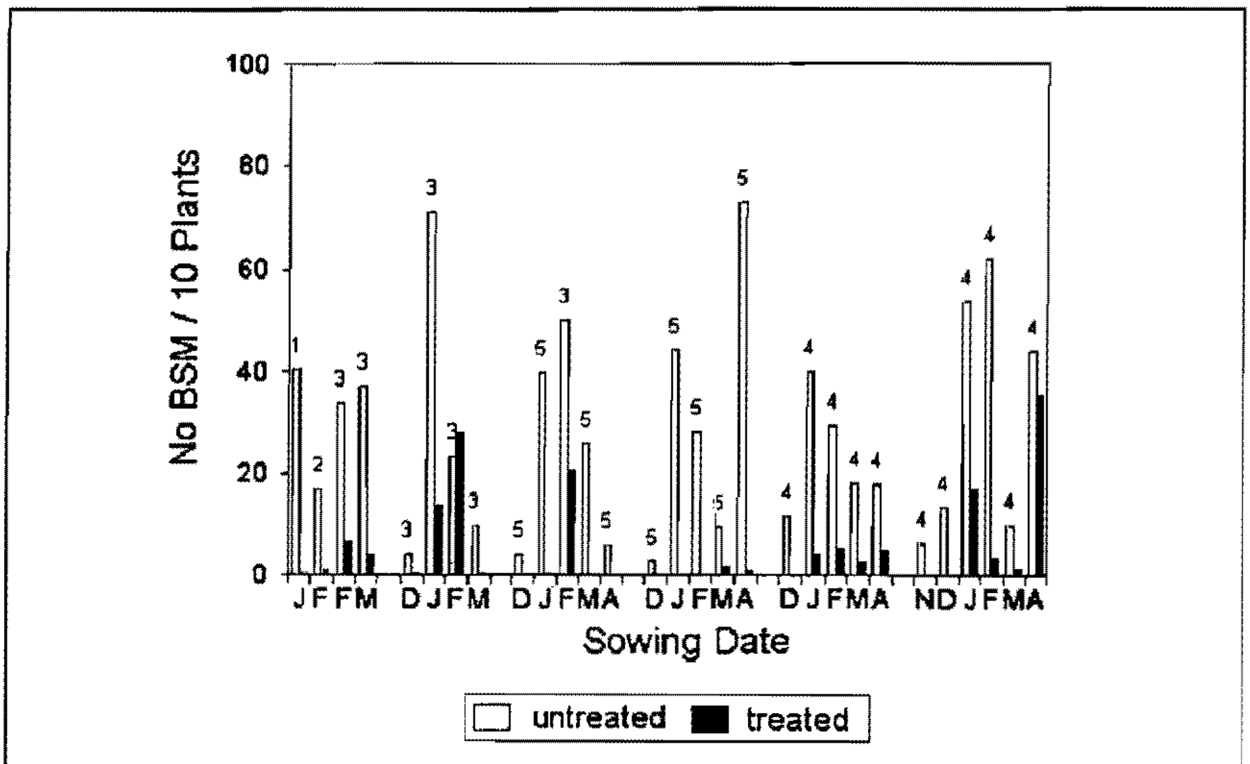


Figure 7 BSM infestation with and with out insecticide treatment on bean variety Encarnado, 1989- 94.

1- cipermethrin 2, 7 and 14 dae, 2- cipermethrin 2 and 7 dae, 3- diazinon 0.06% seed treatment, 4- diazinon 2 ml/kg 5- endosulfan 7.5 ml/kg

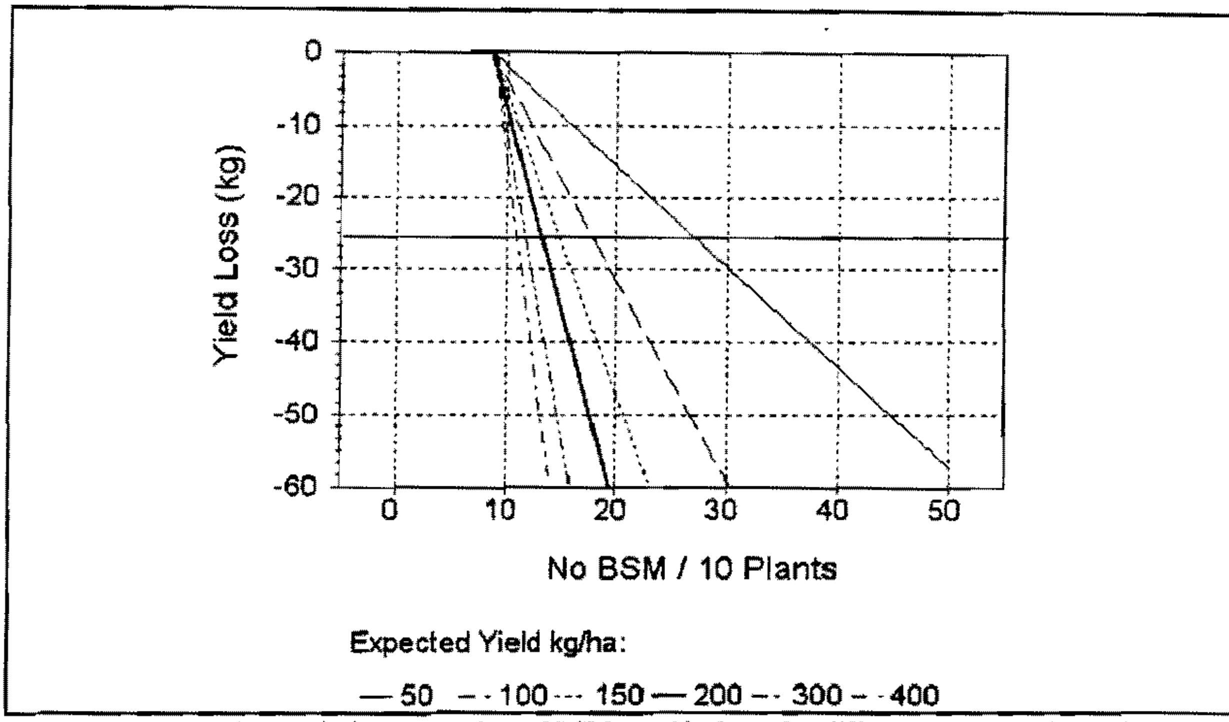


Figure 8 Yield loss (kg) with number of BSM per 10 plants for different expected yields of beans.

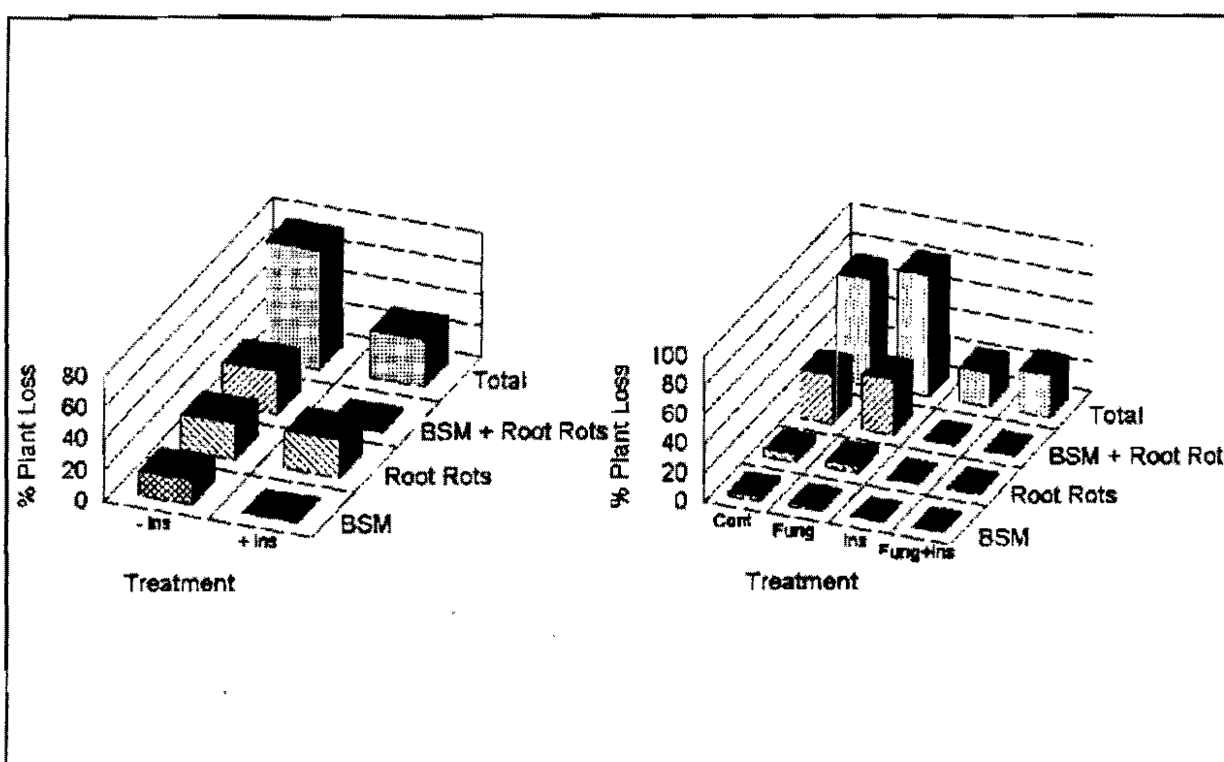


Figure 9 Mean plant mortality for various causes with pesticide treatment in two seasons, 1992- 93.

1992 1993

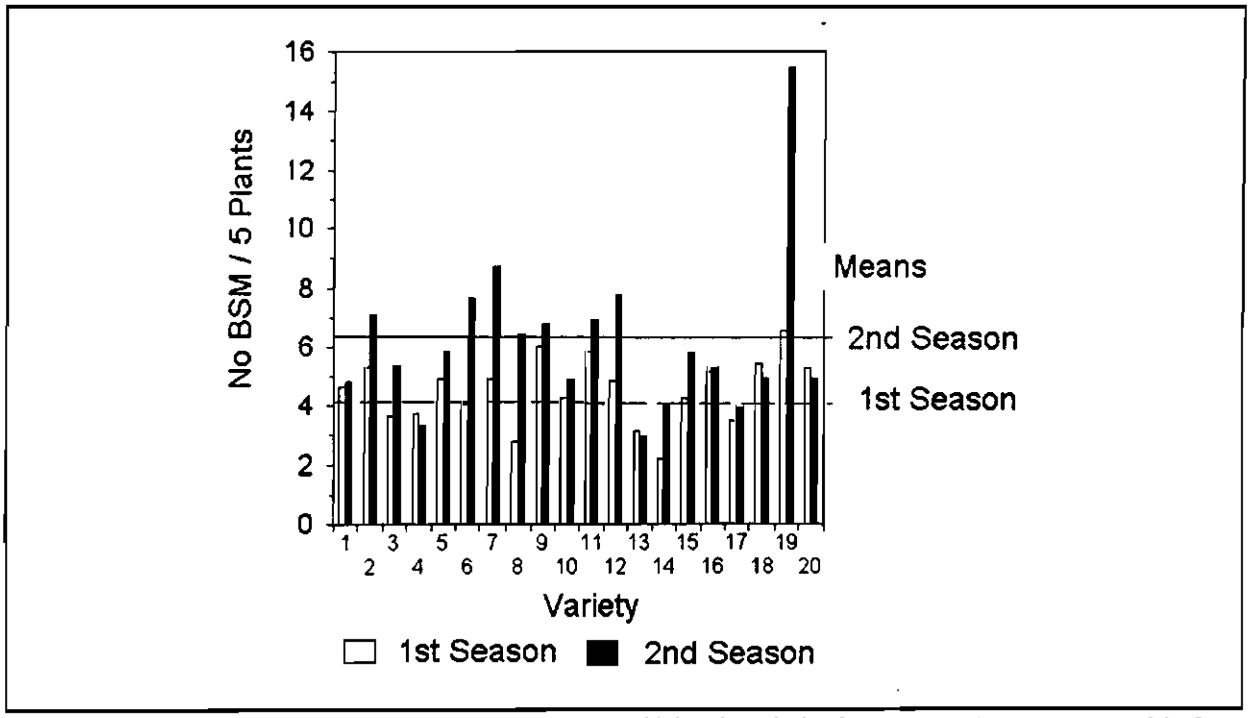


Figure 10 Mean number of BSM per 5 plants in 20 local varieties in two growing seasons and in four main seasons, 1989- 93.

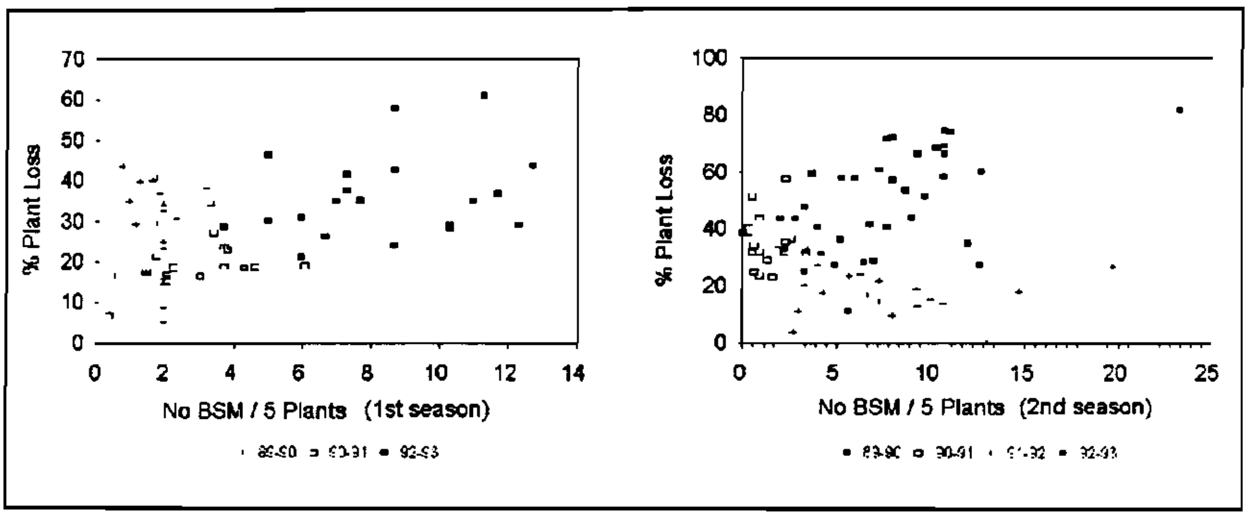


Figure 11 Percentage plant loss as a function of BSM infestation for all local varieties in the first and second bean growing season, 1989-93.

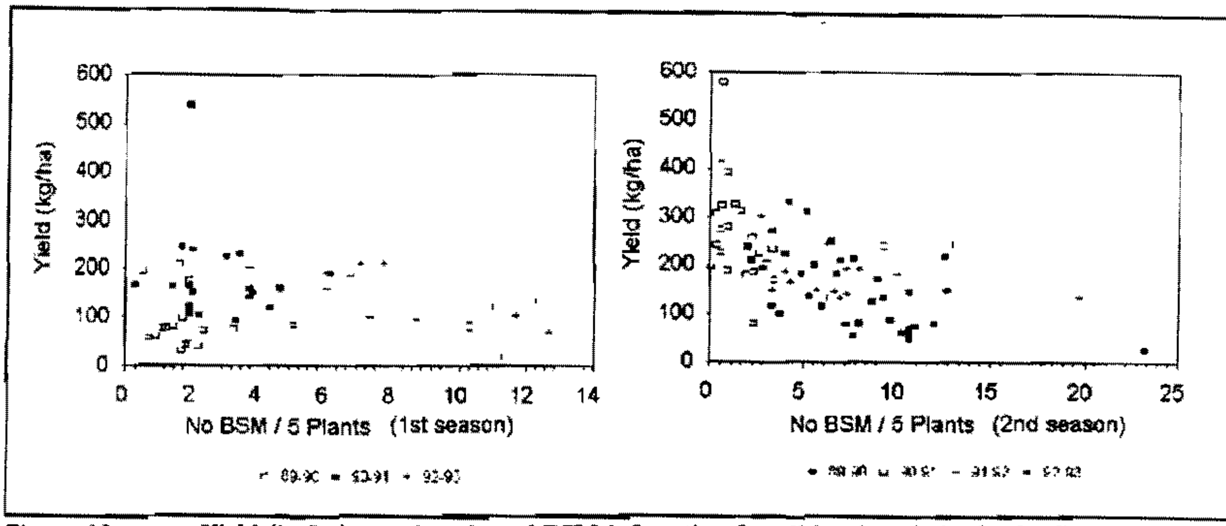


Figure 12 **Yield (kg/ha) as a function of BSM infestation for all local varieties in the first and second bean growing seasons, 1989- 93.**

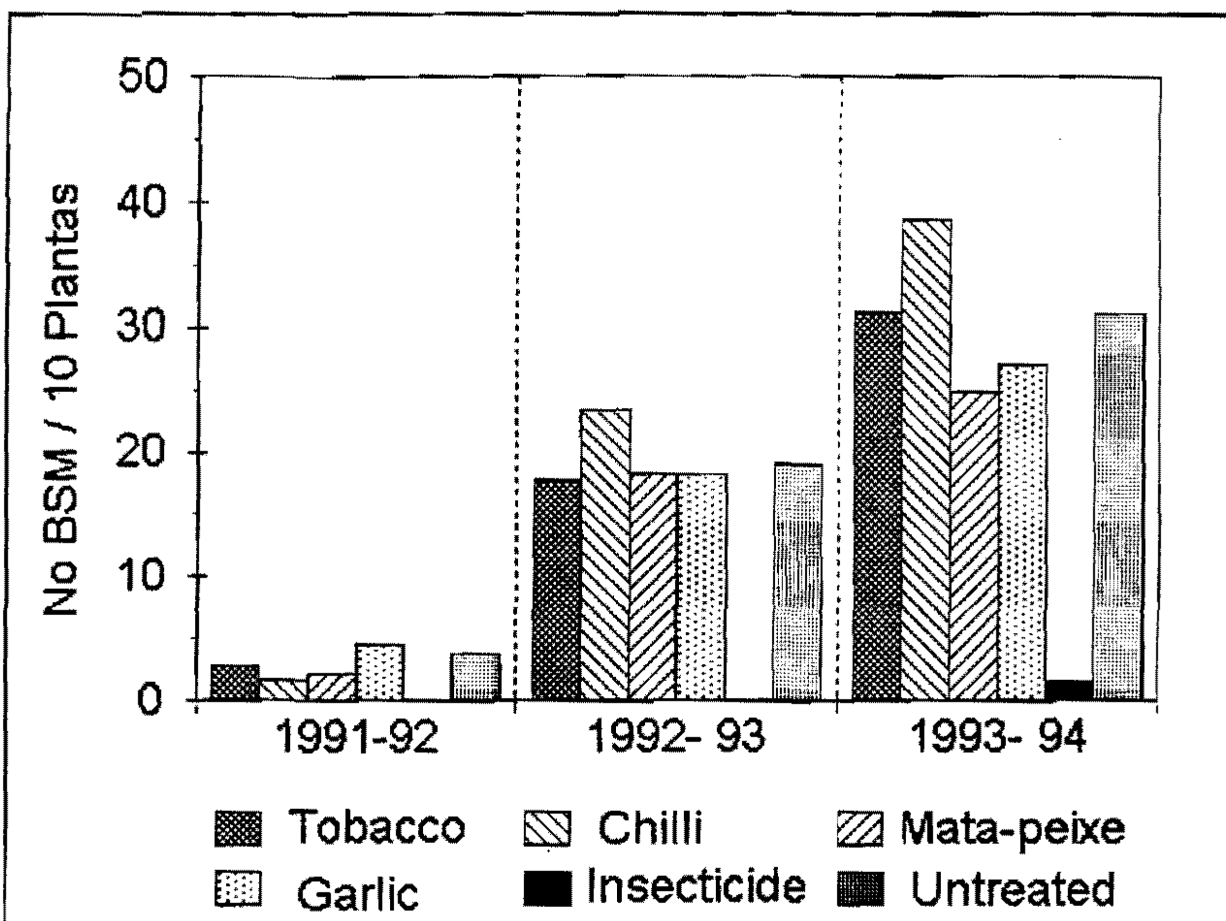


Figure 13 **BSM infestation with treatment by various natural products in three seasons, 1991- 94.**

AN ASSESSMENT OF THE BEAN STEM MAGGOT (*OPHIOMYIA* SPP.) DAMAGE AT GREYTOWN DURING THE 1995 SEASON.

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ABSTRACT

Bean Stem Maggot (BSM) is a serious production problem in many African countries. In South Africa, the problem receives very little research and extension attention. This study set out to assess the magnitude of the BSM problem at Greytown during the 1995 season. Using a split-plot trial, split for insecticide or no insecticide, cultivar reaction to BSM was determined. The trial contained sixteen cultivar entries, including three local controls. Assessment of the potential threat of BSM to local production was made by comparisons across treatments using the local control variety Wartburg. Seed treatment with endosulfan was effective in eliminating seedling mortality due to BSM. In comparing the treated versus untreated plots of Wartburg, the plant population reduction attributable to BSM was 10.9%. On average, treated Wartburg plots supported 0.93 BSM larvae/pupae plant^{-1} compared to 3.7 BSM larvae/pupae plant^{-1} in the untreated plots. The resultant yield loss due to the combined effect of plant stand reduction and the deleterious effects of the larvae and pupae amounted to 11.3%. With subsistence agriculture in KwaZulu Natal (KZN), where low fertility and late plantings are the norm, the effects of BSM can be expected to be more severe still. The findings of this study justify the call for more extension and research resources to be allocated to the BSM problem.

INTRODUCTION

Bean Stem Maggot (BSM), also known as Bean Fly, is often described as the principal insect pest in Africa. Yield losses of up to 100% have been reported (Abate, 1991) to occur as a result of seedling mortality. Three species of BSM occur in Africa; *Ophiomyia phaseoli*, *O. spencerella* and *O. centrosematis*. In the case of *O. phaseoli* the adult fly lays its eggs in the leaf near the petiole. The maggot which hatches from the egg, mines its' way beneath the epidermis from the leaf down to the base of the stem where it pupates. With *O. spencerella* and *O. centrosematis* the eggs are oviposited directly in the stem near the soil surface where feeding and eventually pupation takes place. The feeding activity of the larvae destroys the medullary tissue in the stem and can result in seedling mortality, stunted plant growth or secondary disease infections. The most severe damage occurs when peak infestations occur shortly after plant emergence.

In KwaZulu Natal, Melis (1985) reported the presence of BSM throughout the province and specific cases of BSM damage in up to 100% of the plants in certain fields. Two BSM species were identified (*O. phaseoli* and *O. spencerella*) to be causing the damage, although the extent of the yield loss was not quantified. At Greytown, damage caused by BSM has been noted to have occurred every season since 1987. Before this time, it may have occurred but was not diagnosed as BSM. Bean Fly feeding activity was noted to be highest in the late plantings (late January and early February). Plant population reduction and eventual yield loss were suspected in several cases but never quantified. This study was initiated to quantify the yield losses attributed to BSM in order to establish whether more breeding, research and extension resources need to be allocated to BSM.

MATERIALS AND METHOD

The CIAT Bean Stem Maggot Resistance Reconfirmatory Nursery -3 was planted at Greytown on 30 January 1995. The trial contained three local controls and 13 putative sources of resistance to BSM. For the purpose of this study, only the results of the cultivar Wartburg (the commercially planted local control) will be presented and discussed. The trial was planted in a split-plot design, with insecticidal treatments (insecticide versus no insecticide) as main plots and cultivars as sub-plots. The insecticide treatment used was endosulfan WP(47%) applied to the control plot seed at a rate of 5g kg^{-1} seed. All plots received a spraying of fungicide (Ridomil) in the furrow at planting at a concentration of 8g l^{-1}water. The fungicide was applied to control soil-borne fungi which could confound the expression of BSM damage. Plots consisted of two 4.4m long rows spaced 0.9m apart and replicated three times. The trial was fertilized with 300kg 2:3:2 (30) ha^{-1} placed in the row at planting. Data was collected in accordance with the standard methodology set out by CIAT (Ampofo,1991). At one week after emergence (WAE) and 2 WAE, a plant count was done and the number of seedlings killed by cutworm were recorded. At 3,4,5 and 7 WAE seedling mortality counts (due to BSM) were done. The dead plants were dissected and the number of BSM larvae and pupae were recorded. The puparia were sorted into species based on pupa colour and posterior spiracle characteristics. At 4 WAE, five healthy plants from each plot were dissected and the number of larvae and pupae were recorded. At harvest, a 3m section of row was harvested from each plot and the number of plants harvested was recorded.

Yields were calculated in tons $hectare^{-1}$ and the trial was analyzed using Genstat 5.1.

RESULTS

Bean Fly activity at the time of the trial emergence was high with 100% of the plants sampled showing the characteristic puncture marks on the leaf left by the fly's ovipositor. The species of BSM identified in all cases in this trial was *O. phaseoli*.

TABLE 1: The effects of Bean Stem Maggot infestation on the trial at Greytown during the 1995 season.

	Plant count 2 WAE[1]		
	Control[2]	Untreated	LSD (0.05)
Wartburg	42.00	39.67	9.62
Mean[3]	42.58	41.04	2.79
	Total BSM in 5 plant sample[4]		
	Control	Untreated	LSD (0.05)
Wartburg	4.67	18.67	4.59
Mean	3.12	13.98	1.33
	Mortality[5]		
	Control	Untreated	LSD (0.05)
Wartburg	0.00	4.33	1.39
Mean	0.15	1.31	0.40
	Grain Yield (T/Ha)		
	Control	Untreated	LSD (0.05)
Wartburg	0.784	0.704	0.179
	1.034	1.009	0.124

[1] Mean plant count 2 weeks after emergence.

[2] Treated with 5g Endosulfan kg^{-1} seed.

[3] Trial mean of all 16 varieties.

[4] Mean number of BSM pupae and larvae in a sample of 5 healthy plants.

[5] Mean number of dead plants $plot^{-1}$ as a result of BSM.

A sample of 120 pupae were excised from border plants and it was found that 44% of these were parasitised by a wasp. It is not known whether this would affect the results of the trial but no difference in the damage associated with parasitised and unparasitised pupae was detected. Table 1 shows the analyzed trial results applicable to the cultivar Wartburg.

Some damage was done by cutworm, but there was no significant difference in initial plant count between the means of the treated plots and the untreated plots. This indicates that the endosulfan treatment had no effect on cutworm, and that the cutworm damage did not confound the main-plot analysis. The endosulfan treatment effectively prevented seedling mortality whereas the untreated plots experienced a population reduction of 10.9%. In the surviving plants, the endosulfan treatment restricted the pupae/larvae count to 0.93 pupae plant^{-1} compared to the 3.7 pupae plant^{-1} in the untreated plots. Yield difference between the endosulfan treated control and untreated plots amounted to 11.3%.

DISCUSSION

The trial contained some good sources of resistance to BSM which showed little or no effects of BSM infestation. Wartburg is a determinate speckled sugar cultivar with a growing season of about 95 days. It is well suited to late planting conditions in Greytown and the rest of KZN. The use of the cultivar Wartburg is by no means a worst case scenario. It has been noted that there are breeding lines far more sensitive to BSM damage than Wartburg, but no trials on the commercial cultivar range have been done to establish how sensitive Wartburg is relative to other local commercial cultivars. It should be expected with Wartburg that a loss in plant population would result in a direct loss in yield, due to the cultivar's determinate growth habit and short growing season. The harvesting technique minimised the effect of seedling mortality because the best 3m of row in the plot was harvested. The absolute yield loss as a result of BSM damage is larger than that reflected because the endosulfan treated control plants sustained on average 0.93 maggots plant^{-1}. The yield loss could have been greatly accentuated if the trial had been planted on low fertility soil, if no fertilizer had been applied and had good rains not fallen in the latter half of the season. This study quantifies the damage caused by BSM at Greytown during the 1995 season. It cannot be widely extrapolated to other farming situations with any confidence and should only be used as a pilot study. It can however be expected that under harsher farming conditions, such as those commonly found with the low input small scale farmers in KZN, BSM damage from this level of infestation would be in excess of 11.3%.

This data is not conclusive but it does support Melis and co-workers' (1985) call for more attention to the BSM problem. The initial need is for this study to be followed up with a multi-season entomological survey of the distribution of *Ophiomyia* spp. and the further quantification of the damage. This needs to be followed by good extension in order to get the farmer to correctly diagnose the problem and use the most appropriate measures to restrict the damage.

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SESSION 2

PLANT PROTECTION (Continue)

CHAIRMAN : J.K. AMPOFO

FARMERS' EVALUATION OF INTEGRATED PEST MANAGEMENT (IPM) COMPONENTS FOR THE CONTROL OF BRUCHIDS IN STORED BEANS

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ABSTRACT

Previous studies on this subject were confined under laboratory conditions, neglecting farmers' experiences. This trial was designed to evaluate the effectiveness of various techniques for the management of bruchids under farmers' conditions, including farmers' technology.

The study was conducted in Mbulu and Babati districts in Arusha region commencing July 1994. Five farmers from each district were identified and given 6 treatments; control, sunning, cowdung/wood ash, neem seed powder, tumbling twice a day and actellic dust were assigned in a randomized complete block design. Villages involved in this study were Dongobesh, Tlawi and Moringa in Mbulu; and Singe and Nakwa in Babati districts. The data was collected from a sample of 400 seeds stored for 3 months. Observed parameters were number of seed damaged, number of bruchids in infested seeds, %seed damage, number of eggs/seed and number of exit holes/seed.

Data collected indicated that all treatments except control were equally effective for the control of bruchids. Control treatment had significantly higher levels of infestation and damage than other treatments. Out of 400 seed samples, 13% seeds and 17.4% seeds in Mbulu and Babati respectively, were infested.

Other techniques were not significantly different. However, neem and ash treatments had consistently lower levels of infestation and damage.

Seed damaged was 0.1% and bruchids/infested seeds was 0.4 for neem treatments in Mbulu. In Babati, neem treatments were free of infestation. Ash treated seeds had 0.3% damaged seeds and 0.2 bruchids/infested seeds in Mbulu. Whereas in Babati ash treatment had 0.1% and 0.8 for damaged seeds and bruchids/infested seeds, respectively. Hence these two methods were found promising, sustainable and environmentally friendly.

INTRODUCTION

Bean bruchid (*Acanthoscilides obtectus* Say and Zabrotes subfasciatus Boh) are the most important insect pests of stored beans. Various levels of post harvest losses due to bean bruchids have been documented in different places; 35% in central America (McGuire and Crandall, 1967), 73% in Kenya (Schoonhoven, 1976. Khamala, 1978) and in Tanzania 30% (Karel, 1984). There are various management techniques used by small scale farmers for the control of bruchids and they have variable effectiveness in different areas, probably due to differences in methodologies among farmers. These ranges from sunning/sieving, admixtures with oil, insecticides with dust formulation, sand and various botanicals (Giga *et. al*, 1992). Tumbling is another technique whereby beans in a container are rolled one circumference twice a day (Quentin, 1991). Most of the previous studies on this subject were concentrated on station and farmer experiences were neglected.

Thus the objective of this study was to evaluate the effectiveness of various control measures for the management of bruchids under farmers' conditions. The farmers will then choose cheap convenient and effective method(s) for bruchids control in their stores.

MATERIAL AND METHODS

The trial was initiated in Mbulu and Babati districts in Arusha region commencing July 1994. Five farmers from each district were given 6 treatments; (1) Control (nothing was applied), (2) Sunning (3) Cowdung/wood ash (200g/kg seed), (4) neem seed powder (40g/kg seed) (5) Tumbling (one circumference twice a day) and (6) actellic dust (1g/kg seed). These treatment were assigned in a randomized complete block design. Villages involved in this study were Dongobesh, Tlawi and Moringa in Mbulu district; and Singe and Nakwa in Babati district. The data was collected from a sample of 400 seeds of beans stored for a period of 3 months. Observed parameters were number of seeds damaged, number of bruchids in infested seeds, % seed damage, number of eggs/seed and number of exit holes per seed. Farmers were also interviewed on methods they use for storing food or seed beans (Annex 1).

RESULTS AND DISCUSSION

Generally, all treatments except control were statistically equally effective for the control of bruchids in stored beans. In both districts and for all the parameters observed, control had higher levels of infestations and damage compared to other treatments. However, during the study period, bruchids infestation was generally low. At most 13.1% and 17.4% out of 400 seed sample from Mbulu and Babati respectively, were infested in untreated seeds. This could probably be associated to low temperatures experienced in July (16.5°C) which might have interfered with growth and development of the insects. The favourable temperature for bruchid development ranged between 20-32°C (CIAT, 1986).

In Mbulu district, *Acanthoscelides obtectus* was the only bruchid species recovered from the infested seeds. But in Babati district both species (*A. obtectus* and *Z. subfasciatus*) were present. This was just an observation since no detailed survey was done on species distribution during the study. However, the presence of *Z. subfaciatus* in Babati has also been documented (Giga et al.; 1992). The results showed similar trend in terms of infestation levels and damage whereby control consistently had higher values (Table 1).

Out of 400 seed sample, 32.2 seeds (13.1%) and 69.3 seeds (17.4%) in Mbulu and Babati respectively, were infested in untreated seeds. The number of bruchids recovered from infested seeds was 44.4 in Mbulu and 41.5 in Babati, districts for the untreated seeds. There were significant differences between control and other treatments for infestated and damaged seeds with a range of between 2.2 (tumbling) and 0.2 (Neem seed powder) for number of damaged seeds in Mbulu. In Babati, the number of damaged seeds ranged between 1.0 (actellic) and 0.0 (neem seed powder). For the number of bruchids in infested seed, neem seed powder had no infestation in Babati, whereas in Mbulu, cowdung/wood ash and neem seed powder were the treatments least affected by bruchids.

The results from the two districts followed similar patterns whereby control had significantly higher levels of infestation and damage than other treatments (Table 2). However, no significant difference were observed between wood ash, neem seed powder, tumbling and actellic dust. In the previous study, wood ash and neem seed powder were found effective for the control of bruchids in stored beans (Slumpa and Ampofo, 1990). The results further showed that interaction between methods and districts (locations) were not significant indicating that similar methods could be used in both districts.

This study have shown that the techniques used had the same effect on controlling bruchids in stored beans. This suggests that the farmers can choose either of them i.e. wood ash, neem seed powder, tumbling or actellic dust. However, the choice of any technique by the farmer will depend on its convenience and reliability/availability. For instance in both districts, most farmers were discouraging tumbling and sunning as inconvenient and time

TABLE 1: Effect of different treatments on bean bruchid infestation and damage.

	Mbulu				Babati				
Treatments	No. of Seeds damaged	No. of bruchids/ infested seeds	%Seed damage	No. of holes/ seed	No.of seeds damaged	No. of bruchids/ infested seeds	%Seed damage	No. of holes/seed	No. of eggs/seed
1. Control	52.2^{a*}	44.4^{a}	13.1^{a}	2.2^{a}	69.3^{a}	41.5^{a}	17.4^{a}	1.9^{a}	0.8^{a}
2. Cowdung/wood ash	1.2^{b}	0.2^{b}	0.3^{b}	0.4^{c}	0.5^{b}	0.8^{b}	0.1^{b}	0.3^{b}	0.0^{b}
3. Neem seed powder	0.2^{b}	0.4^{b}	0.1^{b}	0.2^{c}	0.0^{b}	0.0^{b}	0.0^{b}	0.0^{b}	0.0^{b}
4. Tumbling	2.2^{b}	3.0^{b}	0.6^{ab}	-	-	-	-	-	-
5. Actellic dust	1.2^{b}	0.2^{b}	0.3^{b}	1.0^{b}	1.0^{b}	0.3^{b}	0.3^{b}	1.5^{a}	0.0^{b}
Mean	11.4	9.6	2.9	1.1	17.7	10.9	4.0	0.9	0.2
SE$\pm$	15.7	13.0	3.9	0.6	26.6	18.2	6.6	0.5	0.4

*The mean number followed by a common letter in a collumn are not significantly different at P>0.05 (DMRT)

TABLE 2: Effect of different treatments on bean bruchid infestation and damage combined over 2 districts.

Treatments	No. of seeds damaged seeds	No. of bruchids/ infested	%seed damage	No. of holes/ seeds
1. Control	61.4^{a*}	41.8^{a}	15.4^{a}	2.1^{a}
2. Cowdung/Wood ash	1.0^{b}	0.5^{b}	0.3^{b}	0.4^{a}
3. Neem Seed powder	0.1^{b}	0.0^{b}	0.3^{b}	0.1^{a}
4. Actellic dust	1.6^{b}	2.4^{b}	0.1^{b}	1.6^{a}
Mean	16.0	11.2	16.0	1.1
SE $\pm$	12.1	8.9	3.0	0.3
SE $\pm$ (Method x District)	24.7	18.5	6.2	0.7

*The mean numbers followed by a common letter in a collum are not significantly different at $P>0.05$ (DMRT)

TABLE 3: Farmer methods used for bruchids control.

	Mbulu	Babati
1.	Cowdung/Wood ash	Actellic dust
2.	Actellic dust	Cowdung/Wood ash
3.	Botanicals	Botanicals

consuming unless the techniques were modified to suit farmer conditions. On the other hand, the use of pesticides in agriculture is negatively advocated due to their hazardous effect on the environment. Pesticides are also expensive and not readily available to farmers when required. These were important constraints mentioned by farmers as far as pesticides use was concerned. Therefore, out of the four products/techniques used in controlling bruchids, cowdung/wood ash and neem seed powder seemed promising. These two methods are cheap and sustainable; wood ash is readily available to small scale farmers though it may have some implication on the environment as far as deforestation is concerned. The neem seed powder has an added advantage over other methods; it can also be used as foliar sprays to control a wide range of field pests (Spore, 1995). Further more, farmers can be encouraged to grow few trees of neem (*Azadiracta indica*) in their backyard for ensuring healthy environment.

Farmers' experience in the two districts showed that they use the same practices for controlling bruchids in their stored beans (Table 3). These are actellic dust, cowdung/wood ash and various botanicals, but most farmers use actellic and ash for storing their produce. The same methods are used for storing both food beans and seed beans.

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Q: S David
Did you get farmers to evaluate the various treatments?

Would the results of treatments have been different if a more participatory approach has been used, that is, if treatments had been selected by the farmers?

A: S. Slumpa
No, we did not have farmers evaluate such treatments.

No

ANNEX

Annex 1: **QUESTIONNAIRE ON THE EXISTING MANAGEMENT STRATEGIES FOR THE CONTROL OF BEAN BRUCHIDS IN MBULU AND BABATI DISTRICTS.**

Region -------------- Enumerator ----------------

District ------------ Date ------------------------

Village ------------- Altitude --------------------

Farmer -------------- ge --------------------------

Sex ------------------------

Education -----------------

QUESTIONS

1. List in the order of their effectiveness various management practices you are using to protect beans from stored product pests.

PRACTICES **CONSTRAINTS LIMITING THE PRACTICE**

(a) --------------------- (i) ----------------
(ii) ----------------
(iii) ----------------

(b) -------------------- (i) ----------------
(ii) ----------------
(iii) ----------------

(c) ------------------- (i) ----------------
(ii) ----------------
(iii) ----------------

(d) ------------------- (i) ----------------
(ii) ----------------
(iii) ----------------

(e) ------------------- (i) ----------------
(ii) ----------------
(iii) ----------------

2. From the list in no.1 above separate the practices into those used to store beans for seed and those used to store beans for food, with reasons.

Beans for seeds	Beans for food
(i)	(i)
(ii)	(ii)
(iii)	(iii)

BEAN BRUCHID SUB-PROJECT: TRADITIONAL TECHNIQUES FOR BRUCHID CONTROL IN STORAGE

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ABSTRACT

This paper presents some of the research results of a sub-regional project on bean bruchids funded by SADC/CIAT. A series of experiments were conducted to evaluate the potential of i) solar disinfestation of bruchid infested beans, ii) bean tumbling as a control measure and iii) traditional grain protectants.

Beans infested with mixed-age larvae of Zabrotes subfasciatus and Acanthoscelides obtectus were placed on clear, black polyethelene sheets or inside polyethylene pouches ('solar heaters') and exposed to the sun for varying periods. Sunning treatments significantly reduced the development of insects.

In the second set of experiments tumbling of beans as a control measure for the common bean weevil was evaluated. Brief daily tumbling (twice or thrice a day) of beans stored in clay pots or small gunny bags for a two week period after oviposition resulted in a significant reduction (74-83%) in common bean weevil numbers compared to the stationary control.

Trials have been set up in small farmers' granaries to evaluate the efficacy of traditional grain protectant admixtures such as vegetable oil, wood ash, termite mound soil, and diatomaceous earth under artificial and natural infestations. These experiments are in still in progress.

INTRODUCTION

The results of research completed and on-going since the 3rd SADC/CIAT Regional Bean Workshop held in Swaziland from 5-7 October 1992 are presented here. The results of two completed studies are reported and details of an on-going on-farm trial are given in this paper. One of the major objectives of the 'Bean Bruchid Sub-Project' was to develop and evaluate simple cost effective bean storage technologies for small farmers. The aims of the experiments presented in this paper were i) to assess the potential of solar disinfestation of infested beans ii) to assess the effectiveness of bean tumbling for bruchid control and iii) to determine the efficacy of edible vegetable oil and traditional grain protectants in small farmer storage.

Surveys conducted in several countries in Africa have shown that farmers use a host of different traditional techniques to protect stored beans from attack by *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman). Trials were therefore undertaken to evaluate some selected practices as part of the brucbid sub-project.

POLAR DISINFESTATION

Regular exposure of grain to the sun (sunning) to control insect pests is a common practice. The heat from the sun tends to drive out adult insects and kills eggs and early instar larvae. However the success of this technique depends on the temperature attained and the frequency and duration of exposure to the sun. For most stored products insects, prolonged exposure to temperatures less than 13°C and greater than 35°C are fatal (Fields 1992). The present study evaluated the effectiveness of sunning as a technique for controlling bean bruchids, and considered the effects of duration of exposure and type of material used for trapping radiant heat.

MATERIALS AND METHODS

One kilogram batches of beans were separately infested on four different occassions till a cumulative total of 275 sexed adult pairs of *Z.subfasciatus* and 540 unsexed *A.obtectus* adults were in each 1 kg replicate. Infestations were made immediately after the beans were weighed out and on the 4th, 8th and 12th day so that mixed-stage larvae would be present within the seeds at the time of exposure to the sun. Eighteen days after the first infestation, all adults were removed and the beans subjected to various sunning treatments.

The batches of seed were spread on black and clear polyethylene sheets (70 x 50 cm) outdoors and exposed to sunlight for five hours each day for 0, 3 and 5 consecutive days. In addition, infested seeds were also placed inside 70 x 50 cm pouches made of black (lower surface) and clear (upper surface) polyethelene sheets and exposed to the sun in the same manner above. Each treatment was replicated three times. The controls, infested but unexposed beans, were kept at ambient conditions in the laboratory. The surface temperatures of the seeds and temperatures within the pouches were recorded at 20 minute intervals in each replicate. After five hours in the sun each day, the seeds were transferred into 1000ml jars and stored at ambient conditions. Following sunning and a seven-week incubation period, the number of insect adults (Fl generation) emerged and the number of damaged seeds were counted. Percentage seed damage was then determined. Data were analysed as a 3 x 3 factorial experiment with three replications (blocks) (i.e. 3 polyethylene heaters x 3 treatments (unexposed control, 3-day exposure and 5-day exposure).

RESULTS AND DISCUSSION

The number of insects that developed in the different treatments are shown in Table 1.

Exposure of larve-infested seeds to the sun inhibited the development of insects and the analysis of variance showed significant ($P < 0.001$) treatment, exposure period and treatment x exposure period interaction effects. Adult emergence in all treatments was significantly less than the controls. In the case of *A.obtectus*, the three-day exposure treatments were as effective as the five-day exposures. An additional two days exposure resulted in a significant decline in emergence of *Z.subfasciatus*. No insects emerged from the beans heated in the pouches. The black sheets and pouches were very effective in inhibiting insect development while the clear sheets were less so. Damage was less than than 1% in seeds exposed on the black sheets and in the pouches (Table 2). By comparison, the clear sheets were less effective and seed damage levels of 32.1% and 20.9% respectively for *A.obtectus* and *Z.subfasciatus* were recorded after a three-day exposure.

TABLE 1: **Effects of exposure of larvae-infested seeds to the sun on the number of *Z. subfasciatus* and *A. obtectus* Fl adults emerged after a seven-week post-treatment incubation.**

Treatment	Exposure Period [days x 5 h]	*Z. subfasciatus*	*A. obtectus*
Control	0	5249.7	4108.0
Clear sheet	3	1502.0	665.3
	5	495.0	465.0
Black sheet	3	32.7	20.3
	5	0.0	15.7
Pouch	3	0.0	0.0
	5	0.0	0.0

TABLE 2: **Percentage of seeds damaged by *Z. subfasciatus* and *A. obtectus* after exposure to the sun and a seven-week post-treatment incubation.**

Treatment	Exposure Period [days x 5 h]	*Z. subfasciatus*	*A. obtectus*
Control (unexposed)	0	80.5	63.9
Clear sheet	3	32.1	20.9
	5	16.2	10.3
Black sheet	3	1.0	0.5
	5	0.0	0.5
Pouch	3	0.0	0.0
	5	0.0	0.0

However, compared to the controls where seed damage levels greater than 60% were recorded, the data clearly indicate highly significant ($P < 0.001$) reductions in damage levels. Lengthening the exposure period to five days reduced the damage. The results of these experiments show that sunning is an effective technique for controlling bean bruchid larvae developing with seeds.

Temperatures lethal to the immature stages present were attained in all treatments; mortalities being 100% in the pouches where the most extreme temperatures were recorded. Even though temperature differences between clear and black sheets were not markedly different, the clear sheet was less effective than the black sheet. The difference could be attributed to the good heat reflective properties which are a disadvantage in solar disinfestation. As the results portray, its effectiveness was only improved by lengthening the sunning period. The black sheets and pouches resulted in highly significant seed protection as proved by the low F1 emergence and seed damage levels. The drawback of the 'closed heater' is the condensation of moisture and it may therefore not be an appropriate method of disinfestation if the beans are stored at high moisture contents.

The maximum temperatures attained within the pouches were well above the 55°C shown by Fields (1992) to be lethal to insects within a few minutes of exposure. These pouches, adapted from those used by Kitch *et al.* (1992) performed in a similar manner as their tests with maximum temperatures reaching 64°C.

BEAN TUMBLING AS A CONTROL MEASURE

Brief daily tumbling of beans held in jars, buckets and gunny bags was shown by Quentin et al. (1991) to reduce *A.obtectus* populations by 97% relative to stationary beans. Tumbling disturbs the penetration of the larvae which require at least 24 hours to successfully bore in the bean. Since small farmers commonly store small quantities of bean in gunny bags and clay pots experiments were set up to evaluate the potential of this technique.

MATERIALS AND METHODS

Three hundred newly emerged adults of *A.obtectus* were placed on 3 kg of beans stored in small gunny bags and clay pots. The insects were allowed to oviposit and the eggs laid to hatch for four days and thereafter

TABLE 3: **Influence of bean tumbling on *Acanthoscelides obtectus* populations stored in a) clay pots and b)gunny bags.**

a) Clay pots

Treatment	Mean # insects emerged	%Reduction relative to control
Control (stationary)	2328.3	-
Tumbling twice a day	466.0	80
Tumbling thrice a day	403.5	83

SED=109.1, F=2000.81

b)Gunny bags

Treatment	Mean # insects emerged	%Reduction relative to control
Control (stationary)	940.7	-
Tumbling twice a day	238.3	73
Tumbling thrice a day	232.8	75

SED=69.7, F=95.68

the beans in the containers were tumbled daily for two weeks and stored under ambient conditions with no disturbance for seven weeks. The containers were turned end-over-end 12 times on each occasion. The tumbling treatments were i) tumbling twice daily at 8.00am and 4.00pm ii) tumbling thrice daily at 8.00am, noon and 4.00pm and iii) stationary control. The experiment was replicated three times. After the storage period the number of adult insects that emerged were counted.

RESULTS AND DISCUSSION

The mean number of adults emerged and the percent reduction in populations relative to the control is shown in Table 3. There was a significant ($P < 0.0001$) reduction in insect numbers between the stationary control and the tumbling treatments but no difference between the two frequency of tumbling treatments. The results show that tumbling twice a day is just as good as disturbing the grain three times daily. Tumbling the beans stored in the clay pots and gunny bags respectively resulted in 80-85% and 74-75% insect population reduction relative to the control. In Quentin *et al.*'s (1991) studies regular tumbling lowered *A.obtectus* populations by 97%

irrespective of type of container.

We found that shaking the gunny bag had and added advantage in that larvae moving freely on the beans before boring into the beans may be sieved out. These results confirm those of Quentin and Miller (1991) that tumbling is an effective control measure. However, more research needs to be done to determine whether the frequency of tumbling could be reduced and whether this technique would be acceptable to farmers.

ON-FARM EVALUATION OF TRADITIONAL GRAIN PROTECTANTS

The admixture of substances to beans as protectants is an ancient practice. Surveys have indicated that farmers treat beans with a wide range of plant substances having insecticidal properties, or with inert products such as wood ash and fine soil which act mechanically (Giga *et al.* 1992). Coating seeds with vegetable oil is also a common practice. Those treatments found to provide good protection are now being tested in six small farmers' granaries. The following treatments are currently being evaluated: wood ash (20% w/w), termite mound soil (20% w/w), vegetable oil (5 ml/kg) and a commercial preparation of diatomaceous earth, [R]Dryacide (1 g/kg).

The surveys by Giga *et al.* (1992) in Eastern and Southern Africa however, have indicated that protection varies considerably using these traditional practices. Laboratory studies were therefore conducted by Giga and Chinwada (1993) and Chinwada and Giga (1993) to evaluate the efficacies of a range of products at different application rates. Samples of beans are being collected every six weeks and the number of insects and damage levels are being monitored.

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Q: MM Liebenberg

Have you determined if post harvest heat treatment against such pests has any effect on cooking quality?

A: Prof Gija

No, we have not, but this could possibly be a factor.

BACTERIAL BROWN SPOT; DISEASE INCIDENCE AND PRIMARY INOCULUM SOURCES.

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ABSTRACT

The first major outbreak of bacterial brown spot of dry bean, caused by Pseudomonas syringae pv. syringae, in South Africa, occurred in 1992 on the Eastern Transvaal Highveld. The incidence of the disease, and damage caused by it, remained significant ever since. Primarily inoculum sources of bacterial brown spot were determined. Infected or contaminated seed was found to be a major source of P. syringae pv syringae. The pathogen was found to survive between seasons in infected debris left on the field. Volunteer bean plants, resulting from spilled seed left in bean fields after harvest, was also found to be a potential source of bacterial brown spot. Diseased plantings, and some plantings without the disease, was found to host high epiphytic populations of P. syringae pv syringae that can serve as primary inoculum for other plantings in the season. The pathogen could not be isolated from plants or plant material other than bean. Elimination of primary inoculum sources will help to control bacterial brown spot.

AIM

Bacterial brown spot (BBS) is caused by *Pseudomonas syringae* pv. *syringae* (PSS) and took on epidemic proportions in dry bean plantings on the Eastern Transvaal Highveld for the first time in 1992. The aim of this work was to determine the incidence, primary inoculum sources and possible means to control bacterial brown spot in South Africa.

PROCEDURES

The incidence of the disease was monitored by observation since the first major outbreak during the 1992 season.

An investigation was launched to determine the primary inoculum sources of BBS. Four commercial bean fields, of which three showed BBS symptoms, were monitored for the presence of PSS between harvest and the following growing seasons. The investigation was done over two seasons, two fields per season. Bean debris and seed left on the field and volunteer bean plants were sampled. An attempt to isolate the organism from soil was abandoned due to the high population of non-target organisms. Stem and pod material could be distinguished early in the season, but not later after the first rains and total debris were sampled. Five samples of measured quantities were taken of each material type and shaken in a Ringer-Tween 20 solution for 2 h at room temperature. Dilutions were plated onto a semi-selective KBC medium, incubated and observed for syringae type pseudomonads (STP's). Suspect oxidase negative, fluorescent colonies were purified and bean pods were inoculated to determine pathogenicity. The number of samples from each material type yielding PSS were noted. Fields were sampled twice during the first season and three times during the second season.

The presence of epiphytic PSS populations on bean, maize and common weed species were determined during two successive growing seasons (1994 and 1995). The 1994 sampling was done in early March during which twelve fields were sampled, and five fields were sampled early in February 1995. Leaf samples, showing no visual BBS symptoms, were either hand picked or cut with scissors, placed in plastic bags and kept on ice in a cool bag for transport to the laboratory. The presence of BBS and other diseases were noted during sampling. Samples were kept overnight in a cold room after which isolations were made. Thirty grams of leaf material were shaken for 2 h at room temperature in 200 ml Ringer-Tween 20 solution and dilutions were plated on KBC medium, incubated and observed for STP's. Between 4 and 6 suspected STP colonies of each sample were purified and tested for pathogenicity on bean pods.

The presence of PSS in certified seed was monitored by including KBC medium in the routine seed testing programme of the certification scheme. The transmission of the disease in seed was monitored in the plantings of the post-harvest controls of seed lots that yielded PSS.

RESULTS

Rainfall during the 1992 and 1995 seasons was sub-normal. It was during these seasons that BBS caused most damage in fields affected. During the 1992 season, few fields were affected but estimated yield losses in some were up to 55%. During the 1995 season, the disease was more widespread and severe, especially in fields damaged by hail. Some fields were even ploughed before harvest. Above average rain fell during the 1994 season and BBS was widespread. It did, however, not seem to cause major yield losses. An interesting observation during the 1994 season was that the individual plants affected most severely by brown rust were also severely affected by BBS.

PSS was isolated from three of the four fields monitored (Table 1). PSS survived under natural conditions between growing seasons of both years in all the material analised. The number of volunteer samples which were positive for the presence of PSS, generally increased during planting time in November. The fields were also visited later in the growing season. Vast numbers of volunteer plants were present in some of the fields throughout the following season. Most of the volunteer bean plants showed symptoms of BBS and other seed borne diseases.

Of the 12 bean fields sampled for epiphytic PSS populations in 1994, eight showed symptoms of BBS. STP's were isolated from symptomless leaves from 10 of the fields. PSS was, therefore, present as an epiphyte on symptomless leaves from fields with symptoms of BBS as well as in fields without BBS symptoms (Table 2.).

TABLE 1: Recovery of *Pseudomonas syringae* pv. *syringae* from bean fields between growing seasons.

Field	Sample Date	Number of samples out of five which tested positive for PSS				
		Stem Debris	Pod Debris	Debris (a)	Seed	Volunteers
Field 1	Sept. '92	5	4	-	-	2
	Nov. '92	-	1	5	-	4
Field 2	Sept. '92	0	0	-	0	-
	Nov. '92	0	0	-	-	0
Field 3	May '93	5	3	-	3	-
	Sept. '93	4	1	-	5	2
	Nov. '93	-	-	4	-	5
Field 4	May '93	5	5	-	0	1
	Sept. '93	2	4	-	0	0
	Nov. '93	-	-	0	-	4

(a) Debris was divided into pod or stem debris or analised as a mixture.

TABLE 2: **Recovery of epiphytic *Pseudomonas syringae* pv. *syringae* from symptomless leaves in commercial bean fields.**

Field No.	Brown spot symptoms (a)	STP's on KBC (b)	CFU x 10^6/ gram leaves (c)	Non-virulent STP's present (d)
94-1	+	+	20	-
94-2	+	+	7.4	-
94-3	-	+	0.27	-
94-4	+	+	6.2	+
94-5	-	+	6.2	+
94-6	-	-	0	
94-7	+	+	0.44	+
94-8	-	-	0	
94-9	+	+	0.67	-
94-10	+	+	3	+
94-11	+	+	>20	+
94-12	+	+	10	+

(a) Planting showing brown spot symptoms marked +, without symptoms marked -

(b) Syringae type pseudomonads (STP's) isolated on KBC medium

(c) Colony forming units (CFU) of STP's per gram of green leaf material as indicated by dilution isolation on KBC medium

(d) Presence of non-virulent STP's in mixed culture with BBS producing *P. syringae* pv. *syringae* indicated by +. Only BBS producing *P. syringae* pv. *syringae* isolated indicated by -

Sampling of five fields in 1995 was done in an area that showed no BBS symptoms. None of the fields yielded STP's on KBC medium. The pathogen could not be isolated from any of five weed species generally present on the Highveld, nor from maize leaves, even from fields adjacent to heavily infected bean fields.

Since KBC medium has been included in the routine seed testing programme of the dry bean certification scheme, PSS has been isolated regularly. Most of the commercial seed produced on the Eastern Transvaal Highveld and in the Free State Province subjected to testing during the past year contained PSS. Seed transmission of the disease was confirmed by the presence of BBS in post harvest trails from seed that tested positive for PSS. A visible difference in disease incidence in commercial plantings on the Highveld was evident where farmers used commercial seed from the previous as well as certified disease free seed.

CONCLUSIONS

From the observations it was seen that most damage by BBS was caused during seasons of sub-normal precipitation. The reason could either be due to the fact that the plants were stressed, the form of precipitation or both. Precipitation during drought years is mostly in the form of heavy thunderstorms accompanied by strong wind and sometimes hail. These conditions are conducive for the development of bacterial diseases. The association between PSS and brown rust is not clear. Infection of bean leaves by rust may possibly serve as infection sites for PSS. The possibility that PSS is distributed by rust spores will be investigated.

Different sources were identified as possible primary inoculum sources of BBS. All these sources are associated with beans, and no alternative host could be identified to date. Infected or contaminated seed is possibly the most important source of BBS. PSS can, however, also overwinter in infested bean debris and seed left on the field after harvest. This debris and volunteer beans may be important sources of primary PSS inoculum. The high epiphytic populations of PSS in diseased and some bean fields without disease are possible sources of the pathogen during the growing season. Curative treatment to control bacterial diseases of beans are not effective. The elimination of the identified primary sources will be valuable in controlling the BBS.

HALO BLIGHT OF BEANS IN SOUTH AFRICA

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ABSTRACT

Halo blight caused by the bacterium Pseudomonas syringae pv. phaseolicola is a destructive disease of dry beans in South Africa. Chemical control is not effective and the only long term control is with resistant cultivars. Breeding for resistance is complicated by the presence of nine different races of the pathogen that were identified across the world. Race identification is a prerequisite for resistance breeding.

During the past three seasons pathogenic strains, representative of various hosts and geographical regions, were submitted to race identification by means of host differential lines. From 1992 to 1994 race identification was done on 101 isolates. Sixty percent of all the isolates were identified as race 8. Twenty two percent of the isolates belonged to race one. A low percentage of isolates of races 2, 6, and 9 were found.

During the 1994/95 season race identification was done with 62 isolates. Thirty eight percent of the isolates were identified as race 1; 32,3% as race 6; 16,2% as race 8 and 6,5% as race 2. Two new races were identified namely race 7 (4,8%) and race 4 (1,6%). Race 7 was isolated from cv. Drakensberg collected from Cedara in Natal. Race 4 was an isolate received from PPRI at Rietondale which was isolated from bean seed from Malawi. In the past, race 1 was isolated only from large white kidney beans which are mainly cultivated in the Eastern Transvaal Highveld. This year the majority of race 1 isolates were collected from a wide variety of cultivars in this region. Kidney beans are not included in the disease free seed scheme and it would appear that this bean type was a source of inoculum in spreading race1.

The reaction of thirty commercial cultivars to the prevailing races (races 1, 2, 6, 8 & 9) was also determined. Susceptible and resistant cultivars as checks were included. Bean seedlings were inoculated with each race and maintained under high humidity conditions. All cultivars tested were moderately (plants rated 3) to highly (plants rated 4-5) susceptible to all local races. These results stress the importance of breeding for resistance to this disease in South Africa. Cultivar Edmund which was included as one of the checks showed resistance to all the races tested. A backcross program was initiated to incorporate the race non-specific recessive gene present in Edmund into 11 local cultivars and promising breeding lines.

INTRODUCTION

Halo blight is a serious seedborne disease of dry beans caused by the bacterium *Pseudomonas syringae* pv. *phaseolicola*. The bacterium is distributed worldwide and is associated with moderate temperatures. The extent of yield losses in South Africa has not yet been determined but yield losses in other countries ranged between 23 and 43%

Typical leaf symptoms are small, water-soaked spots on the lower surface surrounded by a halo of greenish yellow tissue. General plant chlorosis with leaf yellowing and malformation may also develop as a result of systemic infection.

The implementation of the disease free seed scheme in South Africa has reduced yield losses to a certain extent, but epidemics still occur annually if conditions are favourable. The use of disease free seed, crop rotation and chemicals have limited success in controlling the disease. Long term control depends on the breeding of resistant cultivars.

Breeding for resistance is complicated by the occurrence of nine races of the pathogen. It is important to know which races occur locally so that breeding material can be screened for resistance to all the known local races.

The main objective of research concerning halo blight at OPSC are:

* the identification of local races
* evaluation of local cultivars for resistance against the prevailing races
* breeding for resistance

MATERIAL AND METHOD

Infected plant material was collected from all the dry bean production areas in South Africa. Various cultivars were collected to determine host range, and as many localities as possible were sampled to determine geographical distribution of the races. Bacteria were isolated from diseased tissue and those identified as *Pseudomonas syringae* pv. *phaseolicola* were stored in glycerol at -72°C until use, as loss of pathogenicity becomes a problem when subcultured frequently.

Identification of races

Races were identified on the basis of their interactions with seven differential cultivars of *Phaseolus vulgaris* and an accession of *Phaseolus acutifolius* according to research by Dr. Dawn Teverson at the Horticultural Research International, Wellesborne. These differential cultivars were received from Dr. Teverson and multiplied.

A study was made from 1992 to 1994 of 101 isolates representative of those available. During the 1994/95 season 62 isolates were used. Inoculum for experiments was prepared by suspending the bacteria in sterile water. The inoculum consisted of $\pm 10^8$ bacterial cells/ml water. Bean seedlings of the set of differentials were inoculated with an airbrush as soon as their primary leaves had expanded. Leaves were inoculated by forcing the bacterial suspension into the tissues in two small areas (5mm diameter) either side of the leaf midrib. The whole leaf area was sprayed until completely wet. Immediately after inoculation the plants were placed in a humidity chamber at a temperature of ± 19°C for two days before being returned to a greenhouse with high humidity.

Infection was rated on a 1-5 scale as follows for example:

1 : red brown necrotic reaction in area of maximum inoculation either side of the leaf midrib - highly resistant and

5 : being large water-soaked lesions (1-3 mm diameter) distributed at random over the leaf undersurface - fully susceptible (Teverson, 1991).

The reaction of the differential cultivars to the pathogen for the known races was used as a standard to identify local races (Table 1). Edmund was also included.

TABLE 1 : Race differentiation in *Pseudomonas syringae* pv. *phaseolicola* (Teverson, 1991)

CULTIVARS	RACE								
	1	2	3	4	5	6	7	8	9
Canadian Wonder	+	+	+	+	+	+	+	+	+
ZAA 54 (A52)	+	+	+	+	-	+	+	+	+
Tendergreen	+	+	-	-	+	+	+	+	+
Red Mexican U13	-	+	+	+	-	+	-	+	-
1072	+	-	+	-	-	+	-	+	+
ZAA55 (A53)	+	+	-	-	-	+	+	+	+
ZAA12 (A43)	+	-	-	-	-	+	-	-	-
Guatemala 196-B	-	+	-	-	-	+	-	+	-
* Edmund	-	-	-	-	-	-	-	-	-

+ = susceptible   - = resistant   1072 = *Phaseolus acutifolius*

EVALUATION OF DRY BEAN CULTIVARS

Two seeds of each cultivar were planted in 10cm pots. Six pots of each cultivar was used, each plant representing a replicate. The experiment was repeated three times. Inoculum preparations and inoculation procedures were the same as mentioned above. Susceptible (Canadian Wonder) and resistant (Edmund) checks were also included.

Plants were scored on a 1-5 scale, ten days after inoculation.

RESULTS & DISCUSSION

Race identification

The identified races for the 1992-1994 period are given in figure 1. The y-axis shows the percentage of the total isolates of the pathogen of each race. The races are shown on the x-axis. Race 8 was the most dominant race identified. Sixty percent of all the isolates were identified as race 8. Twenty two percent of the isolates belonged to race one. A low percentage of isolates were found to be races 2, 6,and 9.

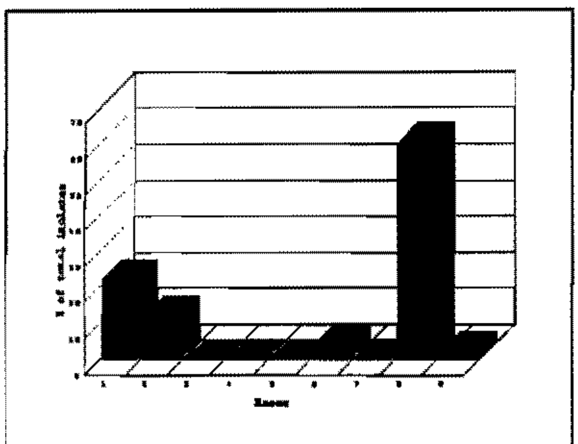

Figure 1. Races identified during 1992-1994

The races identified during the 1994/95 season are given in figure 2. Thirty eight percent of the isolates were identified as race 1; 32,3% as race 6; 16,2% as race 8 and 6,5% as race 2. Two new races were identified namely race 7 (4,8%) and race 4 (1,6%). Race 7 was isolated from cv. Drakensburg collected

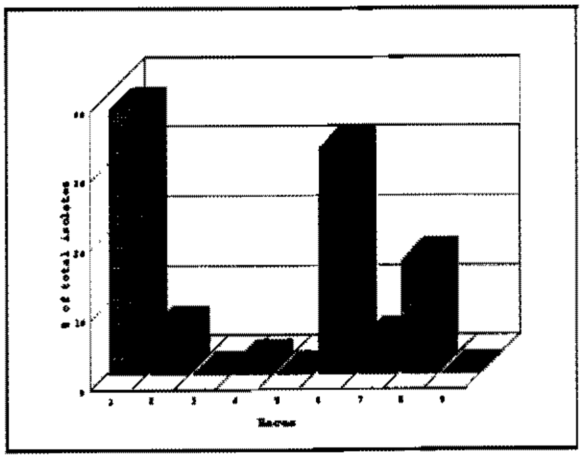

Figure 2. Races identified during 1994-1995

from Cedara in Natal. Race 4 was an isolate received from PPRI at Rietondale which was isolated from bean seed from Malawi. In the past, race 1 was isolated only from large white kidney beans which are mainly cultivated in the Eastern Transvaal Highveld. This year the majority of race 1 isolates were collected from a wide variety of cultivars in this region. Kidney beans are not included in the disease free seed scheme and it
would appear that this bean type was a source of inoculum and spread of race 1.

Evaluation of cultivars

All cultivars tested were moderate (plants rated 3) to highly (plants rated 4-5) susceptible to all local races. These results stress the importance of breeding for resistance to this disease. Edmund which was included as one of the checks showed some resistance to all the races tested.

A backcross programme to incorporate race non-specific resistance into local cultivars would probably be the best way to combat halo blight in South Africa. This is of special importance in the large seeded types, e.g. the speckled sugars and alubias. Race identification is necessary in order to identify specific resistance genes in any backcross programme.

A backcross programme was therefore initiated to incorporate the race non-specific recessive gene present in Edmund into 11 local cultivars and promising breeding lines.

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CHARACTERIZATION OF SOUTH AFRICAN RACES OF *COLLETOTRICHUM LINDEMUTHIANUM*

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ABSTRACT

Anthracnose of beans (Phaseolus vulgaris), a fungal disease caused by Colletotrichum lindemuthianum, is a world wide problem under cool humid conditions. In South Africa the occurrence of the disease is sporadic. Isolates of the fungus were collected from the major dry bean production areas. Fourteen-day old seedlings from two sets of differential cultivars were inoculated by spraying with conidial suspensions of the fungus. Inoculated seedlings were incubated for seven days at 20 °C and under plastic bags to maintain high humidity levels. Disease severity was rated 10 days after inoculation. By using the binomial system proposed by CIAT, races 3, 65, 80, 81, 83, 119 and 593 were found to be present in South Africa. Races 65, 80, 81 and 593 resemble the race alpha-Brazil. Differential resistance to the local races of the fungus was identified in the bean cultivars currently being evaluated in South Africa. At present only two local bean cultivars, a small white and a red speckled sugar, showed resistance to all local races of the fungus under glasshouse conditions. These results suggest that anthracnose resistance in the local dry bean breeding programme should receive attention.

DETECTION OF *COLLETOTRICHUM LINDEMUTHIANUM* ON BEAN SEED

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ABSTRACT

Colletotrichum lindemuthianum, the cause of anthracnose of beans (Phaseolus vulgaris), is a seed-borne fungal pathogen. The use of disease free seed is an important disease control measure. In the case of anthracnose it also ensures that different races of the fungus are not spread to uninfested areas; this is particularly important if resistant lines are not available. Different laboratory detection methods, namely the blotter test proposed by ISTA, 2 % Water agar, filter paper in Petri dishes and the "paper doll" method were compared. All methods were successful. The "paper doll" method was the most reliable and inexpensive. This method consists of cellulose wadding, backed by germination paper and rolled up after placing seed onto the wetted wadding. To maintain high humidity levels, the rolls are covered with plastic and incubated upright in the dark at 20 °C. After seven to ten days the seed coats are removed, the seed lobes inspected for anthracnose symptoms and the presence of the fungus is microscopically verified. This method is currently used by South African bean seed testing laboratories.

Q: DE Malan
Is benomyl effective as a seed treatment in the control of colletotrichum?

A: S. Koch
Yes, it protects the seedlings after emergence.

PATHOTYPE IDENTIFICATION IN *PHAEOISARIOPSIS GRISEOLA*

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ABSTRACT

The differentiation of pathotypes of Phaeoisariopsis griseola, the cause of angular leaf spot of dry beans, presents difficulties due to the fact that disease is also influenced by environmental factors. The objective of this study was to find a reliable way of determining genetically different pathotypes. Twenty isolates from Malawi and South Africa were inoculated on eight differential cultivars and the disease reaction was observed at 13, 24 and 33 days after inoculation, using the CIAT 1-9 rating scale. Pathotypes were tentatively determined by designating cultivar reactions as resistant or susceptible. The feasibility of three different cut-off ratings, namely 1.99, 2.99 and 3.99 was determined. The data were also subjected to cluster analysis. The cluster analysis for observations at both 13 and 24 days indicated the existence of two major groups. These results correlated with an isozyme study, which gives an indication of underlying genotypic differences, and provide evidence of the probable Meso-American and Andean origins of the isolates. The clustering obtained with observations made at 24 days after inoculation provided additional information on the probable relationships of the isolates. The grouping was comparable to that obtained by the conventional method at 24 days with a severity cut-off rating of 2.99. It was concluded that the most useful and reliable information is obtained using observations made 24 days after inoculation and a cut-off rating of 2.99. Cluster analysis can therefore be regarded as an aid in the choice of isolates for germplasm screening.

Angular leaf spot (ALS), caused by the fungus *Phaeoisariopsis griseola* (Sacc.) Ferraris, is a serious disease of dry beans in the more humid parts of Southern Africa, in Central- and Eastern Africa and in many other bean producing countries. Where a pathogen exhibits pathogenic variation, as is the case with *P. griseola*, it is important to determine the nature and distribution of the various pathotypes present in a particular region. The most important pathotypes can then be used as an aid for the detection of resistance genes suitable for use in a resistance breeding programme.

Various reports of pathogenicity differences between isolates of *P. griseola* have been made (Brock, 1951; Marín-Villegas, 1959; Alvarez-Ayala & Schwartz, 1979; Buruchara, 1983; Correa & Saettler, 1986; Correa-Victoria, 1987; CIAT, 1989). These authors reported a pathotype:isolate ratio ranging from 3:35 to 15:18. The relatively large number of pathotypes is probably partly a reflection of the wide genetic diversity of the cultivars grown in the area of origin. However, it has been reported that the manifestation of angular leaf spot is influenced by factors, for instance leaf age and temperature, other than the genetic makeup of the host cultivar (Alvarez-Ayala & Schwartz, 1979 and Buruchara, 1983). It is therefore possible that all "pathotypes" identified from a group of isolates may not be genetically different and that experimental conditions may influence ratings to such an extent as to change pathotype grouping.

In the case of ALS, very little is known about the genetics of resistance, and methods of pathotype identification have not yet been standardized. It is therefore necessary to firstly decide how to characterise a pathotype of *P. griseola* and secondly, which of the known pathotypes should be used for the screening of germplasm and breeding material.

When applying the conventional method of pathotype identification, cultivars comprising the differential set are inoculated with cultures established from single conidia. After disease rating, the differentials are classified as resistant or susceptible to each isolate. Isolates which cause similar reactions are then grouped together as a pathotype. Coded triplets (Limpert & Müller, 1994) or binary codes (Hapgood, 1970) can be assigned to each pathotype. These codes facilitate easy recognition but still reveal little about the evolutionary relationships between the different pathotypes. Another disadvantage is the loss of information, as the actual rating is reduced to two categories. Before using the method, two basic decisions must be made. Firstly, the period after which disease assessment is done must be chosen. The choice of assessment time may influence the rating, as a cultivar might, for instance, be resistant when assessed at 13 days after inoculation, but susceptible when assessed at 15 days. Secondly, a cut-off rating which will be used for the distinction between a resistant and susceptible reaction has to be chosen. The criteria applied may therefore influence the number of pathotypes identified and the actual grouping of the isolates within the pathotypes.

The purpose of this study was to find objective criteria for the phenotypic method of pathotype differentiation which would reflect the presumed underlying genetic differences. Twenty isolates from Malawi and South Africa were inoculated on four replicates of a set of eight differential cultivars, namely Montcalm, Seafarer, BAT 332, Pompadour Checa, G 5686, Cornell 49242, A 339 and BAT 1467. Each inoculation was repeated, usually two weeks later. Disease development was rated after 13, 24 and 33 days, using a modified version of the CIAT 1-9 disease assessment scale (Correa-Victoria, 1987), with zero indicating no visible signs of disease. Ratings were averaged for each isolate on each cultivar. The data was analyzed by means of the conventional method using different cut-off ratings. For each of the disease assessment times (13, 24 and 33 days), a dissimilarity matrix was analyzed by the SIMINT programme of NTSYS-pc version 1.80. A dendrogram was derived from the matrix with the SAHN programme of NTSYS using the unweighted pair group arithmetic mean method (UPGMA) of cluster analysis (Rohlf, 1993). Cluster analysis has the advantage of using all the available data and not merely the two categories, as no cut-off is involved. When disease assessment was done at 13 or 24 days (Figures 1 and 2) two main groups were distinguished by means of cluster analysis. Group one contained eighteen of the isolates, and group two contained two isolates (MPg93KM43 and MPg93KM44) from Bembeke, Malawi. The latter isolates were obtained from the small seeded Meso-American cultivar BAT 477. Eleven of the isolates in group one were collected from large seeded cultivars. The cultivars from which six of the isolates originated were unknown. However, they were probably from large seeded cultivars, as they were collected in areas where these cultivars were almost exclusively grown. One isolate (RSAPg93CE18) in group one was collected from a small seeded cultivar.

The main grouping resulting from the cluster analysis is in agreement with the results of an isozyme study which was done by Boshoff *et al.* (in press) with most of these isolates. The same two major groups were obtained, group two containing only the two Bembeke isolates. These findings support results of studies undertaken recently by Guzmán *et al.* (1995). Using random amplified polymorphic DNA (RAPD) markers to characterize *P. griseola* isolates, they reported the existence of two major groups, viz those of Meso-American and Andean origin, respectively. These groups appear to have coevolved with beans originating from two different gene pools. Beans from the Meso-American gene pool are generally small seeded, and those from the Andean gene pool are generally large seeded. The coevolution of pathogens and beans had previously been hypothesized by Gepts and Bliss (1985). Guzmán *et al.* (1995) reported that 92% of the Malawian isolates tested could be placed in the Andean group. For the isolates used in the present study the figure was 90%.

The results of the isozyme study (Boshoff *et al.*, in press) provided evidence of genotypic differences underlying the main phenotypic differences detected when cultivar reactions were subjected to cluster analysis. When only the conventional method is used, the existence of two major groups of isolates is far less obvious and could easily be overlooked.

The clustering of the 18 isolates within group one when disease assessment was done at 13 days after inoculation (Figure 1) was not very definite, due to the fact that in some cases the incubation period was longer than 13 days. However, when data obtained 24 days after inoculation was used, the 18 isolates fell into clearer groups (Figure 2). This grouping coincides almost precisely with the results obtained by the conventional method at 24 days with a cut-off of 2.99, and it would appear that 2.99 is a very satisfactory and perhaps the most natural cut-off point. Cluster analysis can also be used to reduce the number of groups identified by the conventional method, depending on which level of similarity is chosen. Although no genotypic evidence underlying the minor grouping is available, the grouping is rational, as the Malawian isolates (denoted by an "M") and the isolates from eastern South Africa ("RSA") tend to group together, and a good concept of the probable relationships among isolates is obtained. The grouping also gives some indication of which isolates should be used for germplasm screening. Although the resistance genes involved should play a major role in the choice of isolates for the screening of germplasm and breeding material, one would nevertheless include one isolate from each of the two major groups, and preferably also one isolate from each of the larger minor groups.

Using data obtained 33 days after inoculation, the grouping obtained with cluster analysis was less meaningful. This is perhaps due to the cumulative influence of slight differences in environmental conditions when isolates were tested over time, and it would appear that less reliable results are obtained when a longer period is used.

It is concluded that cluster analysis is likely to be a very useful aid in the determination of pathotypes, and for the understanding of their relationships. However it should always be used in conjunction with the conventional method, as it does not indicate the resistance genes involved.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the valued contributions of the following persons: Mrs. B. Janse van Rensburg (technical assistance), Mr. I.A. Sebakeng (general assistance), Mr. G.S. Strydom (maintenance of glasshouses and electrical equipment), other staff members of the Grain Crops Institute, and international colleagues working on ALS (support and advice), and CIAT, Colombia and Michigan State University (seed of the differential cultivars).

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Q: Allan Femi Lana

Gene block can create a problem of mutation. How often can this occur?

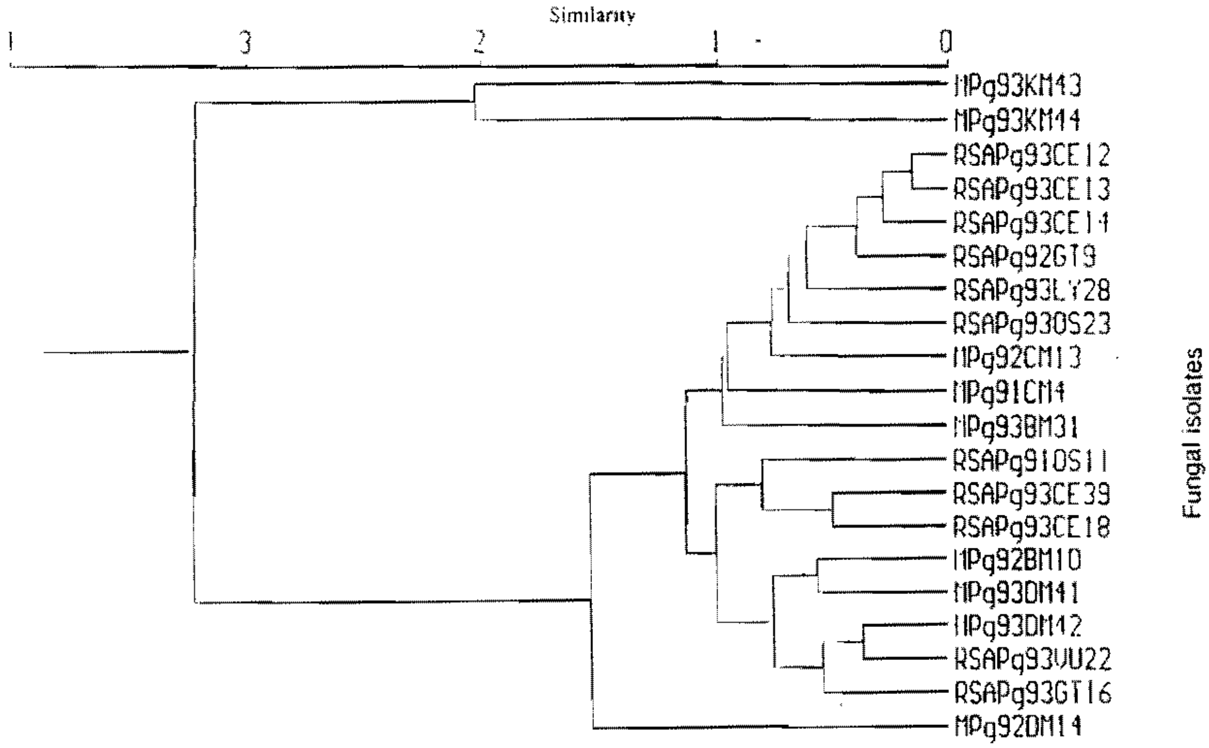
A: MM Liebenberg

There is always a possibility of mutations taking place. I do not know if the chances of mutation within the gene block are higher than for any other genetic structure. Mutations can also lead to positive changes as far as resistance is concerned.

Q: KW Pakendorf

This seems a unique way of characterising pathotypes, but has it brought us closer to identifying susceptibility or resistance?

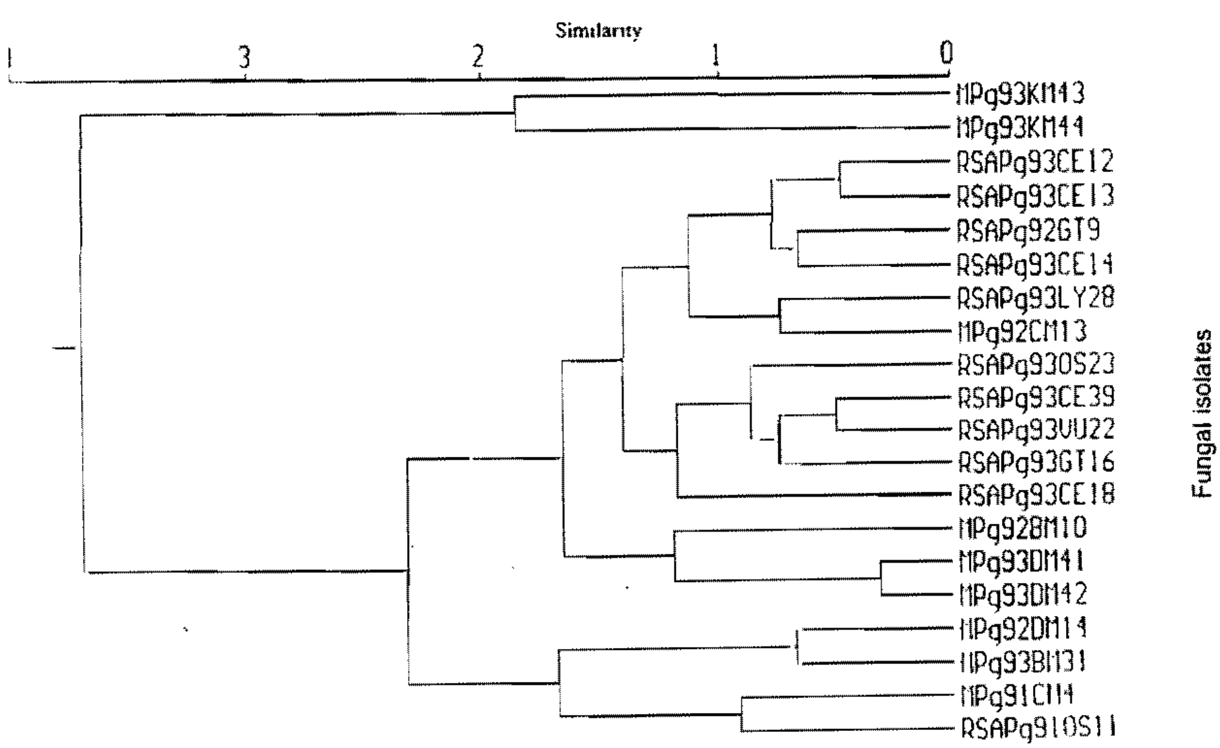
Figure 1 UPGMA* dendrogram illustrating similarities in amount of disease caused by 20 *Phaeoisariopsis griseola* isolates** inoculated on eight cultivars of *Phaseolus vulgaris*. Disease assessment done 13 days after inoculation



* Unweighted paired group arithmetic mean method

** Isolates from Malawi are prefaced by an "M" and those from South Africa by "RSA")

Figure 2 UPGMA* dendrogram illustrating similarities in amount of disease caused by 20 *Phaeoisariopsis griseola* isolates** inoculated on eight cultivars of *Phaseolus vulgaris*. Disease assessment done 24 days after inoculation



* Unweighted paired group arithmetic mean method

** Isolates from Malawi are prefaced by an "M" and those from South Africa by "RSA")

SESSION 3

BREEDING, GERMPLASM EVALUATION

CHAIRMAN : V. AGGARWAL

BEAN BREEDING IN THE SADC REGION

C.S. Mushi

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ABSTRACT

The status of varietal improvement in different countries in the SADC region is described. The Southern Africa Region Bean Nursery and Trial as a means of exchange of germplasm within the region are briefly discussed.

Emphasis is now breeding for specific traits such as resistance to bean stem maggot, bruchid, anthracnose, BCMV, angular leaf spot, and drought. Regionally funded sub-projects are important for these activities to achieve targets.

Technique used in Tanzania for integrating farmer expertise into bean varietal development is also described.

BACKGROUND

Bean is the most important food legume in the highlands of Southern Africa. For millions of people, especially among the poor, bean is the main source of dietary protein. It is also an important source of carbohydrate and, as such, the bean is the second most important food crop over much of the area. However, economic studies reveal that the demand for beans is outstripping supply, so that efforts directed at increased productivity are urgently required.

Bean production in the SADC region amount to over 503,700 tons. Tanzania, Malawi, Mozambique and Angola are principal producers (Table 1). Within Tanzania, the major zones of production are the Northern Highlands of Kilimanjaro, Arusha and Tanga regions; the Central Highlands of Morogoro region, the Southern Highlands of Iringa, Mbeya, Rukwa and Ruvuma regions, Kigoma and Kagera regions of Western Tanzania. Other areas of bean production in the SADC countries include: Northern Zambia; Highlands of Malawi, Niassa, Tete and Manica districts of Mozambique; the Central and Eastern highveld of Zimbabwe; Lowland /foot hills of Lesotho. Transkei and Natal in South Africa (Table 2).

Bean yields are low and stagnant in most of the SADC countries, and fluctuate widely in response to environmental factors, both biotic and abiotic. The main factors responsible for low yields are; the high disease and insect pressure from which the crop suffers; drought; sparse plant densities; weeds; soil infertility; and farmers reluctance to use inputs to avoid risk or due to the high cost and inaccessibility.

This paper examines past bean varietal improvement in some SADC countries, current and future varietal improvement.

PAST BEAN VARIETAL DEVELOPMENT

The only situation we know where the products of organized breeding programmes are cultivated on large scales are in Ethiopia, Northern Tanzania, Kenya and commercial lands of Zimbabwe (Simithson, 1989). This excludes South Africa. All relied on introduced cultivars for production of caning, snap and other types of beans for export to Europe. In Northern Tanzania, the multiplication of bean seeds for export to Europe is an important industry.

Elsewhere the cultivars being evaluated are the descendants of successive introductions directly or indirectly from the Americas from the sixteenth century onwards (Simithson, 1989). Usually these are bush or semi-climbers. Climbing types are common in the highlands of the Great Lakes. However, they are also found in the region in compounds scrambling over fences or cereals. Whenever suitable support is provided they yield up to four times higher than the bush types.

The local cultivars are often cultivated as mixtures of seed types that vary in complexity from very complex like in Great Lakes, Southern Uganda, Malawi and some areas of Southern Highlands of Tanzania. The mixtures average ten or more components ranging in colour from white, through yellow and green to red brown and purple and of varying colour patterns, size and shape. In Northern Zambia mixtures are less complex, being based mainly on yellow and white seeds. In Western Tanzania beans are sown unmixed when, across the boarder in Southern Uganda and the Great Lakes, mixture are the rule. In the region improvement of bean mixtures have taken a low profile. Breeding methods like component breeding could be appropriate for this kind of work .

CURRENT ADVANCES IN VARIETAL IMPROVEMENT

Several national bean programmes have initiated their own hybridization programme while others have relied on progenies generated at CIAT from crosses made at their request. Serious evaluation of over 3,000 bean materials that have been introduced into Africa have resulted in the release of improved cultivars by several national programmes as shown in Table 3.

TABLE 1: Average annual bean production in the SADC region

Countries	Hectares	Productivity (kg/ha)	Production (t)
Angola	110,000	364	40,000
Lesotho	7,000	357	2,500
Malawi	135,000	553	74,000
Mozambique	180,000	343	62,200
South Africa	87,000	700	60,900
Swaziland	2,000	400	800
Tanzania	465,000	494	230,000
Zambia	24,000	653	16,000
Zimbabwe	24,000	691	16,000
Total	1,034,000	487	503,700

Source: Wortman and Allen (1994).
Data for Botswana and Namibia are not available.

TABLE 2: **Principal bean-growing areas in SADC countries**

Environment	Bean growing area	('000ha)
AFBE1	Tanzania: Northern	80
AFBE2	Tanzania: Usambara and Uluguru	50
AFBE3	Malawi: Misuku Hills, South	70
	Mozambique: Lichinga (Norther)	75
	Tete	15
	Western Highlands	25
	Tanzania: Southern Highlands	110
	Zimbabwe: Highveld	15
AFBE4	Angola: Central Highlands	80
	Mozambique: Northern (Rumphi)	20
AFBE5	Lesotho: Lowlands/foothills	7
AFBE6	Tanzania: Kagera	90
	Northern Mid altitude	40
	West (Kigoma)	45
AFBE7	Malawi: Central Plateau	35
	Zambia: East	5
	Zimbabwe: Mid-veld	6
AFBE8	Tanzania: N. Fringe areas	30
AFBE9	Angola: Fringes	30
	South Africa: Transkei	70
	Natal	17
	Zimbabwe: Mid-veld fringes	3
AFBE10	Zambia North East	11
AFBE11	Zambia:N.C and N.W	8
	Swaziland: High and mid-veld	2
AFBE12	Malawi: C. (r.m[4])	10
	Mozambique: S. (r.m)	20
AFBE13	Tanzania: Morogoro	20
	Total	989

Source: Wortmann and Allen (1994)Hybridization programmes are evident in Malawi, Tanzania, South Africa, Zambia and Zimbabwe. These programmes utilize promising introductions, adapted commercial cultivars and local landraces in their crossing blocks. The programmes have employed several breeding methods to advance the crosses. These include pedigree, single plant/pod descent, a combination of these two, recurrent selection and backcrossing. A breeder in Zambia attempted to do mutation breeding but left the programme before going far.

Types of crosses being made range from one way to four way crosses. These crosses are made for various purposes. Some are made to improve yield of adapted cultivars or transfer genes of resistance for

TABLE 3: **SADC bean technology developed for farmers**

Country	Recommended to farmers	Restricted availability	Very promising for future
Angola	NO	RECENT	RESEARCH
Lesotho	Introduced cvs: Harold, Nodak		Introduced AND lines, and Malawi landraces
Malawi	Local cv:Chimbamba bred cv: Bunda 93 Introduction: Kalima(=PVA 692)	Introduced cvs:A344,A286	Introductions:CAL 143 A197
Mozambique	Local cvs:INIA-10, Encarnado Introduction:PVA773	Introduced cvs:Diacol Calima, Ica Pijao. Also local cvs:INIA-Zambeze	Intodutions: AND628, Colombia
Namibia	BEAN	RESEARCH	RECENT
South Africa	Many cvs of following types:speckled sugar, navy, brown/yellow haricot,carioca, large white (*P.coccineus*).	A few cvs released 1993/94	Entries in 94/95 Nat.Cv.Trials
Swaziland	Introduced cvs: BAT1713;PVA894; Carioca		Introduced cv: Puebla Cafe
Tanzania	Introduced cvs: Lyamungu 85; Lyamungu 90; Uyole 84&90; Local cv:Ilomba&Selian94 Herbicides: Flex, Galex, Stomp.	Introduced cvs:EP4-4, SUA 90, PVAD 1156, EA 2525. Hedgerow macro-contours	Introductions G8864, PVA773. IPM against stem maggot; IPM against bruchids.
Zambia	Introduced cv: Carioca, Stem maggot seed dressing	Introduced cvs:A197, PAT10.	2 local cvs: SolweziRose, ZPV 29: also introductions
Zimbabwe	Introd. cvs:Ex-Rico 23; C20. Bruchid control: silica dust and sun drying. Plant population	Introduced cv:H140-Z2PE	Introductions: MCM5001, PVA773, Carioca

various pathogen and insect pests from introductions to the adapted cultivars. Within the region crosses are being made to develop resistant varieties against BCMV (Zimbabwe), bruchids (Tanzania), bean stemmaggot (Tanzania), rust and CBB (South Africa) and for tolerance to low pH, acid and infertile soil (Malawi), to mention just a few. In South Africa inter-species crossing for resistance to heat and drought are done in order to incorporate these resistances that are present in *Phaseolus acutifolius* into *Phaseolus vulgaris*. Suffice to emphasize here the dramatic advances made in the breeding programmes is a result of the many bean materials that have been introduced from mainly U.S.A and Latin America.I would also like to emphasize that the presence of CIAT experts in Africa have helped enormously in developing screening techniques and hence identification of lines with resistance to some pathogens and insect pests. These lines are being utilized by different national programmes in their hybridization projects.

FARMER PARTICIPATION IN VARIETAL IMPROVEMENT

In most countries in the SADC region it is a pre-requisite to test promising bean materials on farmers' field before a variety is released. In the past researchers used to hire farmers' land and conduct trials without farmers' full participation. This approach led to rejection/slow adoption of released varieties by farmers/consumers. So from this it was concluded that breeders were not meeting farmers'needs; and accumulating evidence suggests that many instances where farmers' goals are not necessarily breeders' goals (Sperling, 1989).

Since the presentation of a paper entitled "Breeding to Meet Farmers' Needs" by Dr. Lonise Sperling in the Workshop on Bean Varietal Improvement in Africa, Maseru, Lesotho 30 Jan - 2 Feb 89, breeders have changed their approach and are now involving farmers in varietal development.

In Tanzania since 1990, farmers are brought to the research stations to evaluate promising bean varieties and select those that they would like to test further in their own fields. I am confident that some papers addressing this topic will be presented by other colleagues in this workshop.

GERMPLASM EXCHANGE

National bean programmes in the region differ in size depending on the importance of the crop and availability of resources. Therefore the amount of breeding materials handled within programmes differ from several hundreds to thousands. Large nurseries from CIAT like VEFs cannot be handled by every country. Regional nurseries and trials were proposed in the Bean Varietal Improvement in Africa Workshop that was held in 1989. The objectives were to (a) exchange germplasm within the region and (b) promote collaboration with one another and (c) accelerate technology transfer. Since the trial was to contain less than 20 entries and the nursery around 100 lines many countries felt that they could handle it. However, this couldn't take place until two years ago when a CIAT breeder was in position in Malawi. The first trials and nurseries were evaluated by national programmes in Malawi, Zambia, Zimbabwe Tanzania, Swaziland, Lesotho Mozambique. Results obtained from 9 sites were presented in the last bean breeders workshop.

BREEDING REGIONAL SUB-PROJECTS

Most of the biotic and abiotic constraints facing bean production can be solved permanently through breeding. Some of the constraints are common in bean producing areas in Africa. Taking into consideration the limited resources available it was deemed necessary to embark on collaborative research in which senior scientists would lead a research project. In breeding therefore, there are four sub-projects or components of sub-projects viz (i) breeding for resistance to bean stem maggot (ii) breeding for resistance to bruchids (iii) bean common mosaic virus and (iv) tolerance to drought. Progress made in these sub-projects will be presented by their respective leaders in this workshop.

FUTURE

With continued CIAT supply of germplasm and other technical back stopping, the national programmes need to evaluate the introductions for adaptability and sources of resistance to diseases, insect pests, drought and adaptation to low soil fertility. Those with hybridization programmes need to incorporate resistances found adapted cultivars into seeds of desirable background. Through the regional nurseries and trials promising crosses will reach these national programmes without hybridization programmes. Finally better screening techniques need to be developed and more sub-projects initiated so that permanent solutions to the bean constraint are made available to farmers.

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Q: S David
Is there any conflict of interest between breeders' desires for multiple releases and release procedure/policies in some countries in the Region?

A: C Mushi
In the past the station was like you have described. However, situation is improving.

BEAN BREEDING RESEARCH PROGRAMME IN THE SOUTHERN HIGHLANDS OF TANZANIA

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ABSTRACT

Common bean (Phaseolus vulgaris L.) is a first research priority crop in the Southern Highlands zone of Tanzania. The main bean produetion constraints are low yields, diseases, insect pests, poor soils and erratic weather.

The breeding programme involves evaluation of introduced and local germplasm at the main research station, for yield, disease reaction, adaptation and agronomic characters. Promising genotypes are then advanced for further evaluation in replicated yield trials in 5 substations located at different ecological zones. The best lines after about 2-3 seasons of testing are then advanced to uniform cultivar trials over more locations. Currently, the best 3-4 genotypes are evaluated in on-farm trials where farmers' opinions on adaptability, cookerbility and marketability are also evaluated.

The programme is also involved in genetic improvement of local and elite varieties for yield, disease resistance, cookerbility and acceptability. Early generations are evaluated for seed and plant types, maturity periods and disease resistance. Testing for yield in replicated trials over locations starts at F4. Similar procedures as above are used in evaluation of the advanced generations.

The breeding programme has recently recommended two large-seeded and one medium size seeded varieties for release. More promising materials from germplasm and from F4 populations have also been identified.

INTRODUCTION

The Southern Highlands (SH) of Tanzania is situated between 7 and 9° South and 30 to 38° East which comprise of the four regions of Mbeya, Iringa, Rukwa and Ruvuma. The zone occupies an area of 244,224 km^2 which is 28% of the Tanzania mainland. Most of the SH lies above 1000 m.a.s.l. ranging from 400-3000 m.a.s.l. The area generally receives good rainfall but areas with short and unreliable rainfall exist.

The main research centre is MARTI, Uyole, close to Mbeya town. The research is also conducted in 4-6 substations representing different ecological zones in the SH.

The common bean (*Phaseolus vulgaris* L.) is an important food legume in the SH of Tanzania. Beans are mainly grown in areas lying around 800-2000 m.a.s.l. but the crop has now been extended to low, dry altitudes of rice areas and in high altitudes of pyrethrum-pea-round potato areas (Anon 1994).

The bean crop is grown for both cash and food. Both grains and leaves are consumed in the SH. Bean grains are sold in local and distant markets while leaves are sold in local markets only. The leaves are dried for use during dry season where 73% of dried leaf vegetables were reported to be of beans around Mbeya (Maganga, unpublished report).

Beans of various plant and seed types are grown in the SH. Preferences are, however, strong among the farmers and the consumers. Acceptability, culinary factors and market values of grains are currently among the major characteristics considered in breeding programme.

The bean yields are fairly low in farmers fields ranging from 300 - 500kg/ha (ASSP, 1991) compared to the potential yields of up to 2500kg/ha (UAC 197/76 - 1992/93, MARTI, Uyole 1993/94). The factors that account for low bean production are genetically poor yielding, disease susceptible local varieties, diseases, insect pests, poor soils, erratic weather and late planting. Poor production technologies and socio-economic factors which affect farmers adoption of new technologies also contribute to low production.

The breeding programme at Uyole started since 1974/75 season to-date. Progress has been made in releases of high yielding varieties that are tolerant to

TABLE 1: Mean yield (kg/ha) of the released varieties evaluated at Uyole, Mbimba, Nkundi and Ismani during 1984/85 to 1989/90 seasons.

	Locations				
Varieties	Uyole	Mbimba	Nkundi	Ismani	Means
Kabanima	1766	1294	1363	921	1336
Uyole 84	1957	1270	1961	915	1526
T3	1689	991	1443	729	1213
Ilomba	1830	1209	1402	882	1331
Uyole 90	1884	1384	1970	1106	1561
Njano	2793	1483	-	1467	1914
*Lyamungo 85	1367	704	1524	881	1119

Lyamungo 85 was released for the Northern zone but was evaluated as T23 in the SH.

TABLE 2: Seed type, growth habit and disease reaction of the releasd varieties for the SH of Tanzania.

Varieties	Seed types	Growth habit	Anthra-cnose	Angular leaf spot	Rust	Ascoc-hyta
Kabanima	Calima M-L	Ia	R	S	R	MR
Uyole 84	Cream S-M	IVb	R	MR	Slow Rust	S
T3	Red S	3b	S	MS	S	MR
Ilomba	Coffee S	2b	MR	MR	R	MR
Uyole 90	Carioca S	2b	MS	R	R	MS
Njano	Orange S-M	4a	R	R	R	S
Lyamungo 85	Calima L	Ia	S	S	S	MR

L = Large, M = Medium, S = Small
R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible,
S = Susceptible

some of the major diseases prevalent in the SH (Table 1). The released varieties are of different plant and seed types and maturity periods (Table 2).

Since 1990/91 season the bean breeding programme included an element of acceptability, culinary factors and market values as some of the important characteristics. As a result another variety tested under the name of Red Kasukanywele has been recommended for release as Uyole-94 last year. It is a large-seeded variety with red stripes on white-cream background. It is highly rated in on-farm trials and demonstrations.

Some of the earlier varieties, although high yielding have seed types and culinary factors that are not readily accepted by farmers and the consumers.

OBJECTIVES

The objectives of the breeding programmes in the SH are:

1. To select and breed for high yielding varieties that are resistant to major bean diseases.

2. To select for varieties that are acceptable with good culinary factors and high market values.

3. To select for genotypes that are adapted to the SH in terms of maturity periods and tolerant to drought.

MATERIALS AND METHODS

Several bean genotypes are evaluated in different breeding trials at MARI, Uyole and at the substations. The respective locations cover different ecological zones in the SH. The evaluations normally start from germplasm observations. The promising materials are evaluated in replicated yield trials over different locations in preliminary, advanced and uniform cultivar trials.

The germplasm observation is conducted at Uyole in non-replicated single rows of 2-5m long. The germplasm is observed for 1-2 seasons before the promising genotypes are advanced to yield trials or shelved. About l00 - 200 germplasm lines are evaluated each season. The sources of germplasm are VEF and SABREN materials from Lyamungo and CIAT-Malawi, as well as the local germplasm.

Selected 25-30 lines from germplasm are included in preliminary yield trial in two replications. The trial is conducted over 4-5 locations for two seasons. Some of the best materials from the preliminary yield trial and from the other trials are included in advanced yield trial. About 25-30 lines are evaluated in 2 replications at 4-5 locations, for two seasons.

The final testing of the materials is carried out in uniform cultivar trial where 16-20 entries are evaluated in 4 replications over 4-6 locations. The most promising varieties are also evaluated in on-farm trials. The report at this on-farm trial is summarized in another report.

Bean Improvement

The bean breeding programme is also concerned with the genetic improvment of local and elite varieties for yield, disease resistance, plant types, maturity periods and acceptability. Initial crosses and evaluations of progenies are done at MARTI, Uyole and progenies are advanced to F2-F3. The promising populations are evaluated in replicated yield trials from F4-F5.

Collaborative trials

Several collaborative trials are conducted at MARTI, Uyole. These include VEF series of germplasm from the National Programme. Other trials are SARBEN germplasm yield trial from CIAT-Malawi.

Trial managment

All the trials in the SH are evaluated for yield and yield components, disease resistance, agronomic characters, plant and seed types and maturity periods.

All the replicated yield trials are laid in 4 rows of 4m long with the spacing of 50cm x 10cm and single plant per hill. Data is taken from 2 centre rows of 4m long. Fertilizer rate applied is 40:20 (P_2O_5: N) kg/ha. The beans are protected from bean fly damage by spraying with Thiodan 35% EC or Sumithion 50% EC at 4-5 days after germination using the recommended rates. Other recommended management practices for bean production are followed.

RESULTS AND DISCUSSIONS

The results for 1993/94 and 1994/95 seasons for few advanced trials are summarized in this report. Both seasons were characterized by cool weather which ended in frost at Uyole that was more severe this season. Data for this season is only from Uyole because harvesting is not complete at the other locations.

Phaseolus Beans Uniform Cultivar Trial (PBUCT)

This is the final stage of variety evaluation over different locations. Twenty entries including checks were evaluated at 5 locations in 1993/94 season. Unfortunately, the trial at Ismani was lost due to drought. The results are presented in Table 3. Generally, there are different varieties best to different locations. However, there are varieties like PBPYT 91/22 and Uyole 90 which performed uniformly across the locations. Most varieties yielded above Kablanketi and Kabanima and few above Uyole 90.

Poor yields were observed at Nkundi due to drought, and at Mbimba and Mitalula possibly due to poor soils. Most of the genotypes were fairly susceptible to angular leaf spot.

Another set of 20 entries was evaluated at 5 locations during 1994/95 season (Table 4). The best varieties are PBPYT 91/22, DRK-5, LB 465-1, line Masusu x Kabanima (F7) and Red Kasukanywele (Uyole 94). Uyole 90 had poor yields due to drought and frost damage.

There was a serious incidence of rust which reduced the yields of Uyole 84 x T299 and Ikinimba compared to their yields in 1993/94. Lines PBPYT 91/92 and LB465-1 will be considered for high altitudes because they have less disease problems. Their yield is high in Ilembo/Usafwa and Shiborya, the areas that are in the range of 2000 m.a.s.l.

Phaseolus Beans Preliminary Yield Trial (PBPYT)

This is one of the preliminary stages of yield trials. Twenty entries including checks were evaluated in two replications over 4 locations in 1993/94 season and 5 locations in 1994/95 season. The data for 1993/94 season is presented in Table 5 and in Table 6 for 1994/95 season. The yields were fairly high at Uyole in both seasons. There are some varieties that have good performance across all the locations.

There are more high yielding varieties in 1994/95 season than in the previous season (Tables 5 and 6) and the mean yields was 2481kg/ha in 1993/94 ~ and 2658kg/ha in 1994/95 seasons. The high yielding varieties with good seed types will be maintained and evaluated again for another season.

Phaseolus Beans Short Term Variety Trial (PBSTVT)

There are areas in the SH which experience short and erratic rains (Madata 1992). The farmers also tend to plant beans late to escape diseases, growing of two crops per season, relay cropping and labour shortages. Currently the programme is selecting for varieties that can yield more than Kabanima and the local varieties under such conditions.

Red Kasukanywele, UACG 161 were identified as better yielders under drought conditions in 1993/94 season at Uyole (MARTI, Uyole 1993/94).

A set of 10 varieties from PBUCT was planted on March 23, 1995 while the rain stopped on March 28, 1995. The beans, therefore, experienced drought throughout the growing season. The yield data is presented in Table 7. The best varieties were LB465-1, PBPYT 91/92, Red Kasukanywele and DRK-4. Variety Kabanima was the lowest yielder.

It is therefore important to identify varieties that can be grown over a wide range of environments such as the ones mentioned above.

Another set of 14 entries was planted at Uyole on March 30. Unfortunately the trial was killed by frost.

Bean Variety Improvement

The bean programme is involved in improvement of local and elite varieties. A set of populations at F7 and F4 from various crosses were evaluated at 5 locations this season.

Yield data for Uyole is summarized in Table 8. There are promising populations in terms of yield. However, a linkage is suspected between yield and seed coat colour in crosses involving Kablanketi. Better plants will, therefore, be selected from bigger bulks in F5 populations for the desired seed types with high yields.

Bean Collaborative Trial

A collaborative trial, Southern African Regional Bean Yield Trial (SARBYT) was planted at Uyole in early March, 1995. The trial is coordinated from CIAT - Malawi. Varieties included in this trial were from 5 countries. Most of the varieties included in this trial showed good performance (Table 9) with the mean yield of 2576kg/ha. The best varieties are PBPYT 91/22, PVA 773, DRK~ 57, A 197, CAL 143 and CAL 113.

CONCLUSION

The bean breeding programme in the SH has identified high yielding varieties during the 1993/94 and 1994/95 seasons. The varieties identified as high yielding include Red Kasukanywele (Uyole 94), DRK-4, DRK-5 EGERM 74, PBPYT 91/92 and LB465-1. Several high yielding populations have also been identified in crosses involving local and elite varieties.

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Q: Allan Femi Lana

You have talked about emphasis on disease resistance. What about insect resistance in the Southern Highlands?

A: C. Madata

CIAT is doing variety evaluation. Once we get the resistant varieties we will use them eg. Ikinimba but has now shown serious sustainability to rust.

TABLE 3: **Yield performance (kg/ha) and disease reaction of bean varieties evaluated in PBUCT at 4 locations during 1993/94 season.**

	Locations Yield					Angular Leaf Spot			
Varieties	Uyole	Mbi-mba	Mita lula	Nkundi	Means	Uyole	Mbi	Mit mba	Mita lula
UAC 183	2144	1075	628	485	1083		3.3	5.0	2.5
PBABL	2588	1300	853	300	1260		2.5	3.3	2.5
Red Kasukanywele	3223	1350	903	418	1473		3.3	7.0	2.5
DRK-4	3122	1063	806	518	1377		3.5	7.0	3.8
DRK-5	2964	938	988	484	1347		2.5	6.0	3.5
UAC 168	2308	1431	796	541	1269		2.3	3.8	3.8
EGERM 74	2820	1631	1031	513	1499		3.3	3.0	3.5
UACG 159	2533	1475	1078	489	1394		3.0	3.8	4.0
PBBL 1 Nkundi	2384	1338	969	435	1281		3.0	5.8	3.5
PBBL 19 Nkundi	2624	938	721	808	1272		5.3	9.0	5.0
EGERM 76	2484	1000	1384	427	1334		3.5	5.5	3.0
GO 5476(Y)	2654	763	1131	927	1369		3.5	6.3	4.0
UACG 161	2713	1125	1188	433	1365		1.5	4.3	3.3
Kablanketi-2	2459	1188	763	565	1244		4.0	6.8	2.3
UACG 160	1964	969	669	483	1021		5.3	6.0	5.0
*PBPYT 91/22	3513	1750	766	699	1682		2.0	2.3	2.8
Mexico 142 (Black)	2589	1381	1044	246	1315		1.0	1.5	1.0
Kablanketi	1745	775	602	441	891		3.8	9.0	2.8
Uyole 90	2846	1881	1125	264	1529		1.0	1.5	1.0
Kabanima	2254	1125	750	433	1140		3.3	4.5	3.0

TABLE 4: **Yield (kg/ha) and reaction to diseases of bean varieties evaluate in PBUCT at Uyole in 1994/95 season.**

	Varieties	Yield kg/ha	Disease (1-9 scale)		
			A. Leaf spot	Rust	F. Leaf spot
1.	Red Kasukanywele	2849	2	2	4
2.	UACG 161	2501	2	5	6
3.	EGERM 74	2662	3	1	5
4.	DRK-4	2712	2	2	4
5.	DRK-5	3141	2	4	4
6.	Kablanketi-2	2145	2	2	4
7.	GO5476(Y)	2572	4	1	4
8.	PBBL 136	2143	1	4	2
9.	Masusu x Kabanima-8	2638	3	4	2
10.	Y23 x Kabanima-3	2596	5	1	4
11.	CAL 143	2860	4	5	5
12.	Uyole-84XT299-18	1658	1	8	1
13.	LB465-1	3086	1	4	7
14.	PBPYT 91/92	3817	1	1	1
15.	Masusu x Kabanima	2905	4	4	1
16.	YC-2 x Kabanima	2463	3	1	4
17.	EGERM 77	2340	4	1	4
18.	Ikinimba	2164	1	8	1
19.	Uyole 90	2649	1	1	4
20.	Kabanima	2526	2	1	4
	MEANS	2621	2.4	3.0	3.6
	CV%	13.6			
	SE	178			
	P	***			

TABLE 5: Yield performance (kg/ha) and angular leaf spot reaction of bean genotypes evaluated in PBPYT at 4 locations during 1993/94 season.

	Locations Yield					Angular Leaf Spot	
Varieties	Uyole	Mbi-mba	Nku-ndi	Mita lula	Means	Uyole	Mbimba
Diacol Calima	2363	1125	568	1513	1392	4.7	8.7
Sapele Kedwa	2187	833	485	1767	1318	6.0	9.0
Pho Meko	1830	858	288	1154	1033	3.7	6.7
Kilyumukwe	2134	1092	602	1692	1380	3.7	4.3
Pan Meko	2147	883	657	1792	1370	4.0	8.3
Ilomba	2944	1200	462	1654	1565	4.3	4.0
Ikinimba	3323	1342	738	1350	1688	3.7	2.0
PBPYT 92/22	3527	1100	655	1592	1718	1.0	2.7
EGERM 77	2389	1050	558	1375	1343	3.7	3.3
LB465-1	3342	1442	603	1643	1757	1.0	2.3
EGERM 62	1831	875	635	1283	1156	4.7	6.0
Masusux Kabanima	2101	1142	700	1358	1325	3.7	7.7
PBAYT 92/93-17	2348	1175	283	1982	1447	1.0	1.3
OQC 253	2161	875	538	1199	1193	4.7	8.7
OQC 288	2061	975	399	875	1077	3.0	4.0
UACG 162	2426	1150	638	1100	1329	4.7	8.3
EGERM 93	1782	892	618	1283	1144	5.7	9.0
EGERM 74	2724	1308	510	1217	1440	3.7	3.7
UACG 134	1844	1000	508	1333	1171	4.0	6.7
YC-2X Kabanima	2698	925	531	1117	1318	4.2	5.3
FB/GP246-3	2691	1483	238	2108	1630	1.0	1.0
Uyole 84 (P)	2715	1250	601	1800	1591	1.0	2.3
Uyole 84 (W)	2920	1583	365	1425	1573	1.0	2.7
Kabanima	2444	1008	532	1408	1348	3.7	5.7
Uyole 90	3100	1625	330	2067	1780	2.0	0.0
Means	2481	1128	522	1483	1404	3.3	5.0
CV%	19.2	24.2	32.7	23.4			
S.E. ±	275	158	98	200			
P	***	**	***	**			

TABLE 6: **Yield (kg/ha) and disease reaction of bean varieties evaluated in PBPYT at Uyole in 1994/95 season.**

	Varieties	Yield kg/ha	Disease (1-9 scale)		
			A.Leaf spot	Rust	F. Leaf spot
1.	CAL 143	2995	1	1	3
2.	AFR 632	2553	1	7	7
3.	AFR 632	1904	1	8	5
4.	AND 979	1680	1	7	1
5.	AND 998	2707	1	1	5
6.	AND 961	3129	4	1	5
7.	Cargabello	2830	2	4	5
8.	Uyole 94 (RK)	2776	1	1	4
9.	Carib 8903-23	3021	1	6	2
10.	TM 27JIJ2	2997	3	6	5
11.	AND 992	2201	1	7	4
12.	LSA 189	2637	3	1	6
13.	LSA 191	3077	5	5	5
14.	DRK 45	2865	4	1	6
15.	AND 905	2881	4	1	5
16.	AND 945	2716	3	6	3
17.	ANT 2	2432	5	3	6
18.	137722	3020	4	7	5
19.	T23 x Kabanima (D)	2880	4	5	5
20.	YC-2 x Kabanima	2402	5	1	5
21.	T23 x Kabanima (L)	2292	3	4	5
22.	YC-2 x Kabanima	2917	1	1	3
23.	Masusu x Kabanima	2982	6	6	1
24.	Masusu	1919	5	6	5
25.	Kabanima	2648	3	1	4
	Means	2658			
	CV%	16.8			
	SE	315			
	P	NS			

TABLE 7: **Yield (kg/ha) of bean varieties evaluated under late planting at Uyole in 1994/95 season.**

	Varieties	Yield	Seed size	Seed Quality *(1-5)
1.	Red Kasukanywele	1892	Large	1.0
2.	UACG 161	1587	Large	1.5
3.	EGERM 74	1512	Medium	1.5
4.	DRK-4	1867	Large	2.0
5.	DRK-5	1796	Large	2.0
6.	Kablanketi-2	1448	Medium	1.5
7.	LB465-1	2002	Medium	2.5
8.	PBBL No: 19 (NK)	1710	Large	1.0
9.	PBPYT 91/22	1956	Small	1.5
10.	Kabanima	1260	Medium	3.0
	Mean	1703		
	CV%	15.0		
	SE 0.05	147		
	P	*		

* 1-5 Very good - very poor

TABLE 8: Yield (kg/ha) of bean progenies and of their parents evaluated at Uyole in 1994/95 season.

	Progenies	Lines	Yield kg/ha
1.	[YC-2 X KABAN] UAC 160	L5	2182
2.	[YC-2 X KABAN] K'Nywele	L1-1	3651
3.	EAI 2525 X Kablabketi	L1	1982
4.	EAI 2525 X Chipukupuku	L2-3	2526
5.	[Masusu X KABAN] UAC 160	L2	2339
6.	[YC-2 X KABAN] UAC 160	L1	2535
7.	Uyole 84 X Kablanketi	L1	2537
8.	Uyole 84 X Kablanketi	L3	2340
9.	EAI 2525 X Kablanketi	L5	2438
10.	[Masusu X KABAN] UAC 160	L4	2763
11.	[Masusu X KABAN] UAC 160	L5	1929
12.	EAI 2525 X Kablanketi	L5	3793
13.	EAI 2525 X Kablanketi (N)	L2	2586
14.	YC-2 X KABAN	L2F7E3	2829
15.	Masusu X KABAN	E6	3270
16.	Uyole 84 X T299	E4	2649
17.	T23 X KABAN-4	E11	2730
18.	YC-2 X KABAN-8	E6	3143
19.	Kabanima	P	3286
20.	Masusu	P	2720
21.	Chipukupuku	P	2465
22.	UAC 160	P	3156
23.	EAI 2525	P	3355
24.	Uyole 84	P	2229
25.	Kablanketi	P	1161
	Means		2664
	CV%		19.2
	SE		362
	P		*

TABLE 9: **Yield (kg/ha) and disease reaction of bean varieties evaluated in Southern African Regional Bean Yield Trial (SARBYT) at Uyole, 1994/95 season.**

	Varieties	Origin	Yield	Diseases (1-9 scale)		
				A.leaf spot	Rust	F.leaf spot
1.	Limpopo	South Africa	2404	4	1	1
2.	Wartburg	South Africa	2249	5	5	1
3.	PAN 127	South Africa	2342	3	3	3
4.	Enseleni	South Africa	2428	2	1	3
5.	Nandi	South Africa	2311	1	1	5
6.	TB 79/467	Tanzania	2393	1	1	1
7.	Lyamungo 90	Tanzania	2424	3	1	1
8.	PVA 773	Mozambique	3042	2	1	1
9.	ZPV 292	Zambia	1705	1	3	1
10.	A 197	Zambia	2941	4	1	4
11.	CAL 143	Malawi	2802	1	1	6
12.	DRK 57	Malawi	2987	2	1	1
13.	CAL 113	Malawi	2002	2	2	1
14.	KID 31	Malawi	2002	2	2	1
15.	PBPYT 91/22	Tanzania	3713	1	1	1
	Means		2576			
	CV%		14.9			
	SE 0.05		192			
	P		***			

CULTIVAR DEVELOPMENT OF BEANS (*PHASEOLUS VULGARIS* L.) FOR ZIMBABWEAN FARMERS

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ABSTRACT

The agricultural production structure in Zimbabwe is characterized by a small number of large-scale (6400) and a large number of small scale producers (over 1 million). Dry beans (Phaseolus vulgaris L.) are mainly produced by small scale farmers, large scale farmers concentrating on production of small white-seeded "navy" beans. However, dry bean yields are low, averaging 500-700 kg/ha. A recent farm survey identified inadequate levels of tolerance to pests, diseases, low soil fertility, drought and competition with weeds as being important constraints to bean productivity.

Bean improvement efforts to develop high yielding cultivars resistant to important diseases and pests and also with acceptable seed characteristics are discussed.

Improved bean lines have been identified through screening introduced germplasm and segregating populations and most entries outyielded the local cultivars. A number of high yielding lines have been identified (Carioca, MCM 5001, RAB 332, DOR 275), but they are small seeded and not usually preferred by Zimbabweans. Limited on-farm evaluations have shown that although the "speckled sugar" types have the most preferred seed and culinary characteristics, farmers and consumers also accepted the pinto and carioca types.

The bean research programme aims at making available to farmers small seeded beans.

INTRODUCTION

The agriculture production structure in Zimbabwe is characterised by a small number of large scale (6400) and a large number of small scale producers (over 1 million).

The common bean, *Phaseolus vulgaris* L. is widely grown in Zimbabwe and is an important source of inexpensive dietary protein. Small scale farmers are the main producers of dry beans, while large scale farmers concentrate on the production of small white seeded "navy" or Michigan Peabeans, mostly for export. However, dry bean yields obtained by farmers are low, averaging 500 to 700 kg/ha.

Despite these low yields, there is a well established production area in Zimbabwe, covering about 60 000 ha (FAO, 1989). A wide diversity of large (>300 mg) coloured-seeded cultivars are grown, the most widespread seed colour type being the speckled sugar or cranberry (i.e. cream with red mottles). Moreover, beans are held in high regard by consumers: the retail price is about twice that of groundnuts and four times that of cowpeas.

PRODUCTION CONSTRAINTS

The major constraints on bean production are biotic. Disease and insect damage are recognised as the main production constraints for beans.

The most important diseases are the seed borne diseases namely bean common mosaic virus (BCMV), common bacterial blight (CBB), and halo blight. Anthracnose, angular leaf spot and rust are also prevalent although their severity varies from season to season.

The most important pests of beans in Zimbabwe are beanfly (*Ophiomyia* spp.) and bruchids. A farm survey conducted in 1989-90 in the main bean producing districts of Zimbabwe to obtain information on bean production constraints, production systems and cultivars grown indicated that the farmers perceived the crop to have inadequate levels of tolerance to diseases, pests, low soil fertility, drought and competition by weeds. These perceptions are broadly consistent with the conclusion of researchers.

In line with the findings of the farm survey and taking into account the characteristics of the small scale farmers in Zimbabwe i.e. low income and low capital inputs, the research objectives of the bean programme are to generate stable low cost production technologies. Hence the emphasis of the bean breeding programme in Zimbabwe is to develop high yielding cultivars that combine resistance to the most important diseases and pests with an acceptable seed type to both farmers and consumers (preferably cream with red mottles). Such cultivars will be likely to have a major impact on bean production.

BEAN BREEDING PROGRAMME

Research strategies/Materials and Methods

A two-spronged approach is followed to generate superior cultivars. The first approach is through introducing diverse germplasm, mainly from CIAT. The second approach is through hybridization between local cultivars and specific sources of resistance from germplasm, followed by selection of lines that combine disease resistance and the desired seed characteristics.

a) Introductions

Introductions are a fast and cost-effective way of increasing genetic variation in a breeding programme and of identifying well adapted lines for release to farmers.

Since the inception of the bean breeding programme in 1985, over 1 000 lines from various sources, mainly CIAT have been introduced and evaluated. By and large the introductions were "finished" or advanced lines, mostly from the IBYANS, disease nurseries and from the VEF nurseries.

The testing procedure for the introductions is as follows: The introductions are tested in a non-replicated observation nursery at Harare Research Station. (This also serves as a form of open quarantine for the new introductions).

Promising lines are selected and progress through preliminary variety trials (plots of 4 rows, 3m long, 3 reps), grown at two sites; through to the intermediate variety trials (plots of 6 rows, 3m long, 3 to 4 reps) grown at 5 sites and finally to advanced variety trials (plots of 10 rows, 3 to 4m long, replicated four times) at seven or more sites.

The sites used are all research station sites. Promising lines are tested in the AVTs for up to 3 seasons. At each stage of testing, trial records are taken and they include time to maturity, disease and pest incidence as well as seed yield.

Although yield is the most important criterion used to identify promising lines, other characteristics such as level of resistance to diseases and pests, seed size and seed colour are also considered.

b) Crossing/Hybridization Programme

In order to increase range of genetic variability availability to the breeding programme, hybridizations have been made since 1985/86. Initially crosses were made between high yielding lines and locally grown lines in order to improve the latter and also between high yielding lines.

However, from 1990, the thrust changed to breeding for resistance to diseases, notably the seed borne diseases BCMV and CBB whilst trying to maintain the desired characteristics. To achieve the latter, crosses were made between sources of resistance and locally grown cultivars. Also, as part of a subproject, a backcross programme which aims to transfer the recessive bc3 gene which imparts resistance to all known strains of BCMV into various adapted genetic backgrounds is in progress.

An average of 25-30 new genetic combinations are made during every summer season and the F1 generation is grown in the greenhouse during spring for positive identification. Starting from the F2 generation, two generations are grown in the field per year, one in summer under rainfed conditions and the other one in winter under irrigation at frost-free sites. Segregating populations are being advanced by the modified single seed decent method. Diseased and poor plants are rogue from each population prior to advancement to the next generation. Single plant selections are made at the F6 stage based on agronomic traits, disease resistance and seed characteristics. progeny of single plant selections with acceptable seed characteristics is evaluated in a non-replicated observation trial. Promising lines are tested further in the preliminary variety trials, through to the intermediate variety trials and finally in the advanced variety trials as has already been described.

Cooking time tests

These are carried out routinely on all entries which comprise the AVTs. The cooking time of each genotype is determined directly on two samples, each comprising 25 seeds using a Mattson cooker.

On-farm testing of advanced lines

Very little on-farm work has been carried out by the programme. The lack funds to cover travelling expenses has been a major limitation to this work. In the 1994/95 season on-farm trials were carried out in collaboration with a non-governmental organisation as well as with the Farming Systems Research Unit which works with other crops as well.

The agreement with the farmer includes use of his/her land as well as labour for planting and weeding. Inputs used in the trials are provided by the programme.

Although yield data from the trials could not be obtained because of the severe drought that affected the country, data on seed preferences was obtained. On-farm testing will expand in the 1995/96 season.

RESULTS AND DISCUSSION

a) Evaluation of introductions

A lot of progress in yield improvement has been made through introducing material from CIAT. Most of the lines tested have significantly outyielded the locally grown cultivars, Natal Sugar and Red Canadian Wonder. Some of these lines are being tested in the intermediate and advanced variety trials. However, almost all of these lines are small seeded, have brown, red, yellow or black seed coat colours and some of them have shown poor architecture.

Table 1 shows the mean yields, agronomic and seed characteristics of some of the lines that were tested in the 1994/95 advanced trials. Twenty-five of the thirty lines outyielded the two local checks. However, the mean yields of the cultivars were rather low because of the drought experienced in the season. The introductions had mean yields ranging from 1.51 t/ha to 1.93 t/ha representing yield improvements of 6 to 36% over the local cultivars Red Canadian Wonder and 129 to 192 over the local cultivar Natal Sugar.

Some promising lines have been identified from variety evaluation and they include Carioca, MCM 5001, DOR 375 and RAB 332 (Table 1).

b) Crossing/Hybridization programme

About 145 crosses have been made successfully since 1986/87 season. Of these, 51 crosses have been made between the local cultivars (Natal Sugar and Red Canadian Wonder) and high yielding disease resistant lines.

A total of 924 single selections have been taken from the segregating populations for further testing in the variety trials:

In the 1994/95 seasons intermediate variety trials, 26 of the 30 genotypes were from the crossing programme (Table 2), whilst in the 1994/95 AVT, 8 of the 30 were descendants of the hybridization programme (Table 1).

In the intermediate variety trial the genotypes had mean yields ranging from 0.776 t/ha to 1946 t/ha (Table 2). Fifteen genotypes outyielded Red Canadian Wonder by between 2% and 26% whilst 29 genotypes outyielded Natal Sugar by between 34% and 151%.

Screening for BCMV resistance has so far resulted in 60 populations: 20 of which are in the BC1 F4 generation, 20 in the BC2 F2 generation and the remaining 20 will be going through into the BC3 generation. Breeding for rust resistance has led to 3 lines which are currently being tested in the AVT i.e. 37/6/6 and 36/6/10, 36/6/1. Breeding for resistance to CBB has led to 10 lines all 60/6/... which were tested in the IVT during the 1994/95 season (Table 2).

Procedure for release and multiplication

Every variety to be released has to be approved by a variety release committee. Once the committee has approved the release of the line as a variety, the breeder releases the breeders seed to the Seed Coop Company of Zimbabwe, a private company. The Coop has an agreement with government to multiply

Table 1: Mean yields (t/ha), agronomic and seed characteristics of bean varieties tested at 6 sites in the 1994/95 AVTS.

Variety	Growth Habit	Days to 95% maturity	Seed Yield (t/ha)	Seed size (mg)	Seed colour[1]	Source[2]
A 286	3	93	1.93	221	C/Br	CIAT
A 62	2	95	1.83	243	Br	CIAT
36/6/10	2b	94	1.81	205	R	NP
AND 751	2b	94	1.79	212	R	CIAT
38/6/5	2	92	1.79	183	C/B	NP
MUS 97	2	93	1.74	204	Br	CIAT
DOR 375	2	92	1.74	206	R	CIAT
RAB 477	2b	89	1.72	183	R	CIAT
37/6/6	2b	95	1.69	204	C/Br	NP
RAB 482	2b	92	1.67	217	R	CIAT
RAB 332	2	90	1.66	198	R	CIAT
Carioca	2b	92	1.65	203	C/Br	CIAT
RIZ 65	2	93	1.65	201	C-Bg	CIAT
24/6/10	2b	94	1.62	224	C/B	NP
MC 5001	2	96	1.60	202	C/Br	CIAT
36/6/1	2b	95	1.59	196	Br	NP
MMS 253	2b	96	1.56	201	R	CIAT
BAT 332	2	96	1.56	164	Y	CIAT
6/6/9	2b	99	1.55	205	Br	NP
RIZ 102	2b	95	1.54	181	C-Bg	CIAT
A 197	1	96	1.52	472	Bg	CIAT
43/6/6	2	97	1.52	170	C/Br	NP
BAT 85	2	94	1.52	196	C-Bg	CIAT
EMP 86	3	92	1.51	195	Y	CIAT
20/6/11	1	95	1.44	341	R	NP
Red.C.W.	1	92	1.42	308	R	NP*
MCM 2001	2b	99	1.38	201	R	CIAT
A 321	3	99	1.34	271	Y	CIAT
AND 767	2	93	1.28	201	C-Bg	CIAT
Natal Sugar	2b	101	0.66	333	C/R	NP*
Mean		94	1.58	214		
SE Mean		0.96	0.11	13.31		
CV%		2.49	17.05	6.97		
Signif. of F		***	***	***		

1. R = Red C = Cream Br = Brown Bg = Beige Y = Yellow B = Black
2. NP = National Programme i.e. product of hybridizations made by the national bean breeding programme

* Local check variety

Table 2: Mean yields (t/ha), days to maturity and seed of bean varieties tested in the 1994/95 IVTs.

Variety	Days to maturity	Seed size (mg)	Seed Yield (t/ha)	Source
62/6/7	92.84	218	1.946	NP
61/6/3	88.17	175	1.903	NP
61/6/6	90.67	183	1.797	NP
61/6/14	87.34	263	1.778	NP
62/6/13	94.92	231	1.774	NP
60/6/13	95.67	246	1.730	NP
Carioca	89.33	212	1.727	CIAT
60/6/8	92.42	199	1.725	NP
62/6/8	90.84	256	1.717	NP
42/6/10	92.75	184	1.708	NP
42/6/11	94.67	207	1.668	NP
60/6/6	88.92	212	1.660	NP
61/6/4	88.75	194	1.657	NP
43/6/3	93.00	165	1.595	NP
60/6/15	91.91	181	1.578	NP
Red.C.W.	89.42	332	1.547	NP
60/6/7	94.83	218	1.530	NP
60/6/14	93.42	254	1.521	NP
61/6/5	88.92	199	1.480	NP
61/6/1	88.50	203	1.477	NP
43/6/17	92.50	205	1.474	NP
61/6/19	86.83	193	1.466	NP
60/6/10	94.42	212	1.444	NP
PEF 14	88.42	357	1.433	CIAT
61/6/11	88.17	206	1.423	NP
43/6/2	93.83	209	1.374	NP
60/6/3	93.67	198	1.371	NP
60/6/11	95.83	161	1.275	NP
60/6/12	97.67	228	1.042	NP
Natal Sugar	99.58	375	0.775	NP
Mean	91.94	214	1.553	
SE Mean	1.51	6.11	0.117	
CV%	3.28	7.00	15.10	
Signif. of F	***	***	***	

seed of any variety released and it is responsible for the production of foundation seed A, foundation seed B and certified seed which it then distributes and markets. However, there are plans to open this agreement to other local seed companies.

On-farm research and consumer preferences

Results of a consumer preference study using 55 different assessors and a range of seed-types were that for seed colour the cream with red mottles (Natal Sugar) was the most preferred and black was the least preferred (Table 3). Other seed colours that were more than acceptable were white, red with cream speckles, cream with light brown lines/spockles, yellow and plain red. The types that were rated poor were a small red type (MCM 2001), Carioca (cream base colour and light brown lines) and plain light brown (Puebla 152 Cafe). It is evident from these results that the consumers were judging according to a combination of colour and size. A similar trend in preferences was obtained from on-farm consumer tests conducted in the 1994/95 season with four varieties (Natal Sugar and 3 advanced lines) promising lines. Natal Sugar was the most preferred; MCM 5001 was more preferred than Carioca and RAB 332 was the least preferred (Tabel 4).

Table 3: Consumers' Assessment of seed colour and size

Genotype	Seed colour	Mean colour preference score	Seed weight (mg)	Seed size class	Mean size preference score
MCM 3030	white	3.71	224	small	3.24
MCM 2001	red	2.16	296	medium	3.16
MCM 1018	black	1.80	202	small	2.24
MCM 5002	yellow	3.07	223	small	2.70
MCM 2004	red/cream	3.44	244	small	2.97
MCM 5001	cream/brown	3.17	225	small	2.61
Carioca	cream/brown	2.80	216	small	2.43
A 86	cream/brown	3.53	248	small	2.79
Puebla 152 cafe	brown	2.62	273	medium	3.06
Red Can Wonder	red	3.53	366	large	3.79
Natal Sugar	cream/red	4.44	312	large	3.70
Mean		3.38	283		3.15
SE diff		0.449			0.559

Table 4: On-farm consumer preference assessment of seed type (seed colour and size).

Genotype	Seed colour	Seed size class	Mean preference score	SE diff
Carioca	cream/brown	small	3.67	0.256
MCM 5001	cream/brown	small	4.17	0.241
RAB 332	red	small	2.92	0.313
Natal Sugar	cream/red	large	4.60	0.149

It is evident that small red types, despite being high yielding are not preferred by consumers.

CONCLUSION

Because of the prevalence of necrotic strains of BCMV in Zimbabwe (Mukuki, 1992; Spence and Walkey, 1994) and judging from consumer preference results, the bean programme has decided to bulk and release MCM 5001 which has resistance to BCMV whilst working towards an improved large-seeded speckled sugar type.

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Q: S David

Were the on-farm trials conducted in several sites? Why don't farmers like small-seeded types?

A: O Mukoko

Yes at two sites. I am not sure: I suppose it is because they have been exposed to only the large seeded types and have developed strong preferences for such types.

Q: GKC Nyirenda

Do you ask farmers preferences for the possibility of cash income or consumption factors on the varieties?

A: O Mukoko

In this study we asked them only on consumption factors of the varieties.

Q: Allan Femi Lana

Excellent, you have released varieties acceptable to the farmers - have you exchanged these to other breeders within the region in particular tolerance to BCMV?

A: O Mukoko

Yes, we exchanged germplasm in the region. Our major channel now is through the SARBEIN and SARBYT trials coordinated by the CIAT breeder in Malawi. In addition, we exchange germplasm with any other country that requests germplasm, for example we have exchanged material with Zambia, Uganda, etc.

DIALLEL ANALYSIS OF BEAN CROSSES FOR RESISTANCE TO BEAN STEM MAGGOT (*OPHIOMYIA SPP*)

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ABSTRACT

Nine bean lines/cultivars that reconfirmed to have high levels of resistance to bean stem maggot (BSM) were crossed to form a 9 x 9 diallel. The crosses were advanced to F2 and then evaluated at Selian Agric. Research Institute under high BSM population. Trial design used was RCB with three replications. Numbers of black/brown pupae per plant, dead plants due to BSM and plants survival at physiological maturity were recorded.

Diallel analysis performed on the number of plants that survived indicated that additive gene effects were more important than non-additive gene effects in determining the expression of resistance to BSM. However, the study revealed that non-additive gene effects were important in some parental combinations.

INTRODUCTION

In Africa stem maggots *Ophiomyia spp* (Diptera Agronomyzidae) are the most important insect pests of the common bean (*Phaseolus vulgaris L.*). Production losses attributable to bean stem maggots are often quoted as total (Wallace, 1939; Taylor, 1958; Greathead, 1968; Wallace 1960, Karel and Matee, 1985).

All three *Ophiomyia spp viz: O. phaseolis, O. spencerella* and *O. centrocematis* have been reported to occur in Africa. Population, species composition and infestation patterns vary with location and with season within a location (Slumpa and Ampofo, 1990). In some areas for example, Eastern Zambia, there may be complete reversal of species dominance during a single bean growing season (Irving, 1986).

Screening for resistance to bean stem maggot has been conducted by several researchers. In Melkassa, Ethiopia, of the 177 bean lines evaluated for their resistance to bean stem maggot (BSM), only five lines showed no symptoms of attack nor pupal population (Abate, 1983). At the Asian Vegetable Research and Development Centre (AVRDC) in Taiwan, 370 bean accessions from CIAT were screened for resistance to BSM. Based on the number of insects/plant and the percentage of damaged plants, 48 accessions showed low to moderate levels of resistance. To confirm their resistance, seven out of 48 accessions, together with two susceptible checks, were planted in a replicated trial in 1979. Two accessions, G 05478 (*P. vulgaris*) and G 35023 (*P. coccineous*), showed a significantly lower attack than the susceptible check (CIAT, 1983). Screening work done in Morogoro, in Tanzania, in 1983 to 1985 showed low levels of resistance to *O. Phaseoli* in the following lines: A 489, A 429, BAT 1570, TMO 118, BAT 1500, A 476 and TMO 101 (Karel et al., 1983, 1984, 1985). However, no work is reported todate on the confirmation of resistance in these lines. Recently, at Selian Agricultural Research Institute, 214 lines from VEF 90 were evaluated for resistance to BSM. Only 38 showed high to moderate levels of resistance (Slumpa, personal communication 1994).

The CIAT entomologist at Arusha has screened more than 3000 bean lines and 50 have shown various levels of resistance (Ampofo, personal communication).

Screening work done by CIAT entomologist at Arusha has shown that the following lines have reconfirmed to have high levels of resistance:- G 2472, (P1), G 2005 (P2), EMP 81 (P3), G 2072 (P4), ZPV 292 (P5), Ikinimba (P6), G 5773 (P7), G 3844 (P8), and BAT 76 (P9).

Diallel cross

A set of crosses produced by involving "n" lines in all possible combinations is designated as diallel cross and analysis of such crosses is known as diallel analysis. Diallel crossing schemes and analysis have been developed for parents that range from inbred lines to broad genetic base varieties. After crosses are made, evaluated, and analysed inferences regarding the type of gene action can be made.

The theory of diallel was developed by Jinks and Hayman (1953); Jinks (1954, 1956) and Hayman (1954 a, b, 1957 and 1958) using Mather's concept of D,H, components of variation. The recent developments about this techniques have been described in detail by Mather and Jinks (1971). Sprague and Tatum (1991) introduced the concept of general combining ability (GCA) and specific combining ability (SCA) to distinguish between the average performance of parents in crosses or margins (GCA) and the deviation of individuals crosses from the average of the margins (SCA). GCA is an indication of additive gene action while SCA indicates dominance gene action.

In the following study the crosses were made following diallel mating scheme so as to determine type of gene action conferring resistance to bean stem maggot, in bean lines that have shown to have high levels of resistance.

MATERIALS AND METHODS

Nine bean lines/cultivars that had reconfirmed to have high levels of resistance to bean stem maggot were used to produce a set of 9x9 diallel crosses. The crosses were made in 1993 at Selian Agric. Research Institute. True crosses were advanced to F2 to confirm their trueness and increase seed.

During the short rains of 1994, time when beanfly population was high, the crosses were evaluated. The beanfly population levels were monitored by sowing observation strips in the experimental area and when there was high bean stem maggot activity the crosses together with parents were sown.

The entries were sown in two row plots of one meter long and spaced 50cm between rows. Two seeds per hill were sown at an intra-spacing of 20cm. The trial was arranged in a randomized complete block design and replicated three times. No fertilizer was applied but supplemental irrigation was supplied whenever necessary. The trial was kept free from weeds.

Plant counts per plot were done after seedling emergence and sampling of dead plants due to bean stem maggot was done twice every week until flowering. From flowering the trial was sprayed with insecticides (Rogor and Karate) whenever necessary to protect it from flower beetles, pod borers and pod sucking insects. At physiological maturity plant counts per plot were made again and percent survival calculated.

STATISTICAL AND STATISTICAL GENETICS ANALYSIS

Initial analysis of variance were performed to determine if variation among crosses differed significantly from zero.
Using model 1 (fixed effects model) and method 2 of Griffings (1956), general combining ability (GCA) and specific combining ability (SCA) of percent plant survival were estimated.

The model for the analysis of variance was:

$$X_{ijk} = \mu + r_k + g_i + g_j + s_{ij} + P_{ijk}.$$

where μ = mean
r_k = replication effect
g_i and g_j = gca effect
s_{ij} = sca effect
P_{ijk} = experimental error

RESULTS AND DISCUSSION

The initial analysis of variance performed on percent plant survival, to determine if the variation among crosses was significantly different from zero, showed that the crosses differ among them for percent plant survival. This indicates that detectable differences in resistance to bean stem maggot (BSM) were transmitted by the parents to their offspring. Therefore, this warranted further analysis to estimate combining abilities.

Diallel analysis for percent plant survival revealed that there were no significant differences among crosses for both general and specific combining abilities (Table 2). General combining ability (GCA) and specific combining ability (SCA) sum of squares for percent plant survival accounted for 59.6% and

TABLE 1: **Diallel analysis of variance for a fixed model of nine parents to produce the 36 crosses.**

Source	df	MS	EMS
Replication	2		
Crosses	35	M2	σ^2 + rk^2c
GCA	8	M21	σ^2 + [r(n-2)/cn-1)] K^2 gca
SCA	36	M22	σ^2 + {2r/[n(n-3)] K^2 sca
Error	88	M1	σ^2

r and n refer to the number of replications and parents respectively.

TABLE 2. **Diallel analysis of variance for percent plant survival**

Source	df	Mean Square
G.C.A	8	940.2256 NS
S.C.A	36	384.7923 NS
Error	88	252.7039

TABLE 3. **Estimates of general combining ability (gi) effect (in parenttheses), and spesific combining ability effects for percent plant survival**

Parent	P1	P2	P3	P4	P5	P6	P7	P8	P9
P1	(1.14)								
P2	-45.19	(19.33)							
P3	-9.97	28.86	(9.11)						
P4	-4.14	-34.31	10.92	(-21.44)					
P5	56.58	27.42	-37.32	59.48	(-21.44)				
P6	-16.86	-7.03	46.19	-16.97	-92.25	(-6.0)			
P7	-3.35	18.36	107.58	-1.58	-13.86	14.69	(-13.39)		
P8	40.17	43.08	-40.77	-12.86	42.86	-3.58	-4.19	(2.89)	
P9	-14.92	-24.8	1.14	-2.03	-15.31	53.25	-7.36	-18.64	(40.94)

SE (gi) = 55.14 SE (gi-gi) = 107.21 (i$\neq$j)
SE (gi) = 70.45 SE (sij-sik) = 153.15 (i$\neq$j, k; j$\neq$k)

24.3% of the variation among crosses, respectively. This indicates that additive gene effects were more important than no-additive gene effects in determining the expression of resistance to BSM.

The estimate of GCA effects of each parent and the SCA effects of their crosses for percent plant survival are presented in Table 3. The positive values indicate a contribution towards plant survival or resistance to BSM, while negative values represent the opposite. The GCA effects were different among parents. However parents P_1, P_2, P_3 and P_8 had positive effects. The highest GCA effect was expressed by parent P_2.

Different SCA effects were manifested by the crosses for percent plant survival. The combination of P_2xP_5, $P_2x P_3$,P_3xP_4, P_4xP_5, P_3xP_6, P_1xP_5, P_2xP_7, P_3xP_7, P_6xP_7, P_1xP_8, P_2xP_8, P_5xP_8, P_3xP_9, P_6xP_9, had positive effects. P_7xP_3, P_4xP_5, P_1xP_5, and P_6xP_9, had highest effects of 107.58, 59.48, 56.48 and 53.25 respectively. This implies that in some crosses, non-additive gene effects seemed to be of some importance.

It should be noted that since F_2 crosses were used in the study, the coefficients of H_1 and H_2 are ¼ of those of the F_1 statistics, while the coefficients of F is halved being second and first degree statistics in "h" respectively (Jinks, 1956; Hayman, 1958 and Mother and Jinks, 1971).

This study has shown the overall additive gene effects. However in some crosses no-additive gene effect were important.

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Q: KW Pakendorf

Do you have any indication of the number of genes involved?

A: CS Mushi

F2 segregation variation from this study indicate that a few dominant genes are involved.

SOURCES OF RESISTANCE TO ANGULAR LEAF SPOT AND RUST IN SOUTH AFRICA

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ABSTRACT

A search is being conducted at the Grain Crops Institute to identify sources of resistance to rust and angular leaf spot (ALS) of dry beans in Southern Africa, and, where possible, the resistance genes involved. Two methods are being used. Firstly, the set of differential cultivars used for pathotype identification, supplemented by important local cultivars, are planted at localities representative of the various Southern African production areas. The cultivars are monitored for disease reaction and graded with the use of standard scales. This procedure has been particularly successful with rust. Secondly, isolates are tested in the glasshouse by the conventional method for pathotype identification. A standard set of differential cultivars is used, supplemented by cultivars of local interest. Screening of germplasm for sources of resistance will follow as soon as suitable pathotypes have been identified.

Large seeded cultivars are generally very susceptible to both rust and angular leaf spot. Some promising new speckled sugar (large seeded) cultivars show improved rust resistance but are susceptible to ALS.

Thus far, the rust resistance genes/gene complexes known as CNC, Mexico 235, B 190 and Ur3 are the most promising. For angular leaf spot, several small seeded cultivars show good resistance, the best to date in South Africa is the carioca bean A 286, released in SA as Mkuzi. Among the large seeded cultivars, CAL 143 shows fairly good resistance. The large seeded cultivar G 5686 and small seeded cultivar Cornell 49242 show better than average resistance. Genes from these two cultivars may be suitable for use in gene stacking.

PERFORMANCE OF ELITE BEAN GERMPLASM IN SOUTHERN AFRICAN REGION IN 1994-95.

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ABSTRACT

Beans (Phaseolus vulgaris) are grown in several countries, representing different ecologies in the Southern African Region. Two regional trials, Southern African Regional Bean Evaluation Nursery (SARBEN) composed of germplasm lines and Southern African Regional Bean Yield Trial composed of finished varieties from different countries were circulated in the 1995-96 season to 8 countries in the region; Tanzania, Malawi, Zambia, Zimbabwe, Mozambique, Namibia, Swaziland and South Africa. Results are reported from all countries except Tanzania, Mozambique and Swaziland where data had not been received. The analyses showed that the location differences were considerably significant ($p < 0.01$) in both SARBEN and SARBYT, which implied that breeders have to select genotypes for different ecologies. The ranking of varieties in SARBEN was so variable from one location to the other suggesting that there is considerable genotype by environment interaction. This was confirmed by the significant genotype by enviroment interaction ($p < 0.01$) in SARBYT. Among the top fifteen yielding lines in SARBEN, were CAL 143 which does well in Malawi and A 197 which is to be released in Zambia. In SARBYT the top yielding variety was Nandi (small seeded, carioca type) which is released in South Africa. It ranked top, in six of ten locations. Amongst the large seeded types, CAL 143, A 197, DRK 57 and KID 31 were in the group of top five varieties.

INTRODUCTION

Beans (*Phaseolus vulgaris* L.) are grown in many countries in the Southern African Development Community (SADC) region. Some countries have well developed national bean research programmes in comparison to others. One of the activities of the regional bean research network is to coordinate bean germplasm exchange in the region through a collaborative regional nursery (SARBEN) and a yield trial (SARBYT). This enables national programmes to have access to germplasm and varieties from other programmes. Different national programmes are free to utilize these germplasm and varieties in their breeding programmes and variety evaluation in preparation for varietal release to farmers. Since ecologies are different, it is expected that genotypes would not show the same rank order for yield in all environments. This has to be taken into consideration by plant breeders who wish to breed high yielding varieties for a wide range of environments (Weber and Wricke, 1990).

MATERIALS AND METHODS

There were two regional trials coordinated by the national program in Malawi:

Southern African Regional Bean Evaluation Nursery, (SARBEN)

This is comprised of breeding materials developed by different national programmes.

The 1994-95 SARBEN consisted of 100 entries contributed by Zambia (3), Zimbabwe (6), South Africa (12), Tanzania (7) and Malawi (71), and each country had to slot in one local check (1). Except Botswana, which does not have the bean growing climate; Lesotho, which does not have any bean scientists left; and Angola, which had civil war, the other nine countries of the SADC region received at least one set of this trial. Several countries received more than one set. They were South Africa (2), Zambia (2), Tanzania (2) and Malawi (4). The main objective is to provide different countries in the region with different bean germplasm at an early stage so that the national programmes can test these germplasm and use promising ones either in their breeding programmes or they can be further tested and released to farmers upon meeting the necessary requirements. This nursery provides a fairly large number of germplasm lines that might contain a few good ones which can be useful to a national programme without putting too much efforts in breeding activities, particularily to those programmes which don't have a well structured breeding programme, or where the technical manpower is limiting. Such trials also provide access to a much wider genetic variability that can increase the chances of selecting suitable genotypes adapted to a particular growing condition or tolerant to a specific production constraint.

The seed quantities of materials included in the SARBEN are usually limited and, therefore, this trial is grown in unreplicated single row plots, 4 m long. Seeds were sown 10 cm apart.

Southern African Regional Bean Yield Trial, (SARBYT)

This is comprised of released or nearly finished varieties which are contributed by different national programmes in the region. It has a limited number of entries. The idea behind this trial is to share among the national programmes the finished breeding lines which, if found appropriate, can be either used directly as varieties or indirectly as parental material to improve the local germplasm. The trial provides a good measure of genotype x environment interaction for pathogen variabilty, general adaptation and yield. These, therefore, are some of the main objectives of carrying out this trial.

This was a replicated yield trial. It contained 15 varieties including a local check. The varieties were contributed by South Africa (5), Tanzania (2), Mozambique (1), Zambia (2), and Malawi (4). The trial was distributed to the same countries as was the SARBEN. The total number of sets distributed were 13. They were received by Malawi (6), Zambia (2), South Africa (2), Tanzania (1), Zimbabwe (1), Mozambique (1), Namibia (1) and Swaziland (1). The field design was a Randomized Complete Block with four replications. The plot size was four rows 4.0 m long. Data were recorded on important diseases and grain yield. At the time of write up of this report, data were received from Malawi (6 locations), South Africa (2), Zimbabwe (1), and Zambia (1).

RESULTS AND DISCUSSION

Southern African Regional Bean Evaluation Nursery (SARBEN)

Data was received from most of the countries, except Tanzania, Mozambique, Swaziland and one location in Zambia. Each country evaluated this nursery in a typical bean growing area, and these nurseries were visited and evaluated by the CIAT bean staff in South Africa, Zambia, Tanzania and Zimbabwe. Data recorded included information on diseases and grain yield. The multilocation data on yield is presented in Table 1.

Since each location had unreplicated set of entries, the locations were used as replications in the analysis of variance. The entry by location interaction mean square was used to test for location and entry differences. Highly significant location effects were observed in the mean yields. These location differences are probably enhanced by differences in disease and drought stresses (Figures 1 and 2). The highest mean yields (1922 kg ha^{-1}) were observed at Kandiyani, where the crop had good moisture throughout the growing season. The next category of environment had a yield range of 1200 to 1400 kg ha^{-1}, covering locations like Delmas (SA), PANNAR (SA), Chitedze (MW) and Bvumbwe (MW). Harare (ZW), Bembeke (MW), Meru (MW) and Msekera (ZA) made a third category of the environment with a yield range of 700 to 1000 kg ha^{-1}. Namibia formed yet another category of environment with a yield level below 200 kg ha^{-1}.

Among the varieties, no single variety could be considered the highest yielder at all the locations, indicating that there might be some variety x location interaction effects (Weber and Wricke, 1990). It was not possible however to test for the variety x location interaction effects because of the design, no replications. Among the top 15 fifteen high yielding varieties, four were from Zimbabwe (all Mesoamerican with I-gene), one from South Africa and the other ten from Malawi. Both CAL 143 and A 197, which have been doing extremely good in Malawi for the past few years, and were used as check entries in this trial, were among the top 15 varieties. CAL 143 was the second highest yielder (1577 kg ha^{-1}). The other interesting entries, except for the Zimbabwe lines; 36/6/10, 36/6/1, 37/6/6, were AND 1028, AFR 654 and AND 1016.

Southern African Regional Bean Yield Trial (SARBYT)

Data were recorded on important diseases and grain yield. At the time of write up of this report, data were received from Malawi (6 locations), South Africa (2), Zimbabwe (1), and Zambia (1). A combined analysis of these data for yield and diseases at each location are presented in Tables 2a and 2b, respectively.

The analyses showed that there were highly significant differences among locations, varieties at each location, and between varieties and locations. The significant differences among varieties and locations indicating a strong genotype x environment interaction. This means that plant breeders wishing to develop high yielding varieties across environments have hard task, but it would be simpler to recommend different varieties for different ecologies. This underscores the importance for both 1) the continued selection activity in the national programmes because no single ecology represents the rest and 2) the need for continued gerplasm network collaboration to provide the national programmes with broad genetic base from where to make selections. The differences among locations were partly caused by pathogenic variability and differences in rainfall and soil fertility at various locations. The mean yields were highest at Kandiyani (1690 kg ha^{-1}) followed closely by Bvumbwe (1657 kg ha^{-1}) and Harare (1609 kg ha^{-1}) due to good soil moisture at these locations. The disease incidence, particularly of ALS, was also low at these two locations, which might have contributed to the higher yields. The yields at Tsangano were very low (477 kg ha^{-1}) due to low soil fertility caused by soil acidity, and high ALS infestation. The yields at Bembeke were also affected due to low soil fertility, paricularly low nitrogen and low P, and high incidence of ALS. The yields at Chitedze and Delmas were low due to drought stress at these locations. From the pooled analysis the following locations can be grouped into similar ecologies based on the location average yield. Kandiyani (MW), Bvumbwe (MW) and Harare form one category with average yield above 1600 kg ha^{-1}. PANNAR (SA) is alone with location mean yield around 1500 kg ha^{-1}. Delmas (SA), Meru (MW) and Chitedze (MW) form another

TABLE 1: Yield (kg ha^{-1}) response of selected bean varieties in the Southern African Regional Bean Evaluation Nursery (SARBEN) across countries and locations, 1994-95.

Variety	Bembeke	Bvumbwe	Chitedze	Kandiyani	Meru	Pannar	Delmas	Namibia	Harare	Meekera	Mean	Seed size	Seed color
36/6/10	1667	1986	2235	2217	771	2067	2090	135	1517	1213	1590	22.7	Red
CAL 143	2000	1536	2530	2164	1354	1700	2083	179	1271	950	1577	36.9	Red Calima
38/6/1	778	2521	2952	1947	1271	1522	1243	190	1705	1063	1519	22.0	Yellow
37/6/6	1000	2434	1974	1375	1104	1567	2007	110	2667	958	1518	20.6	Cream
AND 1028	889	1247	2194	2078	1250	1867	2200	101	1635	1513	1497	44.1	Red
AFR 654	778	1873	2733	3446	896	1389	1033	118	1288	1163	1472	44.8	Red Calima
AND 1016	1444	1129	955	4009	542	1822	3000	265	1028	425	1462	52.2	Red
24/6/10	778	1829	1867	2638	2063	1322	1353	245	632	1492	1422	25.5	Carioca
RIZ 126	2000	1132	1975	3188	458	1900	587	105	1413	1392	1415	40.7	Red
AFR 648	778	1356	2159	3403	1063	1744	1033	72	906	1371	1388	42.7	Red Calima
CAL 149	1111	1054	1332	2733	1063	1567	2267	348	1531	862	1387	49.1	Red Calima
BRB 80	556	2248	2138	2001	854	1689	1237	145	1215	1583	1367	26.9	Red
A 197	778	940	2347	2604	875	1656	1147	574	1427	1250	1360	53.6	Cream Khaki
AND 651	1000	1133	2442	3436	958	1222	1120	177	1104	867	1346	45.2	Red Pompadour
PC-490-21	1222	1666	1779	2470	1271	1256	1603	171	1687	250	1338	30.5	Cream
MORE-90-026	1333	1869	582	1769	1937	1656	1587	343	653	1317	1305	30.2	Cream pinto
A 197	1333	1010	1470	1841	854	1622	1533	451	1240	1692	1305	53.6	Cream
LRK 31	1333	850	3537	1929	271	1489	1423	71	1233	850	1299	47.6	Pink
SUG 116	222	2467	1416	2269	625	1622	1153	236	1847	1046	1290	34.6	Cream
6/6/9	1556	962	1825	2139	1313	1456	1647	27	1472	446	1284	20.7	Brown
38/6/5	1111	2038	1243	2504	1917	1144	1173	98	615	833	1268	18.6	Carioca
RAA 1	778	1819	1791	2790	937	800	1520	110	1073	1033	1265	44.2	Red
CAL 151	1444	2232	595	3932	688	1244	1070	120	392	842	1256	54.6	Red Calima
DRK 98	556	2100	1502	1958	708	1078	1833	522	1934	333	1252	51.0	Red
SUG 117	333	2251	1436	2094	729	1500	917	74	1549	1562	1245	45.2	Cream
AFR 659	444	2311	2103	2430	812	1133	1003	117	1330	658	1234	39.4	Red Duva
AFR 652	1111	1365	1792	2836	729	1556	1027	132	941	783	1227	52.4	Red Pompadour
CAL 150	1111	1661	1669	2840	583	1311	1243	408	681	696	1220	54.0	Red Calima
SUG 114	556	2310	1120	2295	583	1500	1033	168	1028	1508	1210	36.0	Cream
PC-541-38	1222	1419	1422	1414	1417	2111	1737	257	958	104	1206	47.4	Cream
TM10CRC1	667	2370	1334	1646	604	1567	1163	454	878	1258	1194	49.1	Red
RAD 3	1778	1123	1797	2084	1229	1122	1097	362	740	604	1194	45.2	Red Calima
PC-559-3	1333	1419	1840	1786	1438	1722	1093	187	729	308	1186	39.5	Cream
AFR 658	778	1371	1761	1776	563	1156	1830	157	948	1508	1185	42.5	Red
DRK 92	444	1778	1097	2464	750	1133	1843	17	1500	708	1173	48.8	Red
FOT 17	778	1673	1019	2585	1521	822	1327	261	889	804	1168	41.9	Red Calima
SUG 74	444	1642	1508	2006	917	1900	500	323	1361	1033	1163	43.4	Cream
PC-545-22	1111	1759	2384	1467	896	1711	887	246	653	458	1157	44.3	Cream
DRK 996	1000	587	2086	2585	563	1389	993	0	1667	692	1156	44.0	Red
RAA14	667	2011	870	2134	750	1589	1857	32	917	642	1147	53.6	Red
RAA 13	778	2497	858	2039	729	1222	1317	58	1295	608	1140	30.4	Red Duva
SUG 89	667	2054	1592	1206	604	1456	1757	125	1056	812	1133	40.8	Cream
SUG 73	222	1689	1045	1846	563	1511	920	203	1917	1354	1127	52.4	Cream
SUG 94	444	1951	768	2003	1042	1656	1110	167	1260	700	1110	42.3	Cream
SUG 78	389	2407	967	1943	750	1200	1127	83	1122	1104	1109	43.3	Cream
PC-560-33	1000	1575	1550	1531	708	1956	1290	181	771	513	1107	39.0	Cream
Sinon	444	596	1423	3023	979	1356	1637	212	812	521	1100	44.4	Cream
RAA 4	667	796	1935	3119	417	1222	1083	144	1194	417	1099	42.8	Red
TM1402D1	667	1829	1483	1617	583	1456	1700	11	628	962	1094	31.9	Red
CIFAC 89003	333	1610	1525	2202	625	1333	177	29	2712	342	1089	34.7	Yellow
AFR 661	778	1155	1401	1687	896	1533	1050	30	760	1525	1082	23.2	Red
RWR 951	1000	1075	1955	1642	708	1900	903	113	378	1142	1082	32.3	Red Calima
PC-531-26	1444	1858	1570	1568	521	1122	710	508	1163	242	1071	46.5	Cream

Variety	Bembeke	Bvumbwe	Chitedze	Kandiyani	Meru	Pannar	Delmas	Namibia	Harare	Msekera	Mean	Seed size	Seed Colour
PABL 142	1667	958	910	2233	854	1711	1337	127	469	396	1066	42.1	Purple
DRK 99	556	2876	771	1811	437	944	1150	191	1191	638	1056	49.6	Red
DRK 94	667	1271	892	1714	583	1544	1347	234	892	1338	1048	59.7	Red
CAL 143	889	1712	869	1234	750	1322	1773	99	1010	787	1045	36.9	Red Calima
SUG 100	333	1791	1144	1854	792	1433	493	181	1319	1033	1037	39.6	Cream
SP 2	889	2327	1576	947	708	1656	800	119	757	521	1030	46.0	Red
PC-541-32	889	1312	2318	1057	708	1589	897	179	1205	71	1022	41.7	Cream
AND 1018	889	720	1766	1824	688	1467	827	144	833	1012	1017	47.0	Red
Wartbog	333	1531	1913	2040	875	1022	67	429	854	1092	1016	28.0	Cream
AFR 656	1111	1912	966	2061	313	1456	897	336	667	358	1008	45.6	Red Calima
SP 3	778	793	1086	1014	854	1167	1740	82	1465	983	996	42.7	Purple
RIZ 124	778	642	1151	2056	1188	1633	1343	47	288	829	996	39.7	Red Calima
DRK 96	556	1621	1107	1963	542	1122	1103	164	1163	600	994	51.0	Red Duva
RAA 7	667	601	1604	2686	688	0	1430	189	1215	817	990	38.1	Red
DRK 95	778	1837	395	2036	396	1044	1383	264	1146	600	988	61.2	Red
RAA 8	778	840	875	1772	1250	1233	1460	102	590	925	983	38.4	Red
Limpopo	444	1330	2013	1863	479	967	823	346	688	858	981	39.2	Cream
SUG 92	667	1692	1825	1276	604	911	1030	103	1226	446	978	50.8	Cream
PC-530-7	1000	1890	1182	2027	146	1133	1150	102	628	487	975	36.5	Cream
TM3C5	333	1935	739	1619	583	1578	1307	137	806	421	946	51.3	Red
RWR 1087	556	1045	1258	1016	1083	1022	1433	213	1118	688	943	45.3	Yellow Canario
ZPV 866	1111	1461	1213	1848	479	1411	993	94	174	496	928	22.6	Red
ZPV 865A	1111	819	1182	1293	1396	1222	1360	143	208	483	922	21.3	Red
BRB 40	556	812	2097	1211	313	1078	683	400	955	992	910	42.5	Red Duva
BP4-4	667	285	1015	2441	42	1433	977	178	1000	929	897	45.2	Red
RWR 950	1000	1537	1172	829	750	1244	1563	46	392	379	891	40.4	Purple
Local Control	778	337	198	1404	271	2278	1747	233	906	738	889	53.6	Cream Khaki
Nasaka	278	1565	1646	1222	812	1044	743	266	472	800	885	45.0	Cream
DFA 13	1000	854	1253	1465	667	1011	1450	185	458	471	881	40.2	Red
AFR 655	1000	1641	201	1512	500	1200	1833	110	684	108	879	45.2	Red Calima
KAT 2525	1333	-	292	2035	2667	1211	363	56	108	-	867	29.0	Yellow
DRK 104	778	1075	1113	1538	625	989	1710	328	181	271	861	52.8	Red
RWR 1091	1111	1810	415	773	500	911	1843	89	594	329	848	41.1	Purple
Nasaka	222	826	1303	1873	750	1078	627	307	941	487	841	45.8	Cream
HB1-1	667	281	897	2123	208	1167	1250	433	1035	129	819	27.4	Red Calima
PC-531-21	1000	1254	1399	1143	583	1511	697	142	403	88	802	50.8	Cream
ZPV 482A	667	563	1484	1490	208	1478	907	103	406	683	799	20.3	Red
DRK 60	444	1462	1236	644	729	922	1600	405	104	383	793	63.4	Red Duva
CIFAC 89002	167	1257	617	1805	500	1456	657	59	872	371	776	38.7	Yellow
BRB 20	333	475	1140	1283	500	1467	450	440	1229	429	775	44.1	Red
CIFAC 89001	333	1032	1832	1853	313	1067	550	21	378	271	765	29.6	Yellow
RWR 969	1000	943	1221	857	563	822	723	93	903	429	755	42.4	Purple/yellow
RWR 968	778	1347	358	858	417	1656	773	98	868	358	751	19.4	Carioca
PAN 127	444	1195	1560	711	875	1056	517	173	309	329	717	38.0	Cream
RWR 925	1000	675	650	753	708	1133	1230	70	385	254	686	47.0	Purple/yellow
PABL 226	1222	934	105	1636	458	833	1053	77	316	217	685	43.3	Black
Income 2	778	425	323	830	917	1489	960	13	354	258	635	25.4	Red Calima
Mean	844	1431	1410	1922	795	1367	1224	183	975	745	1090		
Se ±											143.2		
CV%											41		
Sign.											***		

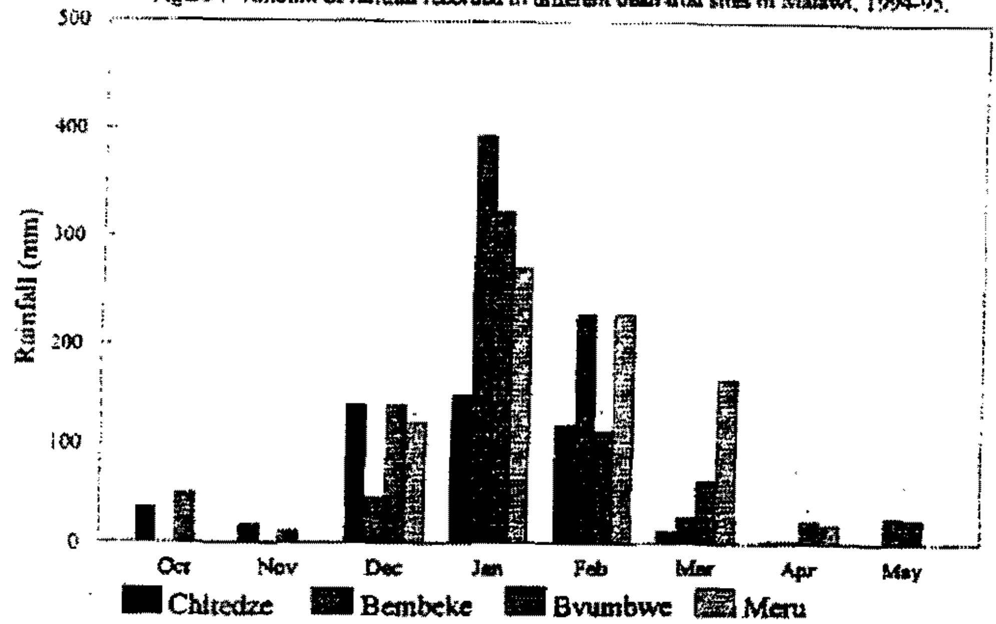
TABLE 2A: Yield (kg ha^{-1}) of selected bean varieties in Southern African Regional Bean Yield Trial (SARBYT) across countries and locations, 1994-95.

Variety	Location										Mean Yield	Seed	
	Bembeke	Bvumbwe	Chitedze	Kandiani	Tsangano	Meru	Delmas	Pannar	Msekera	Zimbabwe		Size	Color
Nandi	1037	3205	1431	2325	490	1991	1976	2180	1244	1477	1736	23.3	Carioca
KID 31	625	1883	1393	2104	554	1038	1083	1719	1116	1894	1341	46.7	Red
Wartbug	687	2325	1300	1846	432	1178	1338	1550	1241	1361	1326	29.0	Sugar
CAL 143	1087	1977	1312	2044	687	1511	672	1256	906	1761	1321	36.9	Red Calima
DRK 57	800	1620	1063	1865	415	1283	1142	1585	814	2031	1262	42.7	Red
A 197	662	1541	712	2274	369	1159	1307	1293	1113	1847	1228	53.6	Cream
Enseleni	687	1521	1315	1292	362	1821	1336	1472	1151	1237	1219	31.8	Sugar
CAL 113	762	1477	801	2005	634	1034	1285	1613	858	1662	1213	42.1	Red Calima
Local	675	1732	792	1527	350	970	1577	1543	1101	1337	1160	44.6	Cream
PVA 773	712	1009	1015	1680	465	1228	992	1446	762	1928	1124	43.4	Red Calima
TB 79/467	737	1626	1340	1744	565	768	699	1240	803	1650	1117	36.5	Pink
Lyamungu90	375	1144	1520	1230	449	1157	1196	1548	701	1735	1105	55.2	Red Calima
Limpopo	675	1375	1124	1418	581	793	1110	1252	993	1514	1084	35.8	Sugar
ZPV 292	875	956	765	1432	412	465	964	1127	1065	1882	994	30.7	Purple
PAN 127	637	1471	431	567	395	909	1201	1331	330	821	809	35.7	Sugar
Mean	775	1657	1087	1690	477	1154	1192	1477	947	1609	1203		
Se ± Loc											70.7		
Se ± Var	130.5	265.4	180.4	183.5	100.7	212.4	170.1	146.5	104.2	130.5	52.8		
Se ± L x V											167.0		
CV%	25	32	33	19	42	36	28	20	22	16	27		
Sign.:Var		**	**	**	ns	**	**	**	**	**	**		
:Loc											**		
:LxV											**		

TABLE 2B: Disease reaction of entries included in the Southern African Regional Bean Yield Trial (SARBYT) across countries and locations, 1994-95.

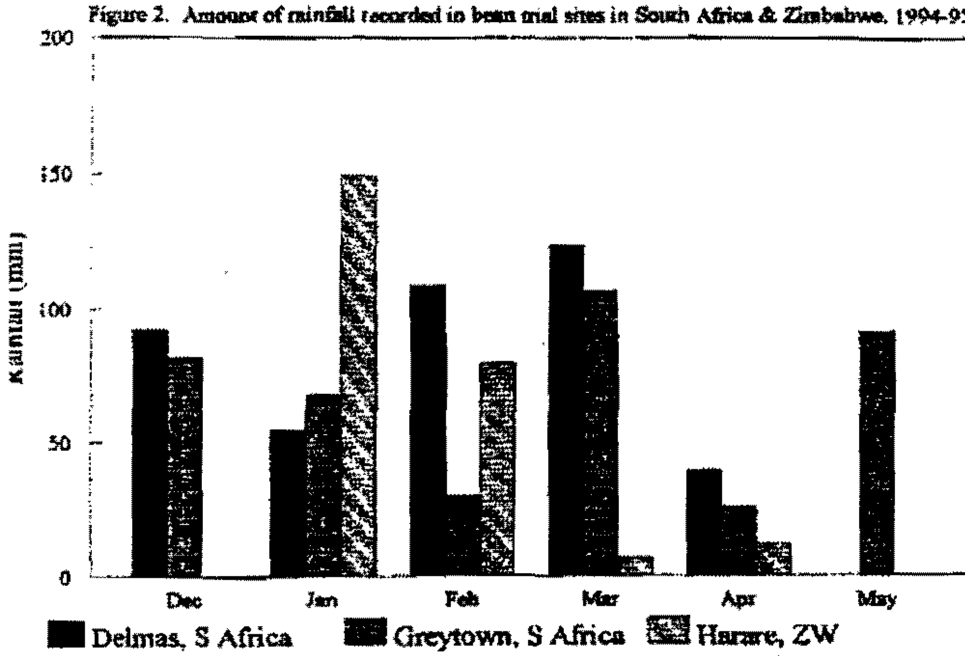
Variety	Bembeke			Bvumbwe		Chitedze			Meru			Tsangano			Delmas			Msekera	
	ALS	CBB	BCMV	ALS	CBB	ALS	CBB	BCMV	ALS	CBB	BCMV	ALS	CBB	BCMV	CBB	HB	RUST	CBB	BCMV
Limpopo	7	3	1	3	5	1	5	1	1	5	1	6	2	1	2	3	1	2	1
Wartburg	7	3	1	3	6	1	6	2	2	6	1	6	3	1	3	3	1	2	2
PAN 127	7	3	1	2	4	1	3	1	4	5	1	5	3	2	3	3	1	1	2
Enseleni	6	2	2	4	7	1	6	3	1	7	1	5	2	1	3	3	1	2	2
Nandi	4	4	4	1	5	1	3	1	1	4	1	5	3	2	3	3	1	2	1
TB 79/467	3	2	2	3	5	1	7	1	1	5	1	3	2	2	3	3	1	1	1
Lyamungu 90	4	2	1	3	5	1	5	2	1	6	1	5	4	2	3	3	1	1	1
PVA 773	5	3	2	5	5	1	3	2	1	4	1	6	2	1	3	3	1	1	1
ZPV 292	4	2	2	7	5	1	6	1	1	6	1	6	2	1	4	3	1	3	2
A 197	6	3	1	3	5	1	3	1	1	4	1	6	2	2	2	3	1	1	1
CAL 143	2	2	1	2	4	1	3	1	1	5	1	4	4	1	3	3	1	1	1
DRK 57	5	3	2	1	5	1	3	1	1	4	1	6	3	1	2	3	1	1	1
CAL 113	5	3	2	4	5	1	4	2	1	5	1	3	3	1	3	3	1	2	1
KID 31	4	2	1	5	6	1	6	1	1	6	1	4	3	1	3	4	1	2	1
Control	6	2	2	5	6	1	6	4	1	6	3	5	3	1	2	3	1	2	1
Mean	5	3	2	4	6	1	5	2	1	6	1	5	3	2	3	3	1	2	1.5
Se ± Var	0.5	0.8	0.7	0.4	0.7	0.1	0.4	0.5	0.4	0.3	0.3	0.7	0.3	0.9	0.3	0.2	0.1	0.4	0.2
CV%	19	53	66	22	23	21	17	55	54	12	45	27	54	55	18	16	25	42	37
Sign.: Var	**	ns	ns	**	ns	ns	**	**	**	**	**	ns	ns	ns	**	ns	ns	ns	ns

Figure 1. Amount of rainfall recorded in different bean trial sites in Malawi, 1994-95.



Note: Planting dates: Chitedze - 3 Jan 1995, Bembeke - 12 Dec 1994, Bvumbwe - 13 Dec 1994 and Meru - 3 Jan 1995.

Figure 2. Amount of rainfall recorded in bean trial sites in South Africa & Zimbabwe, 1994-95.



Note: Planting dates for Delmas - 13 Dec 1994, Greytown - 24 Jan 1995 and Harare - 10 Jan 1995.

category with mean yield from 1100 to 1200 kg ha^{-1}. Msekera and Bembeke form another category with mean yield ranging from 800 to 1000 kg ha^{-1}. Lastly Tsangano is on its own with mean location yield less than 500 kg ha^{-1}.

Among the varieties, the top yielding line across locations was Nandi (1736 kg ha^{-1}). It had a signifcantly higher mean yield than Nasaka (local control), $p < 0.001$. It was the highest yielder at six of the ten locations. It belongs to the Mesoamerican gene pool and the seed is of Carioca type, which even though high yielding, is less preferred by the small scale farmers in many countries. After Nandi, a large number of varieties had a similar mean yield (1213-1347 kg ha^{-1}). This group contained some of the well known varieties like Wartburg, CAL 143, DRK 57, A 197 and a new entry KID 31, and they all belonged to the Andean gene pool. CAL 143 was also one of the highest yielding varieties in the 1993-94 regional trial, and possesses resistance to several major diseases including ALS, HB, and PM. DRK 57, a red kidney bean, also did extremely well in the ABYT in Malawi. In addition to its good seed characters, it has a plant type (2a), which is suitable for intercropping with maize. Such a farming system is quite common in the region, and if accepted, this variety can become very popular with those farmers who intercrop their beans with maize.

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Q: Prof Giga

With the prevalence of drought in recent years, how valid are the yield data?

A: R Chirwa

The yield data in drought years may not be representative for normal years. Nevertheless yield under drought is valid under drought conditions. Breeders can make breakthroughs in drought years to identify cultivars which are drought tolerant by coincidence.

CS Madata

Comment:

We plant the promising material late to see whether they can tolerate drought.

Q: LM Butler

Could you tell us why some of the regional data was not returned? We need to understand the constraints to regional germplasm exchange?

A: R Chirwa

Some national programmes had constraints in processing the data; Tanzania for example they just brought in the data. Mozambique has just harvested the beans, because they planted the crop under winter. I agree we need to know these constraints, and I believe that will be discussed in the Steering Committee.

INTRODUCING NEW BEAN VARIETIES INTO THE LOCAL FARMING SYSTEM ON THE NIASSA PLATEAU, MOZAMBIQUE.

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ABSTRACT

Common beans (Phaseolus vulgaris) are an important component of the local cropping system on the Niassa Plateau in Northern Mozambique. A survey was undertaken, starting in 1989, to collect the local varieties of beans used by farmers and to evaluate their characteristics. The objective of the work was to determine the type of beans the farmers preferred and to orientate research efforts to selecting the preferred types. Twenty five local varieties were identified and characterized. Starting in 1990 a series of trials was started to evaluate new and introduced bean lines in comparison with the local varieties. Most of the new material was introduced through CIAT nurseries including two AFBYANs, three IBYANs 1990 and BALSIT 1989-90. Other material was obtained from the national germplasm bank (also obtained from CIAT in the main part) and included in local ongoing varietal evaluation trials for beans of type 1 and type 2 growth habit. Promising lines from these preliminary trials are undergoing evaluation in an advanced variety trial. The best varieties are being evaluated in trials using the local intercropping system and being multiplied for testing and demonstrating in farmers fields. So far one exotic variety, Ikinimba, has been tested in farmers fields in two seasons with positive results when compared with farmers' own varieties. A programme is being planned to multiply released varieties in farmers fields in the coming seasons.

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INTRODUCTION

Common beans (*Phaseolus vulgaris* L.) are an important component of the local cropping system on the Niassa Plateau in northern Mozambique. The main cropping system is a maize-beans-Irish potato intercrop sown on ridges in the principal (rainy) season and in humid valley bottoms during the dry season. In fact there are three principal bean growing seasons; the first sown on the main farm (machamba) in December in intercrop with maize (and potatoes), the second also sown on the main farm in March in relay crop with maize, and the third sown in August in humid valley bottoms (baixas) which may or may not be intercropped with maize.

Beans are used for their green leaves (plucked 20-25 days after emergence (dae)), green pods and seeds as well as dry grain. Beans are also an important source of income for farmers being sold in the market.

There are various abiotic and biotic constraints to bean production on the plateau depending on the growing season. Apart from soil fertility, in itself an important limiting factor for bean production, other physical factors include excess of humidity in the first growing season (from December and especially in January and February), moisture stress at the end of the second growing season (from April onwards) and problems with water management in the third season (July to November). There is a series of biotic factors that limit bean production including foliar diseases and insect pests. The most important foliar diseases are angular leaf spot (*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*), root rots (including *Rhizoctonia solani*, *Fusarium* spp., *Pythium* spp. and *Sclerotium rolfsii*) and rust (*Uromyces appendiculatus*). Important insect pests include bean stem maggot (*Ophiomyia spencerella*) and foliage beetles (*Ootheca* spp. and *Luperodes quaternus*). It appears that there is an interaction between bean stem maggot attack and root rot infestation.

In 1989 a programme was started to increase and improve research on common beans at the Lichinga Research Station with the general aim of increasing production of beans in the local cropping system. The programme included the collection and evaluation of local bean varieties being grown by farmers, a preliminary evaluation of soil fertility problems, a study of bean stem maggot as one of the major constraints to production, and the evaluation of new varieties for use in the local cropping system. This paper aims to give a general outline of the methods and results of the work undertaken to evaluate new varieties for the local cropping system.

The objective of this work was to evaluate new lines and varieties in comparison with local varieties. The promising material identified was to be used either for multiplication and release or for inclusion in future breeding programmes to improve local varieties. One of the main aims of the programme was to identify varieties resistant or tolerant to the most serious foliar diseases on the plateau.

METHODS

Only a brief description of the objectives and methods of the various components of the work undertaken are included here to give an idea of the programme rather than a detailed account.

Collection of Local Varieties

In 1989 a collection of local varieties was made in and around Lichinga with the objective of identifying the type of common beans being grown on the plateau and to establish a germplasm bank of local varieties at the Lichinga Research Station.

Small quantities of beans were purchased directly from farmers after the harvest of the second bean season. At the same time basic information was requested about the varieties such as the local name, the characteristics of the variety (growth habit, taste, etc.) as well as information as to how the farmer obtained the seed and for how long the variety had been cultivated on their farm. Later a more formal inquiry was made to try and determine the type of beans preferred and the uses for the various local varieties collected.

Evaluation of New Material

Starting in 1990 a series of trials was initiated to identify new and promising material for the agro-climatical conditions on the plateau. The material selected for evaluation was chosen on the basis of the information gathered in the collection of the local varieties.

Most of the new material was introduced through CIAT nurseries including AFBYAN 11-88-19, IBYAN 1990- Grande Roseado- Red Kidney, IBYAN 1990- Grande Roseado- Andino, IBYAN 1990- Grande Moteado- Andino and BALSIT 1989- 20. Recently (1994), a new nursery was grown, AFBYAN 111-93-25, to evaluate additional varieties. The trials were implemented based on advice given in the field books supplied by CIAT, and the methods used for data collection were those recommended by CIAT. In general the trials were sown in monoculture, but on ridges, in the second bean growing season which is usually the best season for bean production. Normally the trials received the local fertilizer recommendation of 45 kg/ha of nitrogen (N) as a top dressing 18 dae and an insecticide treatment against bean stem maggot as a foliar spray 5 dae (cipermethrin 20% EC at 1 ml/lt).

In addition two preliminary trials were initiated at the research station containing varieties from the national germplasm bank. The trials, Ensaio 1 and Ensaio 2, contained varieties of growth habit 1 and growth habit 2 respectively as well as many of the local varieties. In general each trial contained 25 varieties in a triple lattice (5x5) design and was sown on ridges in the second bean growing season. The trials received a top dressing of N 18 dae at the rate of 45 kg/ha with either urea or ammonium sulphate as well as insecticide treatment against bean stem maggot 5 dae (cipermethrin 20% EC at 1 ml/lt). The methods used for data collection were those recommended by CIAT for their nurseries.

Advanced Variety Trials and Seed Multiplication

In 1992 the best varieties were entered in an advanced variety trial, Ensaio 3, which also contained three local checks. The design of the trial was also a triple lattice with 25 varieties. The best varieties in this trial are intended for multiplication of pre-basic seed on the research station as well as evaluation in the local cropping system "on station" and "on farm" for selection of the best performers. Basic seed of the selected varieties will be produced on the research station and later released to local farmers for multiplication in a programme coordinated with the local extension services. The farmers are expected to keep some of the seed but sell or swap any excess production.

On-Farm Trials

A pilot scheme has already been implemented in coordination with extensionists to evaluate the performance of one promising variety Ikinimba in on-farm trials in two seasons. The objective was to establish a methodology for on-farm bean trials and to begin to get feedback from the farmers on the new varieties as well as other bean production problems. In two seasons simple trials were marked out in 12-15 farmers fields in three different villages in Lichinga District. The plots consisted of three separate plots in one of which was sown Ikinimba. In the first year the second plot contained a high yielding local variety selected in the research station, Adija, and the third a local variety of the farmers choice. In the second year first season the two remaining plots contained the varieties Encarnado and Dudusi and in the second growing season Encarnado and Manteiga, both popular local varieties.

SUMMARY AND DISCUSSION OF RESULTS

Collection of Local Varieties.

Initially 18 local varieties were collected, the majority with names in the local language Yão, and within these varieties it was possible to distinguish another seven distinct lines. Most of the varieties had medium to large grain size (> 35 g/100 seeds) and were round or kidney shaped. In fact in a more formal inquiry 85.1% and 84.8% of the farmers families expressed preference for these characteristics respectively. Seed colour varies greatly and there is no apparent overall preference although farmers families expressed most preference for red, cream and white monochrome seed types. These preferences seem to be based more on experience with the varieties than in a preference for the colour in itself. Field observations indicated that the majority of the varieties had an erect determinate or semi-determinate growth habit (type 1 or 2 growth habit according to CIAT descriptions) and that the length of the cycle from sowing to harvest was about three months (90 days).

The formal inquiry revealed that there are different preferences for the utilization of different local varieties, with for example Manteiga (cream) being preferred for commercialization and Encarnado (red) for cooking as it doesn't need oil to bring out the taste.

These observations indicate that the preferred varieties would have an erect determinate or semi-determinate growth habit with large seeds and possibly a monochrome colouring. Shorter cycles are preferred in order to give more flexibility in sowing two bean crops in the single rainy season.

Evaluation of New Material

The CIAT (AFBYAN, IBYAN, BALSIT) trials to evaluate new material were installed in 1990 and 1991. The most promising lines were incorporated into the local trials Ensaio 1 and Ensaio 2. The high yielding lines were also incorporated into the advanced variety trial Ensaio 3. A large amount of data has been generated from these trials that has been returned to CIAT and the national programme for detailed evaluation. At the local level the results have been evaluated in terms of the adaption of the varieties to local agro-ecological conditions while at the same time taking the farmers preferences into account.

The results of the two local preliminary trials are summarized in tables 1 and 2. The varieties are ranked according to average yield over all the seasons. The number of seasons in the trial are shown together with a subjective indication as to the suitability of the variety in terms of yield (stability as well as quantity of grain), disease and pest resistance, grain size, grain colour, growth habit and length of growth cycle. The varieties that were only evaluated in one or two seasons and then discarded are not shown.

In Ensaio 1 three varieties stand out as promising to be included as advanced varieties and for initiation of seed multiplication; PVA 773, AND 628 and ICA Lin 64. In addition other varieties appear promising for more evaluation as advanced varieties including Dicol Calima, AFR 300 and BAT 1387. Two varieties seem promising for inclusion in future improvement programmes as resistant or tolerant to foliar diseases; ICA Pejão and CAL 3. The local varieties Encarnado and Amina performed well and could be expected to benefit from a simple selection programme.

In Ensaio 2 four varieties are promising for inclusion as advanced lines and for initiation of seed multiplication; Ikinimba, INIA 10, Kilimuyunde and INIA 12. Other varieties appear promising for further evaluation including Bonus and from the point of view of disease resistance including Carioca, AFR 392, ICA Pejão and COS 4. The local varieties Tropa, Nogolo and Mcombesa performed well and should be included in a simple improvement programme by mass selection.

Advanced Variety Trial and Seed Multiplication

The advanced variety trial, Ensaio 3, is summarized in table 3. The most promising varieties for evaluation with farmers appear to be Dicol Calima and AFR 343 and possibly AFR 403 and AFR 451. It is to be noted however that the two local varieties, Encarnado and Manteiga, yield well in comparison to the introduced varieties after selection at the research station. The varieties KID 34 and AFR 528 are promising as sources of disease resistance or tolerance.

Currently the programme is being reorganized to include more of the promising varieties in the advanced trial and to begin producing sufficient seed of the better varieties for farmer evaluation. At the same time more varieties will be obtained for preliminary evaluation in Ensaios 1 and 2.

On-Farm Trials

The variety Ikinimba was chosen to be a part of a pilot scheme to establish the methodology for introducing new varieties to the farmers. The results are summarized in table 4 for four growth season in two years. As yet there are no plans to evaluate the varieties in the third "baixa" season.

The results show that there is a great variation in bean yield depending on season and location. These variations can be put down to the local variation in rainfall, especially in the second season and the timing of sowing in the different locations (fig 1 and fig 2). Also pests and diseases are responsible for the lack of yield in at least one location (Mapaco) where attack by *Ootheca* spp. generally wipes out the crop in the first planting season so that farmers do not usually sow (fig 1 and fig 2).

In general the variety Ikinimba yields better than the other varieties in the trials though this depends on the village and season. The majority of farmers commented on its higher yield potential when compared to the local varieties. It appears that the farmers liked the variety and were not on the whole put off by its unusual colour (black) as this makes an acceptable sauce when cooked. In the first season the variety Adija was strongly rejected even though the farmers recognised it has high yield potential because of it's small seed size and difficulty in cooking.

Apart from actual yield data, these trials have also provided a great deal of related data such as plant sowing density and the importance of taste and cookability to farmers that will be useful in building up a picture of the role of common beans in the local cropping system. They also showed the necessity of trials across a number of seasons and locations because of the great variation in conditions from one season to the next even within locations.

CONCLUSIONS

A programme to introduce new bean varieties into the local cropping system was initiated at the Lichinga Agricultural Research Station in 1989. New bean material was introduced through the CIAT nursery programmes and the national germplasm bank according to results obtained from a survey and characterization of local bean varieties. The work at the research station has been able to identify various types of promising material, from varieties for multiplying and evaluating directly with farmers to possible sources of resistance to foliar diseases for future improvement programmes. Pilot on-farm trials with one promising variety, Ikinimba, have highlighted the great variability between seasons and locations on the plateau and underlined the necessity for testing varieties across a number of locations and seasons. The work also shows the necessity for planning on a long time scale (more than six seasons) to begin to deliver useful varieties to farmers.

MM Liebenberg

Comment:
A very important point has been touched on here. I think it is imperative that we should try and avoid the tendency to divide farmers into two groups, namely those who can afford to apply certain methods and those who cannot. In the process, ecologically sound methods used by poorer farmers can acquire a stigma. The ecology of the area can be seriously affected by the abundant use of pesticides and fungicides, and we should rather encourage the continued use of ecologically sound methods by emerging commercial farmers as well as their adoption by existing commercial farmers.

Q: LM Butler
Please explain how you are training extension agents/farmers to select varieties?

A: G Davies
The research services train extensionists in the principles of seed selection. The research services also provide support to enable them to setup selection plots for beans and implement post-harvest selection methods directly with farmers.

Q: B Liebenberg
Why is there such a difference between trial farmer yields intercropping or poorer management?

A: G Davies
Question originally asked due to unclearness of overhead seeming to indicate yields of 5 000 t/ha which turned.

Q: MET Mmbaga
You said that you five a farmer 1 kg of 2 seed and expect to collect 2 kg. Have you been successful?

A: G Davies
Not with beans in this first season because of low rainfall conditions. We told farmers to keep all seed produced in this season. We have had success with other crops like maize in this respect.

TABLE 1: Summary of characteristics of new varieties in ensaio 1 in 4 seasons (1990- 94).

				Acceptability for local conditions:					
Nº	Variety	Mean Yield (kg/ha)	Nº Seasons	Yield	Resistance/ Tolerance	Grain Size	Grain Colour	Growth Habit	Length Growth Cycle
21	ICA Pejão	575.3	3	*	*			*	
20	CAL 3	556.2	4		*		*	*	
12	**Encarnado**	**492.0**	**3**			*	*	*	*
24	Umvoti	420.8	5					*	*
17	PVA 773	419.5	4	*		*	*	*	*
1	AND 628	418.5	4	*		*	*	*	*
19	Dicol Calima	416.6	5			*	*	*	*
8	ICA Lin 64	415.9	4	*		*	*	*	
2	BAT 1387	396.1	5			*	*	*	*
14	CAL 23	381.5	4			*	*	*	*
6	**Amina**	**373.3**	**4**	*		*	*	*	*
22	Ens 2	356.6	5			*	*	*	*
9	AFR 300	350.8	4	*		*	?	*	*
10	ZAA 83	343.4	4			*	*	*	*
23	**Caone**	**343.2**	**4**				*	*	*
8	AND 634	341.6	4			*	*	*	
11	ICA Lin 66	335.8	4			*	*	*	*
15	ICA Lin 63	330.9	4	*		*	*	*	*
16	PVA 476	330.2	4			*	*	*	*
7	K 20	322.3	4			*	*	*	
25	Ensilene	316.5	4				*	*	*
13	CAL 22	306.6	4			*	*	*	
5	**Manteiga**	**276.1**	**4**			*	*	*	*
3	**Dotolo**	**267.9**	**5**			*	*	*	*
26	**Enc Raiado**	**150.0**	**3**			*	*	*	*

Local varieties in **bold**.

TABLE 2: **Summary of characteristics of new varieties in ensaio 2 in 5 seasons (1990- 95).**

Nº	Variety	Mean Yield (kg/ha)	Nº Seasons	Acceptability for local conditions: Yield	Resistance/ Tolerance	Grain Size	Grain Colour	Growth Habit	Length Growth Cycle
5	Ikinimba	548.2	5	*	*	*		*	*
22	INIA 10	496.2	5	*		*	*	*	*
11	AFR 392	450.4	4	*	*		?	*	
13	Kilimuyunde	425.5	5	*		*	*	*	*
16	Carioca	420.0	5	*	*			*	
20	INIA 12	414.6	5	*		*	*	*	*
12	**Tropa**	**390.8**	**5**	*		*		*	*
1	Bonus	373.0	6			*	*	*	
7	ICA Pejão	369.3	4	*	*			*	*
6	**Nogolo**	**352.3**	**5**	*				*	*
21	**Mcombesa**	**340.6**	**5**			*		*	*
8	**Manteiga**	**336.9**	**5**			*	*	*	*
18	Ens 1	321.5	5			*	*	*	*
17	**Encarnado**	**311.6**	**5**			*	*	*	*
15	COS 4	311.1	6		*		*	*	
3	INIA 23	294.2	5			*	*	*	*
9	Kanzama	286.2	6			*	*	*	
25	INIA 7	273.4	5			*	*	*	*
14	Manteiga sem 1	265.8	4			*	*	*	*
4	**Achukua**	**255.5**	**5**			*	*	*	*
24	INIA 104	245.2	4			*	*	*	*
2	**Kanthesa**	**227.4**	**4**			*		*	*
10	INIA 83 cl	207.9	4			*	*	*	*
19	INIA 83 esc	169.0	3			*	*	*	*
23	ZAA 16	123.5	3				?	*	*

Local varieties in **bold**.

TABLE 3: Summary of characteristics of advanced varieties in ensaio 3 in 4 seasons (1992- 95).

Nº	Variety	Mean Yield (kg/ha)	Nº Seasons	Acceptability for local conditions: Yield	Resistance/ Tolerance	Grain Size	Grain Colour	Growth Habit	Length Growth Cycle
22	AFR 528	489.1	3		*	*	?	?	
9	KID 34	483.0	4	*	*	*	?	?	*
13	Bayo Titan	424.7	3			*	?	?	*
15	AFR 403	393.5	4	*		*	*	*	
19	AFR 451	385.1	4	*		*	?	?	*
2	**Manteiga**	**380.8**	**4**	*		*	*	*	*
4	Dicol Calima	377.5	4	*		*	*	*	*
24	AND 761	363.8	4	*		*	?	?	
5	**Encarnado**	**360.8**	**4**	*		*	*	*	*
17	AND 732	352.7	4	*		*		*	*
21	AFR 334	344.0	4	*		*	?	?	
10	LRK 19	320.6	4			*	?	?	*
18	AFR 524	317.6	4			*	?	?	*
14	AFR 343	311.9	4			*	?	?	*
20	AFR 538	307.3	4				?	?	
12	LRK 13	305.8	4			*	?	?	
16	AFR 245	303.9	4				*	*	*
8	LRK 18	269.2	4			*	?	?	*
7	LRK 11	269.1	4			*	?	?	*
6	LRK 12	267.0	4			*	?	?	*
3	ENS 2	266.2	4			*	*	*	*
1	**Enc Raiado**	**251.8**	**4**			*	*	*	*
23	AND 661	250.8	4			*	?	?	*
11	PVA 111	219.8	4			*	?	?	*
25	Mecostado	203.0	4			*	?	?	*

Local varieties in **bold**.

TABLE 4: **Results of on farm trials in four growing seasons in two years, 1993- 95.**

a) 1993- 94.

First season.

Variety	Ikinimba	no [+]	Adija	no	Local	no
Cycle (sow- har, days)	98.3	6	98.3	6	98.3	6
Cycle (em- flor, days)	37.4	9	36.9	9	36.9	9
Plants/ha sown (est)	61911	7	60793	7	60940	6
Plants/ha harvested		0		0		0
% Plant loss		0		0		0
Yield (kg/ha)	107.2a	13	121.7a	13	74.4a	11

($LSD_{.05}$ = 61.5. C.V. = 75.8%)

Second season.

Cycle (sow- har, days)	93.8	12	93.8	12	93.8	11
Cycle (em- flor, days)	35.0	13	35.0	13	35.0	13
Plants/ha sown (est)	187496	12	186222	12	191377	11
Plants/ha harvested	112906	12	122850	12	110100	10
% Plant loss	39.0	12	31.2	12	36.3	10
Yield (kg/ha)	272.2a	12	207.1b	12	175.9b	9

($LSD_{.05}$ = 45.0, c.v. = 24.6%)

b) 1994- 95.

First season.

Variety	Ikinimba	no [+]	Encarnado	no	Dudusi	no
Cycle (sow- har, days)	92.8	4	92.8	4	92.8	4
Cycle (em- flor, days)	28.0	2	28.0	2	28.0	2
Plants/ha sown (est)	61400	3	61400	3	61400	3
Plants/ha harvested	66446	4	48643	4	53282	4
% Plant loss	1.8	3	42.6	3	19.4	3
Yield (kg/ha)	278.9	4	200.7	4	182.5	4

Second season.

Variety	Ikinimba		Encarnado		Manteiga	
Cycle (sow- har, days)	92.5	15	92.5	15	92.5	15
Cycle (em- flor, days)	31.0	4	31.0	4	31.0	4
Plants/ha sown (est)	152437	16	152616	16	153006	16
Plants/ha harvested	87783	15	117577	15	111361	15
% Plant loss	44.7	15	22.7	15	28.8	15
Yield (kg/ha)	130.7a	15	135.2a	15	102.2a	15

($LSD_{.05}$ = 33.2
c.v. = 36.2%)

[+] no- number of farmers contributing to the data.

Figure 2: Results for on farm bean trials, 1993- 94.

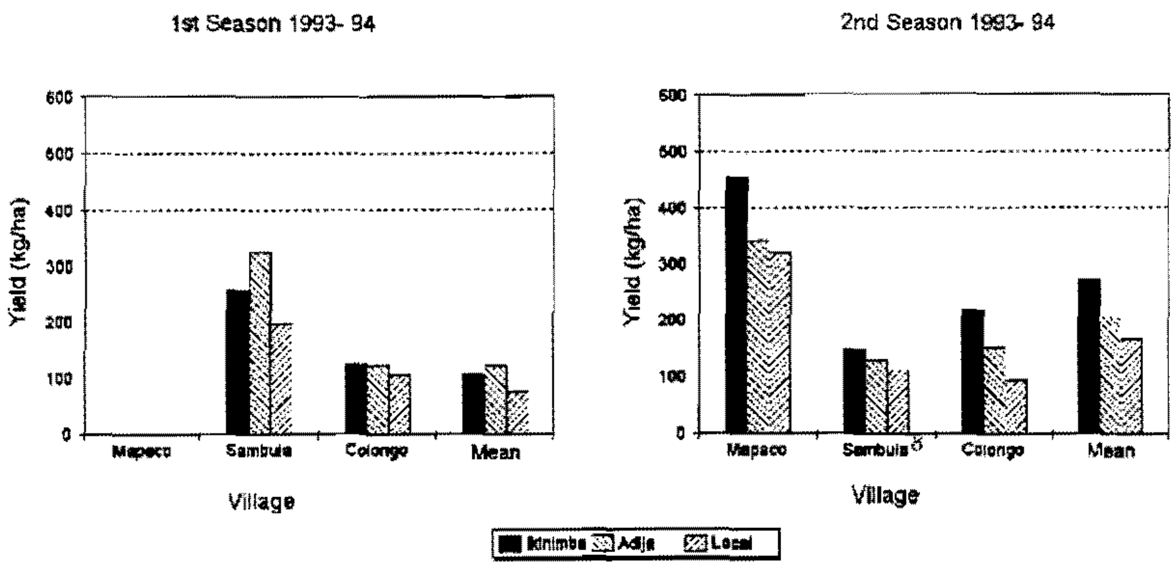
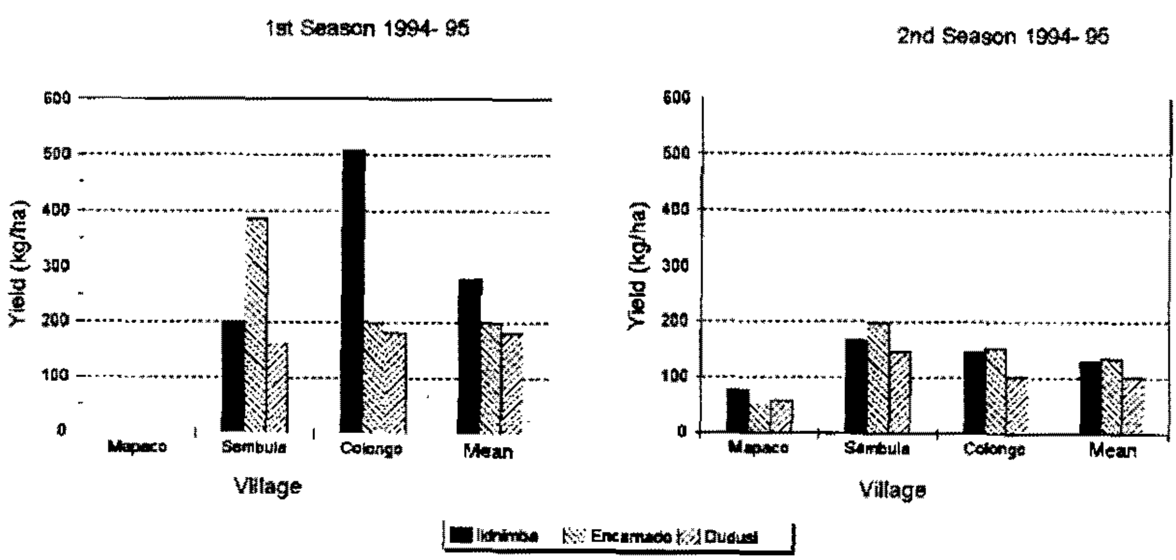


Figure 3: Results of on farm trials, 1994- 95.



SEED QUALITY: ISSUES IN SMALL SCALE FARMER BEAN PRODUCTION

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ABSTRACT

Bean Production in Africa is estimated to cover about 3,7 million hectares per year, with annual seed requirements of approximately 350000 metric tons. The predominant sources of seed are farmers' own seed and purchases from markets and/or shops. Certified seed is rarely used in major bean growing countries of Eastern and Central Africa, due to its unavailability or lack of production because of low demand. Demand is however high for new genetic material. Hence much of the bean seed used for planting is produced by small scale farmers under unspecialised seed production systems.

Given the importance of amounts of bean seed "produced" and used by small scale farmers, studies have been conducted in a number of countries to assess its quality with the objective of determining if there is need for its improvement and also to develop appropriate policies for bean seed.

High quality certified seed is expensive to produce and its cost varies between 2 to 6 times the market price for bean grains. Results from a number of countries in Africa Latin America show little or no evidence that centrally produced certified seed is significantly more disease-free than farmers' seed. Similarly, seed produced by formal systems compare well with, and does not result in significant yield improvement over farmers' seed. However, in certain areas, poor post-harvest management can result in insect attack and infestation by saprofitic fungi which may result in quality reduction. Farmers get rid of apparently diseased or poor seed by selection, but "losses" due to such selection is variable and depends on the source of the seed. Use of high seed rates is practiced where farmers doubt the quality of seed. Renewal of seed is rarely due to quality reasons. Seed acquisitions are meant to get new genetic materials or to compensate for insufficient seed stocks. Implications for research and policy interventions are suggested.

THE COOKING QUALITY OF DRY BEANS

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ABSTRACT

A method has been developed to evaluate the cooking quality of various dry bean cultivars and breeding lines. The cooking quality is determined by the hardseededness, water absorption and the texture of the cooked beans. This has been done to assist the dry bean breeder in selecting lines with the best cooking quality for consumer acceptance. The influence of environmental factors on hardseededness and cooking quality is important and must be investigated.

INTRODUCTION

Dry edible beans are an important food crop that provide an inexpensive and good source of protein, vitamins and minerals to the diet.

Cookability can be defined as the cooking time required for beans to reach the cooked texture that is considered acceptable to consumers. Consumers, concerned with convenience in preparation, will reject beans that need extended cooking times. Cookability is a primary quality characteristic of edible dry beans, and factors that influence the cooking times of commercially grown cultivars and of experimental lines need to be investigated.

Texture is a key measure of quality and processed bean texture can be influenced by many factors including

1) variety
2) growing and storage environment
3) soaking and processing conditions

Dry bean cultivars developed for commercial production are evaluated for agronomic performance but must also be systematically assessed for cooking quality.

OBJECTIVE

This study had two main objectives. The first was to compare different cooking times of sugar beans and determine the best cooking time to evaluate quality in an objective manner for routine measurements as a basis for discriminating among test samples. The second was to determine and compare the effects of cultivar and growing location on the cookability of freshly harvested dry beans.

MATERIALS AND METHODS

Soak water content and soak method have shown to significantly alter texture in processed beans. The method used was to soak the beans for 18 hours in tap water at room temperature without any soak additive. Research has demonstrated a firming effect of the final product when calsium is present in soak and /or processing waters (Ubersax, M.A. et al., 1988).

A cold water soak method has been used because a warm soak has shown an increased effect on the calcium absorption and firming of the product (Ubersax, M.A. et al., 1988).

Hardseededness can be divided in at least two types of hardshells in beans, one related to the seed coat's impermeability and the other to cotyledon impermeability. Subsequent studies (Deshpande, S.S. & Cheryan, M., 1986) on intact and decorticated beans showed that the seed coat's contribution to cooking time exceeded that of the cotyledon in the fresh samples. The cotyledon's contribution to cooking time, however, increased with storage. The biochemical changes in protein and starch and enzymic activity of the seed during storage may therefore be critical to the development of the hard-to-cook beans.

The time required for cooking is a function of several factors such as moisture content, extended storage, and high temperature during storage, all of which increase cooking time. Freshly harvested beans stored at 4 °C were used in this study.

All samples were cooked in a waterbath at boiling temperature to compare different cooking times and to determine the best cooking time for discriminating between the cooking quality of different cultivars grown at different localities.

Starch and protein are the major seed components that **absorb moisture** during cooking. The size and shape of beans, surface area, rate of starch gelatinization, and the nature and amounts of non-starch constituents that act as a physical barrier to the swelling of starch granules may all influence the rate of water uptake during cooking of dry beans.
Unlike the water uptake rates during the earlier stages of cooking which were characteristic of a variety, the water uptake of different varieties when cooked for their respective optimal texture are almost the same (Deshpande, S.S. & Cheryan, M., 1986).

Processed bean samples were analysed for **texture** using a Texture Press equipped with a standard multiple blade shear compression cell. Force of shearing and compression action is recorded using a laodcell. The data is registered electronically with the approprite software on a computer. A shearing force in kg and also a compression force as the surface underneath the curve of shearing force in 12 seconds is registered.

EXPERIMENTS, RESULTS AND DISCUSSION

Experiment 1

Experiment's 1 objective was to determine the accuracy of the texture-meter.

An 18 hour soak period with 90 min of cooking of only one cultivar namely Kranskop, produced at Ermelo (with 10 subsamples) was used. The seedcount per 30 g seed, hardseededness, waterabsorption after the 18 hour soaking period, waterabsorption after 90 minutes of cooking and the texture, both shearing force (kg) and compression force (Sum) has been determined.

ANOVA table of 10 subsamples
Locality: Ermelo
Cultivar: Kranskop

Variable	KV
Seedcount / 30 g	3,1%
Hardseededness	4,9 %
Soaking mass (100g dry mass)	1,5%
Cooking mass (Hardseeded seeds removed)	1,5%
Kg (Shearing force)	1,7%
Sum (Compression force)	1,3%

These results indicate that this texture measurement is accurate and objective.

Experiment 2

In a pilot trial, 21 cultivars have been tested on five different localities. All the cultivars with three replicates on each locality were cooked for 60 (2) and 90 (1) minutes and the texture for the different samples has also been determined.

Analyses of variance have been done for al the localities.

The locality and cultivar interactions were highly significant for cooking periods of 60 as well as 90 min. The parameters determined were the same as in Experiment 1 and no correlations between 60 and 90 min cooking time could be found. This may be due to the masking effect of the hard seeds that were not removed.

We therefore decided to remove all hardseeded beans as a standard procedure in the following experiment.

Experiment 3

In a pilot trial the influence of environment on hardseededness of one cultivar on the various parameters have been determined for 16 different samples of Kranskop grown on the three localities Ermelo, Delmas and Cedara.

Cultivar: Kranskop

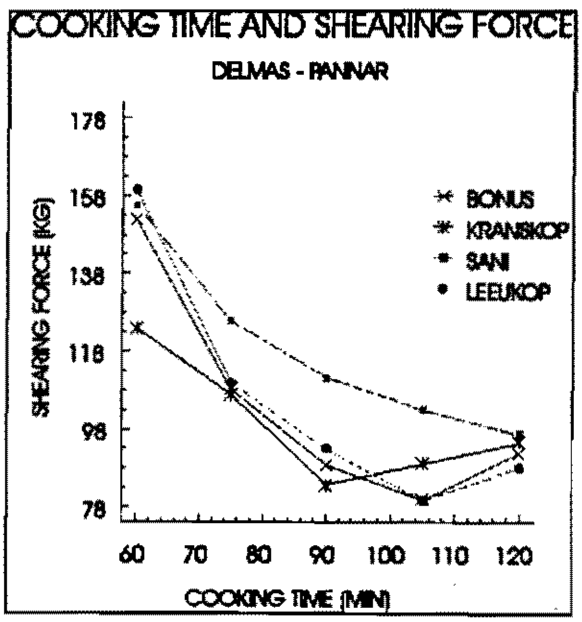
Locality	Hardseededness
Ermelo	47.5
Cedara	26.5
Delmas	1.53

These results indicate that environment has a significant effect on hardseededness.

Experiment 4

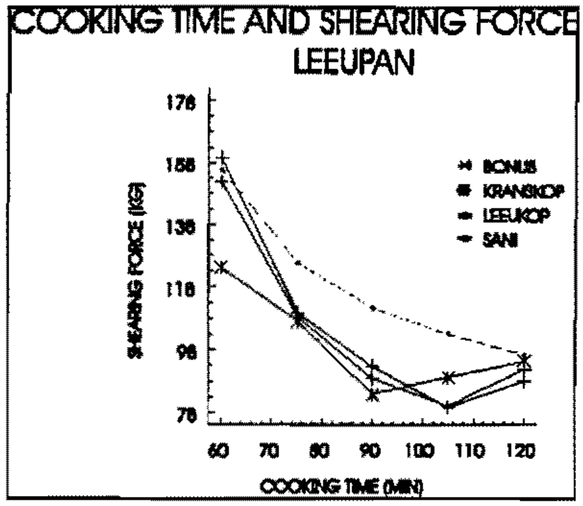
One of the main objectives was to establish the best cooking period for an objective and accurate determination of the cooking quality for the evaluation of the different cultivars and experimental lines. This was also done to determine the effect of the environment on the cooking quality.

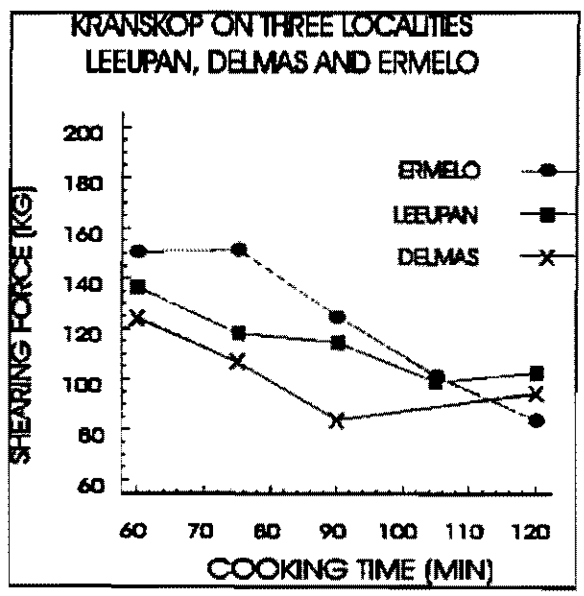
Eight different cultivars from 3 different localities were cooked and texture determinations made after 60, 75, 90, 105 and 120 min for each of these samples.



From these results with only four cultivars from Delmas plotted on this graph it is clear that if cooking time of 120 min is used, it would be difficult to discriminate between these cultivars. Ninety minutes is therefore the best cooking time for discrimination between cultivars.

There is however strong environmental effect as the same cultivars on a different locality show different results. The optimal cooking time and final texture of each cultivar are therefore dependant upon environmental factors which are yet unknown.





Environmental effect could be seen even more clearly if one cultivar namely Kranskop from 3 localities are plotted on the same graph.

CONCLUSION

From these results it can be concluded that an 18 hour soaking method, with the hard seeds removed and a 90 minute cooking time, it is possible to dicriminate between various cultivars. Although the environmental effect must be taken into consideration.

Further research must still be done to determine which factor in the environment is effecting the cooking quality of the different cultivars.

LITERATURE

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KW Pakendorf

Comment:
Refer to experience in India in which seed is germinated for 24-48 hours in order to decrease cooking time . This has the added advantage of decreasing the levels of oligo saccharides and tannins thus in fact increasing the quality. This could be considered in order to popularize bean comsumption in urban environments where little time is available for preparing meals in a conventional way.

RESEARCH EXTENSION-LINKAGES: THE EXPERIENCE OF THE BEAN PROJECT (CRSP) AT SUA

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ABSTRACT

The need for research extension linkages is now obvious but the problems for effective linkages are less well understood. Many of the problems stem from the organizational structures in many countries, which place the research and extension departments in separate ministries which tend to compete for resources and recognition.

Researchers and extensionists in developing countries are very different individuals who are influenced by their varied orientations. These orientations in turn affect the level of interactions between professionals. In order to have a discernable effect on production, research and extension systems must interact closely. The paper describes the experiences of the Bean Project (CRSP) at SUA in establishing linkages between research and extension.

INTRODUCTION

Increased agricultural productivity can be accelerated by three major factors namely the generation of innovative knowledge through research, dissemination of this knowledge through the extension service and the utilization of this knowledge by the end users. The three factors can be termed as the Agricultural knowledge system consisting of subsystems of knowledge generation; knowledge dissemination and knowledge use (Subair 1994). The system will work more effectively if communication between the three subsystems functions. This communication flow should be from research through extension to farmers and vice versa. Bagchee (1994) has also emphasized the importance of good communication between the subsystems in addition to attitudinal reorientation.

In most developing countries the transfer of technology models is still operational, where farmers are treated as recipients of technology, end users, clients and customers. The model operates under the assumption that scientists know or can learn what farmers need and can prepare solutions to these problems using science. This paradigm produces a predominantly one way flow of information through extension to farmers. If this technology is not adopted by farmers there are two assumptions:

1- Extension is not doing its job and 2 - farmers are slow to catch on new technologies. The current paradigm then led to problems of lack of effective linkages among specialized functions in the technology transfer process and the lack of relevance of the technologies, developed under a system based on a predominantly one way flow of information from scientists to farmers (Acker 1992).

We acknowledge that there are difficulties for both researchers and extensionists in strengthening research extension farmer links. These difficulties must be identified and addressed if the links are to be strengthened. The links between research extension are weak for a number of reasons:-

1. The structure of research and extension system is excessively tempered with, one year combined research extension bodies are created, the next they are separated.

2. Training does not link research and extension so people see themselves in very different roles.

3. Competition for scarce resources does not assist cooperation.

- Research publications are written for other researchers not for the people who will put the finding into effect.

- Extensionists and researchers do not cooperate in preparing materials relevant to the village extension worker and the farmer.

- Extensionist have inferiority complex in relation to the higher academically qualified researchers.

- Research and extension managers do not encourage contact and cooperation. Extension personnel are frequently out of touch with research progress. Research stations have generally not had an open door policy which would welcome participation by farmers and extension staff (Kenny, (1991), Acher (1992). According to the World Bank (1985) the principal causes of poor research extension linkages are 1- Organizational separation of research and extension 2 - Educational differences between research and extension officers 3 - Lack of clarification of roles and responsibilities in the technology and transfer process. 4 - Cases where unidirectional knowledge flow prohibits true professional interactions between research and extension 5 - Lack of appreciation for the validity of tasks performed Woods (1985) summarizes factors which affect research - extension linkages into 5 categories namely 1- Organization and management 2 - Education and training 3 - Discipline and background 4 - Human factors and attitudes and 5 - Resources.

Mutimba and Mollel (1990) have classified linkage problems into three categories.

1. Structural problems - where research and extension organizations are a distance from each other.

2. Empire building and protectionism - Where research and extension organizations are situated in urban areas away from farming communities. Initiative to create linkages is often regarded as interference by the other. Each assumes they know what they are doing and that they do not need to be dictated to by the other. The tendency is therefore to build structures that are impenetrable by outsiders.

3. Professional jealousy - Research scientists communicate their results through publications and often papers are written at a level only other scientists can understand. They cannot be understood by the most literate of farmers who are expected to get simplified versions of the same from the extension agents. On the other hand the extension agent also finds difficulty in interpreting the results.

THE NEEDS FOR RESEARCH EXTENSION FARMER LINKAGES

In ensuring stronger links between research and extension closer contact between the creators and users of agricultural knowledge and technology is necessary.

According to Meril Sands and Kaimowitz (1989) strong research, extension farmer linkages help to ensure that:-

- Research tackles users priority problems and needs.
- Farmers and technology transfer workers keep up with research development
- Research results from experiment station are applied to solving farmers problems and expanding their opportunities
- Available technologies are adapted to suit local agro ecological and socio economic conditions.

---- "Researchers can capitalize on users knowledge and obtain feedback on the relevance and performance of technologies. Strong links are not only a matter of efficiency and cost recovery but are also vital for successful technology development and delivery systems.

- Farmers knowledge, inventiveness and experimentation have long been under valued and that farmers and scientists can and should be partners in the real and full sense of that word in the research and extension process" (Rhodes 1989).
- The length of time taken for new agricultural technologies to reach small farmers is reduced.
- The volume of relevant research output being

channelled through the system is increased.
- The quality and quantity of research products to farmers is increased.

MECHANISMS FOR LINKAGES

Ekpere *et al* (1992) have listed mechanisms that will go a long way in strengthening research extension farmer linkages. They include:-

- Farming systems research directed towards small holder agriculture
- Publication of research findings
- Production of leaflets and fact sheets which popularize research findings and recommendations to farmers and extension workers
- Research extension workshops and seminars for extension workers, their supervisors and NGOs
- Field days organized at the institution
- On farm trials (farmers fields)
- Demonstrations
- Regular and informal contacts with donor agencies
- Training courses for prospective extension workers.

It is now becoming increasingly evident that since farmers are the common denominator in the research extension continuum, they ought to serve as the foundation for the linkage between research and extension. Realizing the importance of farmers in the technology development and transfer process the Bean Collaborative Research Support Program (CRSP) at the Sokoine University of Agriculture (SUA) integrated a Farmer Participatory Research component into its breeding program. The Farmer Participatory Research Strategy at SUA is briefly described and the linkage mechanisms in it are highlighted.

FARMER PARTICIPATORY RESEARCH STRATEGY AT SUA

One of the primary objectives of the Washington State University (WSU) - SUA Bean CRSP is to develop a participatory research strategy for increasing the level of small holder farmer participation, including women farmers in variety evaluation and dissemination. In addition to ensuring the acceptance and use of our research findings, scientists will learn more about bean farmers circumstances, their needs and preferences, their constraints and their own adaptive innovations. The Tanzania FPR strategy has been evolving since 1990 and it will continue to change as we learn from farmers, other organizations and from each other. The important elements of the strategy are briefly described below.

IDENTIFICATION OF FARMER BEAN EXPERTS

In the early stages of the program farmer bean experts were identified through an informal rapid survey of two lowland villages in the Morogoro and Kilosa districts. The survey identified men and women farmers with bean growing experience and farmers named most often by others in the community as knowing a lot about beans. A total of 20 bean experts were selected by a team of biological and social scientists including a plant breeder a weed scientist an agronomist and an extension specialist. A female extension agent is also a member of the team. The team collaborated with the village extension agent and village leadership in the identification of the bean experts. Out of the twenty farmers selected sixteen (9 males and 7 females) expressed interest in taking part in the evaluation exercise at SUA site.

This process of farmer bean experts identification have brought together research scientists from the university extension agents from the ministry of agriculture and the farming community. This process facilitates the exchange of knowledge farmers telling researchers their evaluation criteria and selecting beans to evaluate at their own farms. A partnership evolves between researchers, collaborating scientists, farmers and the extension agents.

Research and extension are integrated in this process through inbuilt linkages at village level where village extension agents and farmers are in contact with research scientists and at the district level where an extension agent from the district has been seconded to the bean team.

ON-STATION EVALUATION

Initially the farmer bean experts evaluated 12 improved bean lines at podding and at maturity. The objectives of these evaluations was to identify farmers preference criteria. Farmers rated each variety using a rating form as they walked from plot to plot. The rating ranged from 1 (very poor) to 4 (excellent). Farmers also indicated which three lines they felt were the best and worst and the three they preferred to try at home.

In subsequent years the number of bean lines was increased and the rating form also modified. Farmers did their evaluation at F6 generation.

Recently researchers have also been involved in evaluating beans at the F4 generation. After the evaluation farmers are invited for refreshments and walk through the university to see the different activities taking place. Each bean expert is given a kilogram of a variety of his/her choice to grow in any way he/she likes on his/her farm. The researchers visit farmers in their fields at different stages of growth to determine different cultural practices used by farmers and to see how farmers feel about the variety. In an attempt to reduce costs some of the onstation evaluations are conducted at a Research Station (Ilonga) which is closer to the farmers in terms of distance. The Farming System research team assisted in these evaluations.

Onstation evaluation provides a continuous two way dialogue among different kinds of farmers scientists in different disciplines and extension agents. Farmer to farmer interaction during this process may lead to rejection or adoption of the new varieties. As earlier mentioned this form of communication is important in maintaining and strengthening linkages. Onstation visits also provide an opportunity for the farmers to become aware of the research and development activities of the university and create the desire and interest for further information among farmers. On the other hand researchers at the university will be able to obtain feedback on their work from potential end users.

Farming system research teams are also brought face to face with the farmers and the extension agents.

ON FARM EVALUATION

Farmer managed on farm trials began informally in 1991 following farmers evaluation of promising lines on-station. Farmers Evaluators selected three varieties which they felt would do best on their own farms. Throughout the growing season each farmer is visited twice by a team member. The farmer is asked to compare its agronomic and consumer qualities to those of his or her own varieties. This includes family feedback on cooking time, taste, storability after cooking and colour of broth. Farmers evaluation are documented and analyzed by team members, and findings are verified in farmer group discussions.

Our experience shows that farmers preference criteria are weighted strongly toward number of pods, seed colour, size of seeds and number of seeds per pod. Other plant qualities important to farmers include tolerance to heavy rain, resistance to sun or drought and seed shape. Large, thin and heavy seeds are preferred over smaller seeds and elongated seeds are associated with yield (Lorna *et al* 1994).

On farm farmer managed trials are the norm for validating on station research as well as for satisfying the relevance criteria for research. Farmers near trial sites tend to provide the feedback needed by researchers. Also helps to reduce the reluctance of extension agents on promoting research results to small holder farmers - unless they are first convinced that the results of such recommendations are achievable under local conditions (Ekpere *et al* 1992).

If the on farm farmer managed trials are well managed and evaluated for their impact they have the most potential for encouraging sustained and effective research farmer extension linkages.

TEAM CONSENSUS ON QUALITIES AND VARIETIES

At the end, the onstation and onfarm testing data was analyzed to determine farmers preference criteria. Researchers called farmers onstation or visited them in their fields to provide the feedback. The feedback is provided through group discussion at which researchers inform farmers about their evaluation criteria. The aim of the meetings is to come to a group consensus about the most important selection criteria and about the lines that are most preferred. These meetings serve several objectives.

1. Farmers, extension agents and researchers may agree on criteria for evaluating bean varieties

2. Farmers, extension agents and researchers may provide breeders with information to be incorporated into the breeding program to breed varieties that are accepted by farmers and consumers.

3. Farmers, extension agents and researchers may come to a consensus on varieties to be released and those that will be struck out of the breeding program due to undesirable characteristics. Some varieties may need improvements. Farmer bean experts were instrumental in convincing the Variety Release Committee to release SUA 90 bean variety and their evaluations had significant impact on the probable release of the next two varieties.

To complement the 4 steps of the FPR strategy two workshops have been held for researchers and extension agents who are involved in Participatory research to improve their interview techniques, documentation and data analysis skills. A workshop on Farmer Participatory Research was also organized in Arusha Tanzania by CIAT and the Bean CRSP to improve the skills of both researchers and extensionists. Participants to the CIAT workshop were drawn from the SADCC region. Workshops enable researchers and extensionists to interact and integrate their knowledge and skills.

The Bean research workshops which involve bean researchers from within and outside the country have been an annual event for more than ten years now. Through these workshops scientists share their research results which are also published. The extension agents are also invited to these workshops. These workshops provide an important linkage mechanisms with other researchers extension agents and sometime to farmers.

Farmers groups and NGOs have recently been our collaborating partners in the Participatory Research approach. A group of women were given seeds of two promising lines to plant in their farm. A follow up was made to determine the performance of these lines. An extension agent working under an NGO also assists in advising the women group. Farmer groups provide a good mechanism for the dissemination of seeds. The farmer group may be an important link that would help to unite the farmers and the researchers through development activities.

UNEXPLORED LINKAGE MECHANISMS

A study on adoption of SUA 90 conducted by an undergraduate student identified two factors limiting the adoption of the SUA 90. These included lack of demonstrations and limited information on agronomic aspects of the variety.

Demonstrations - Demonstrations of agronomic practices for SUA 90 in the villages would give farmers an incentive to adopt the variety. These demonstrations would be supervised by an extension agent and may act as a site for teaching farmers new technology.

Leaflets - These would provide specific information on major agronomic requirements of SUA 90, pest and disease control and storage.

These are useful linkage mechanisms for sustaining the interest of extension workers and farmers in research results, technologies and recommendations developed through research. These can be distributed during field days or during workshops.

CONCLUSION

The Bean project at SUA was initially focused on research and training. When breeders produced bean varieties the project was faced with a dilemma of how to disseminate the bean varieties. Two options were available: Create own extension system or use the existing extension system. Working through the existing extension system was more practical to the bean project. However the extension system of the ministry of agriculture is top down in its orientation and does not give farmers and extension agents an opportunity to participate in the technology development and transfer process. A Farmer Participatory Research Program was initiated at SUA to enable the project to develop varieties that meet farmers needs and ensure that varieties reach as many farmers as possible. FPR contains important linkage mechanism that provide feed back to the three agricultural subsystems.

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THE PERFORMANCE OF ADVANCED AND ELITE BEAN VARIETIES IN MOZAMBIQUE.

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ABSTRACT

The results of survey conducted INIA and Extension Services (DNDR) in district of Xai-Xai (Southern Mozambique) and in Lichinga revealed that lack of the bean seed and good quality seed were one of the major constraint of Beans production in these areas.

Since 1990 the research work on beans was concentrated mainly in three research stations of the country. In 1993/94, a National Bean Network was formed. The objective of the network was to get a collaborative support for testing the advanced and elite bean varieties in the major beans production areas.

In 1994, a number of trials were conducted by National Seed company (SEMOC), World Vision and INIA. The results are presented and discussed in this paper.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is the third most important crop after graudnut and cowpea in Mozambique (Heemkerk *et al.*, 1988). The total production area of bean is about 40000 ha and the yield average is 12000 Tons.

Bean production in Mozambique is divided into three categories: Intensive, extensive and communal. Intensive is almost exclusively undertaken by commercial farmers in winter under irrigation conditions. The extensive production under rainfed condition may occur in the highlands of the central and northern parts of the country. Communal production, is undertaken by small holder farmers under rainfed conditions and is mainly for the family consumption.

The research programme on beans in Mozambique started in 1982, and since 1990, more emphasis was given on evaluation and selection of appropriate varieties for local needs. So, quality evaluation of the varieties and disease resistance is also an important consideration in the selection procedure of the varieties. In some agronomic studies plant density and planting dates are also included in the programme.

Until July 1993 all the trials were conducted in three research stations of INIA. From 1994 a National Bean Network was formed and the trails were conducted by SEMOC, World Vision and INIA in different provinces of the country where bean is a important crop. The aim of this collaborative work is access the appropriate selection per location, to get the information of the performance of elite and advanced group varieties over wide range of soil and climatic conditions. And, at last we hope that this type of work might contribute for the seed dissemination of the good varieties.

In this paper, the results of the trial conducted in the South (2 location) and Center (1 location) are presented.

METHODOLOGY

Twenty five varieties considered as the most promising during 4 consecutive evaluations were selected and used as elite advanced group. In both groups the local checks used were INIA-10 (manteiga type, representative for south) and Encarnado (red type, representative for the north).

Both trials were planted as triple lattice, with 25 varieties and plot size was 4 rows x 5m in length x 0.60 m interown x 0.25 m interplant x 2 seeds/site.

The trial had 4-5 irrigations, 1-2 sprays and 2-3 weedings during the growing season.

RESULTS AND DISCUSSION

In general, no critical biological problem was present in all locations, except the high and moderate level of attack of rust observed in few varieties in Chimoio.

Amongst the elite group (table 1) varieties, ICA-PIJÃO and IKINIMBA produced high grain yield across the regions, mostly due to the better disease resistance. Those varieties have a black colour which might be a limitation for farmers adoption. The other promising varieties were ICA-LIN 63, AND-760, INIA-ZAMBEZE.

For the advanced group varieties, the pre-realized variety PVA-773 was identified as the best one in terms of yield production. INIA - ZAMBEZE (1846 Kg/ha) and ICA-PIJÃO (1768 Kg/ha) were the second best varieties in terms of average grain yield. Other varieties such as KAZAMA, AMINA and ICA-LIN 64 seem to be promising material.

Regarding the average yield, table 2 shows that high yields were observed at Umbeluzi (2260 Kg/ha) followed by Chimoio (1620 Kg/ha). The yields at Umbeluzi and Chókwè were adversely affected by poor management of water irrigation.

CONCLUSION

Keeping on new the results of the varieties conducted in this year we conclude that:

1. This type of work must continue.

2. It is important to access the information of the performance of those varieties under rainfed condition, so the work can be done at Lichinga (north of the Country).

3. IKINIMBA and ICA-PIJÃO can be used for the breeding purposes in the programme and also as check for the yield evaluation trial.

4. Further observation has to be made on the promising material encountered in the elite and advanced group varieties.

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Q: CS Mushi

Ikinimbe is a black seeded variety. Do consumers prefer black beans?

A: M Libombo

In National Bean Programme at this moment we found that those varieties can be use in a programme for the breeding purposes and check for yield evaluation. In the South and Centre of the country I am sure that those varieties will be selected by the farmers because of the seed colour and size. But as dr D Gareth said in Lichinga Ikinimbe is already at farmers field testing and is not rejected by them.

TABLE 1: COMPARATIVE PERFORMANCE OF ELITE VARIETIES OF BEANS (*Phaseolus vulgaris* L.) AT VARIOUS LOCATIONS IN DIFFERENT PROVINCES OF MOZAMBIQUE IN 1994 CROPPING SEASON.

	YIELD(KG/HA)				100 SEED WEIGTH(g)				GRAIN COLOR	DISEASE INCIDENCE(1-9)								
	SEMOC		INIA		SEMOC		INIA			S E M O C						I N I A		
										UMBELUZI			CHIMOIO			UMBELUZI		
VARIETY	UMB	CHI	UMB	CHO	UMB.	CHI.	UMB.	CHO		R	B	V	R	B	V	R	B	V
IKINIMBA	3520	2290	1344	1089	51	52	52	53	B	1	1	3	1	1	1	1	1	1
ICA-PIJAO	3390	2140	1328	944	26	25	27	25	B	1	1	1	1	1	1	1	1	1
ICA-LIN 63	2950	2130	933	1067	76	74	66	67	RM	1	1	1	1	1	1	1	2	1
KATRACHITA	2800	1920	1272	922	34	34	34	33	R	1	2	1	1	1	1	1	2	1
AND-760	2720	2180	1511	1017	61	57	60	56	RM	1	1	1	1	1	1	1	3	1
MANTEIGA PONTA OVALADA	2550	1940	747	667	54	59	47	53	C	2	2	1	1	1	1	1	3	1
AND-628	2530	1520	856	1328	67	63	55	57	RM	1	4	1	3	1	1	1	2	1
MANTEIGA CLARA	2490	1790	789		56	64	47		C	1	3	1	1	1	1	3	1	1
MULTIMANTEIGA	2460	1910	1011	1161	57	59	46	56	C	1	1	1	4	1	1	4	1	2
ENCARNADO MEIA ESCURA	2390	1840	1194	794	61	59	52	54	R	1	2	4	3	1	2	3	2	1
INIA-10(L.T)	2360	2010	744	1361	56	63	45	56	C	1	3	2	5	1	1	4	3	1
PVA-773	2330	2540	744	917	63	62	52	57	RM	1	1	1	1	1	1	3	2	1
INIA-ZAMBEZI	2250	2180	1253	1239	79	79	65	60	C	1	1	1	1	1	1	1	3	1
MANTEIGA LOCAL	2240	1810	856	1083	57	65	47	52	C	1	1	1	1	1	1	3	2	1
AFR-524	2210	2250	1178	1017	65	67	56	55	RM	1	2	2	1	1	2	3	4	1
ENCARNADO(L.T)	2150	1700	1211	1117	57	59	47	51	DR	1	3	2	2	1	1	3	4	1
UNVOTI	2110	1450	1267	1178	43	41	34	42	CM	2	5	2	8	1	1	1	2	1
BAT-1387	2080	1990	1133	944	59	59	49	57	RM	1	1	1	1	1	1	4	2	1
PVA-476	2020	2100	911	1144	69	72	56	55	RM	1	2	2	3	1	1	1	1	1
MANTEIGA VAGEM MORANGO	1980	1870	856	970	52	60	46	54	C	1	2	1	1	1	1	3	1	1

AND-740	1960	2260	1467	811	56	56	49	55	RM	1	1	1	1	1	1	3	3	1
ENS-2	1890	1360	989	1167	74	66	47	58	C	1	1	2	5	1	1	4	1	1
DIACOL CALIMA	1880	1890	922	1233	70	73	57	63	RM	1	3	1	1	1	3	2	1	1
DRK-46	1670	2000	1140	1233	83	81	60	65	DR	1	1	1	7	1	1	2	3	2
ENSELENE	1670	1950	1167	1033	41	42	41	41	CM	1	2	2	1	1	1	2	2	1
cal-115	—	—	—	1389	—	—	—	63	RM									
MEAN	2340	1960	1073	1073.02	59	59	50	54		1	2	1	2	1	1	2	2	1
CV(%)	18.85	20.72	26	38.83	4.73	8.02												
SIGN.	***	ns	ns	ns	***	***												
LSD(0.01)	0.97				6.05	10.43												

SEED COLOUR: B = black, RM = red mottled, R = red, DR = dark red, C = cream, CM = cream mottled,

DISEASE INCIDENCE: 1 = no disease, 2-3 = low level, 4-6 = moderate, 7-9 = high incidence, R = rust, B = bacteriosis, V = virosis.

* significant at 1%, ** at 5% and *** at 0.1%, ns = not significant

SITES: Umb = Umbeluzi, Chi = Chimoio, Cho = Chokwe

SEMOC = Mozambican Seed Company , INIA = Agricultural National Research Institute

TABLE 2: COMPARATIVE PERFORMANCE OF ADVANCED VARIEDTIES OF BEANS (*Phaseolus vulgaris* L.) AT VARIOUS PROVINCES OF MOZAMBIQUE IN 1994 CROPPING SEASON.

	YIELD(KG/HA)				100 SEED WEIGTH (g)				GRAIN COLOUR	DISEASE INCIDENCE(1-9)							
Q	SEMOC		INIA		SEMOC		INIA			SEMOC						INIA	
VARIETY	UMB	CHI	UMB	CHO	UMB	CHI	UMB	CHO		UMB		CHI				UMB	
										B	V	R	B	V	R	B	V
ICA-PIJAO	3090	1560	1189	1233	26	25	25	30	B	1	1	1	1	1	1	2	1
AFR-392	3010	1290	556		35	28	32		RM	1	1	1	1	2	1	1	1
PVA-773	2890	2010	1133	1450	63	57	60	50	RM	1	1	1	1	1	3	2	1
kKAZAMA	2620	1950	833	772	75	73	75	60	C	1	1	1	1	1	2	2	1
ENCARNADO(T.L)	2590	1240	839	1294	62	46	60	57	LR	2	1	1	1	1	2	3	1
KATRACHITA	2580	2140	1194	944	34	35	32	37	DR	1	1	1	1	1	1	2	1
ICA-LIN 66	2530	1400	828	1228	75	77	75	47	DR	2	1	1	1	1	1	2	1
MULTIMANTEIGA	2520	1790	1017	622	60	51	60	53	C	2	2	4	1	1	1	2	1
INIA-ZAMBEZE	2500	1670	1367	—	78	73	79	—	—	1	2	1	1	1	2	3	1
INIA-10(T.L)	2490	1590	956	950	55	47	55	50	C	1	2	3	1	1	3	1	3
ICA-LIN 64	2390	2150	733	1383	77	74	77	67	C	1	1	1	1	1	1	2	1
AMINA	2260	1800	1078	1200	84	77	88	50	YG	1	2	1	1	2	1	2	1
HAL-9	2250	1350	633	788	61	59	60	60	RM	1	1	2	1	1	2	1	1
AFR-300	2150	1600	694	1206	72	67	70	70	DR	1	1	1	1	1	1	2	1
CAL-115	2140	2020	683	689	59	66	59	63	RM	1	1	1	1	1	2	1	1
SUGAR-18	2110	1660	917	906	62	63	60	60	CM	1	1	1	1	1	1	2	1
ENS-2	2080	1230	1111	950	76	60	60	67	RM	1	2	6	1	2	2	2	1
CAL-18	2040	1730	1000	983	63	63	62	60	R	1	3	1	1	1	1	3	1
AND-667	2030	1850	1111	928	65	66	60	53	C	1	1	1	1	1	2	4	1
DIACOL CALIMA	1970	1430	1028	1033	68	70	70	50	RM	1	1	1	1	1	2	3	2

AFR-461	1950	1410	972	794	57	59	55	50	RM	1	1	1	1	1	3	3	4
SUGAR-36	1800	1620	889	1022	58	62	55	57	CM	1	1	1	1	1	2	3	1
AFR-368	1780	1250	869	650	55	57	55	47	RM	1	2	1	2	1	2	3	1
RADICAL FROYLAN	1690	1500	717	744	66	68	66	63	DR	1	1	1	1	1	2	2	1
ENSELENE	1140	1380	833	667	45	40	42	40	CM	1	1	1	1	1	1	2	1
MANTEIGA LOCAL	—	—	—	883	—	—	—	67	C								
AND-628	—	—	•	788			—	70	RM								
MEDIA	2260	1620	912.75	955.29	61	58	59.88	55.7									
CV(%)	24.08	22.46	31.65	30.11	3.52	7.87		19.04									
SIGN.	*	***	ns	*	***	***											
LSD(0.05)	0.89	0.598		472.2	4.72	10.05											

Seed colour: B = black, R = red, RM = red mottled, LR = ligth red, DR = dark red, C = creem, CM = creem mottled, YG = yealon green.
Disease incidence: 1 = No disease, 2-4 = low, 5-7 = moderate, 8-9 = very bad, r = rust, B = bacteria blaith, V = virosis.
* significante at 5%,** at 1% and *** at 0.1%, ns not significant
Sites: UMB = Umbeluzi, CHI = Chimoio, CHO = Chokwe
SEMOC = Mozambican Seed Company, INIA = Agricultura National Research Institute

SESSION 4

CROP PRODUCTION

CHAIRMAN : R.J.M. MELIS

PROGRESS IN SCREENING BEAN GENOTYPES FOR LOW P IN TANZANIA

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ABSTRACT

Screening bean genotypes for low phosphorus tolerance in Tanzania was initiated in 1992 with the objective of identifying bean cultivars that produce well in low phosphorus soils.

During the first year, 280 entries were screened using a randomized complete block design of 2 replications. The best 114 entries were evaluated in season II in a randomized complete block design in a split plot arrangement with P treatments as main plots and bean cultivars as sub-plots. During season III best 50 lines were re-evaluated under non and stress P conditions as in season II. Promising cultivars tolerant to low P have been identified. To mention the few this includes: RAYT 19, A 321, PYTMS-40 and KAIRAGUJU. In future these will be used in the breeding programme to incorporate this trait to some of released bean varieties in Tanzania.

INTRODUCTION

Common beans (*Phaseolus vulgaris* L.) are widely grown in Africa as a food crop, of major importance, by both small holders and commercial producers. Africa is second in bean production to Latin America. However yield levels are generally low because of various production contsraints. One of the major problems is soil infertility (Lynch and Piha, 1988) particularly phosphorus deficiency.

The major soil groups found in bean growing areas of Africa are alfisols, oxisols and inceptisol (Mughogho and Wortman, 1988), and all are known for their P deficiency. Besides, their high P fixing capacities, these soils have other characteristics which tend to intensify P-stress problems such as low pH, low exchangeable bases and high exchangeable aluminium and/or manganese to phytotoxic levels.

The P-nutrition of bean crop could be improved by P-fertilizer application, liming and addition of organic residues to match the bean crop requirement or improving the adaptation of the crop to the existing soil environment. The first option, though effective is rather expensive and hence of limited use by resource poor farmers dominating the region. Massive application of P are often required to quench the high fixation capacities of fixing soil (Younge and Pluckenett 1966) Rates as high as 500-1000 kgP/ha have been found to be required in order to obtain dramatic crop yield increases in some oxisols (Sanchez and Uehara, 1976).

Many tropical soils rarely respond to liming if pH exceeds 5.5. Beans as a leguminous crop plant needs high amounts of calcium and is sensitive to Al and Mn toxicity (Lynch and Piha 1988). Liming soils to pH 5.5 eliminate Al toxicity and supplies Ca to plants. However, lime requirements to effect desired pH changes in some tropical soils are in the range of several tons/ha. It is obvious that adequate P-fertilizers and lime application to meet crop requirement cannot be implemented by subsistence small scale farmers with limited capital.

Furthermore, P-fertilizers are relatively expensive and will remain so for several years to come. Moreover, over-fertilization/liming of inherently infertile soil may lead to problems of nutrient imbalance and trace element deficiency which are difficult and expensive to reverse.

Also P is known for its low efficiency in application. In general, fertilizer P-recovery values are in the range of 5-10% for annual crop and 20-30% after 5 years of crop uptake (Russell 1973).

These considerations no doubt justify the second option as the longterm solution to improving bean yields in infertile soils in the SADCC region; hence the need for the plant breeder to develop bean genotypes with improved adaption to low P soils. This approach is feasible because substantial genotypic variation has bean observed in bean adaptation to P stress (CIAT, 1976) and shown to be heritable (Lindgreen et al, 1977). However, the breeder needs to be availed with bean varieties which are tolerant to low P to serve as a source of parents for breeding P efficient plants. It is for this reason that this work was undertaken to systematically screen bean varieties for their tolerance to P. The promising bean varieties will be passed to breeders for subsequent genetic improvement work and/or farmers for production in P stressed soils. The work reported here aimed at establishing optimum P level for screening bean genotypes for tolerance to P stress, and identifying stresses (if any) besides low P which needs to be alleviated to create ideal conditions for bean production . It was also the objective of this study to screen bean genotypes for tolerance to low P.

MATERIAL AND METHODS

Soil characterization

Top and sub soil samples were taken from several fields of Mulama Estate in Kilimanjaro region (3° 10'S and 30° 39'E and analysed in the laboratory for the purpose of initial soil characterization. Available phosphorus was extracted by the Bray I procedure (Bray and Kurtz 1945). Soil pH was potentiometrically determined in water and KCl solution (1:2.5). Organic carbon was determined by Walkley and Black method (Allison 1965) and total nitrogen by micro Kjeldahl digestion method (Bremner 1965). Cation exchange capacity (CEC) was determined by ammonium acetate at pH 7; K by flame photometry; Ca and Mg by atomic absorption spectrophotometry; and exchangeable acidity was determined after percolation with IM KCl. Soil texture was measured by the Bouyoucos hydrometer method (Day 1965).

DETERMINATION OF OPTIMUM P STRESS LEVEL FOR BEAN SCREENING

Towards the end of June 1991, the beginning of main cropping season, a trial was conducted at Mulama using bean varieties from the African Bean Yield and Adaptation Nursery II (AFBYAN II) collection as entries in the subplots. Their characteristics and sources are shown in Table 1. The entries were grouped by growth habits. These were evaluated in a split plot and replicated twice. Phosphorus levels of 0,20, 40, 60, 80, 100 and 120 Kg P/ha from Triple Super Phosphate (TSP) constituted the main plots and entries the sub plots. Basal nitrogen was applied at 40 kgN/ha as calcium ammonium nitrate (CAN) which also supplied calcium to the soils. The subplots consisted of single row 3m long on ridges, spaced 75cm apart, while the main plots consisted of 25 subplots with single quard row on either side. Seeds were sown on ridges with 10cm space between single seed hills. At sowing mixture of TSP and CAN fertilizer was banded. Weeds were controlled using pre-emergence herbicide Galex at a rate of 5l/ha and hand weeding. Endosulfun and Karate were used to control insect pests. Furrow irrigation was applied whenever necessary. The trial was scored for disease incidence and grain yield and yield components were also recorded.

SCREENING TRIAL

Season I

Based on the result of the work above, field evaluation involving 280 bean genotypes was laid out at Mulama on a field adjacent to the previous trial in the short rain of 1991/92. At each growing season the

TABLE 1: **Bean cultivar entry set for the optimum P stress level trial.**

Entry	Sources	Seed size	Growth habit
1. A 197	CIAT	L	I
2. G 12470	Ecuador	L	I
3. T 23 (Lyamungu)	Tanzania	L	I
4. K 2 0	Uganda	L	I
5. 997-XH-193	CIAT	M	Ia
6. A410	CIAT	M	Ia
7. A176	CIAT	S	Ib
8. A370	CIAT	S	Ib
9. GLPX 92	Kenya	L	Ib
10. ANIA 12	Mozambique	M	2a
11. Molel			
12. Ubusosera 6	Rwanda	M	2a
13. HF-56463-1	Mozambique	M	2a
14. INIA 10	Mozambique	M	2a
15. GLP 1004	Kenya	M	2a
16. RED WOLATA	Ethiopia	S	3b
17. GLP 14	Uganda	M	2a
18. EX RIKO	Colombia	S	2a
19. XAN 76	CIAT	S	2a
20. CARIOCA	Brazil	S	Ib
21. NAIN de KYONDO	Zaire	S	3
22. IKINIMBA	Rwanda	M	3
23. G2816(flor de Meyo)	Mexico	S	3
24. GLP3671	Mexico	I	3
25. ZPV-192	Uganda	M	Ia

S = Less than 25g/100 seeds
M = 25 - 40g/100 seeds
L = greater than 40g/100 seeds.

trial was planted in an area where P fertilizer has not been applied. The bean entries were drawn from the Africa network for screening for edaphic stress (ANSES) bean collection. A randomized complete block design with two replications was used. Plot size consisted of single row ridges, 3m long spaced 75cm apart. At sowing only Nitrogen in the form of Calcium Ammonium Nitrate (CAN) was used at arate of 40kgN/ha.

The plots were farrow irrigated at one week intervals. Unfortunately no useful data was obtained from this trial due to severe damage of Bean Stem Maggot and Fusarium wilt despite the use of insecticide. The trial was replanted during the long rains of 1992, the ideal growing season at the site using the available seeds of 242 entries instead of 280.

Season II

The best one hundred and fourteen entries (92 bush and 22 climbers) selected from season I were evaluated in 1993 both at stress and non-stress P conditions. Two rates (0 and 26 kg P) were tested in a randomized complete block design in a split plot arrangement and replicated two times. The plots consisted of two row ridges, 3m long spaced at 75cm apart. Seeds were planted 10 cm apart from each hill.

Nitrogen was applied at sowing as in season I.

Season III

This involved testing 50 lines (40 bush and 10 climbers) selected from season two with and without P application. The experimental design and plot size were similar to that used in season two. Data collected was analyzed using the Nearest Neighbour Analysis.

Season IV

The trial will be planted during short rains in 1995. This will involve evaluating 12 lines (9 bush and 3 climbers) as in season 3 but the plot size will be increased to 4 row plots.

RESULTS

Soil characterization

According to Anderson (1973) soils of Mulama belongs to Umbwe Complex of Masama Umbwe Association and are derived from K-rich acidic lavas. They are mainly humic ferrisol. Their chemical and physical characteristics are presented in Table 2. They are loamy in texture with moderate acidity, moderately well supplied with bases, high in organic matter and has favourable C:N ratio. The available phosphorus decrease with depth from 3 to 1 ppm in the subsoil, a level well below 10 - 15 ppm P considered as critical for bean production (CIAT 1976).

These soil qualities were considered ideal for a P screening site as it was neither extremely low in bases nor did it have pH levels which would allow excessive solubility of Al and Mn known to be toxic to plants.

Optimum stress level for screening

The effect of bean entries and phosphorus application on the agronomic, disease and yield data are summarized in (Table 3).

In this investigation grain yield which is our ultimate goal is used as a criterion for evaluating bean tolerance to phosphorus stress conditions while the other parameters were recorded to back the yield information. This is probably the best measure of adaptation because beans can grow successfully with low P supplied until podding stage but at pod filling phase not all formed pods of P denied plant will fill. As expected there was significant differences among bean genotypes with respect to vigor, grain yield and yield components (Table 3).

The optimum stress level for evaluation of bean varieties for tolerance to edaphic stress is the level at which materials differ greatly in yield. At this level the stress should neither be too mild nor too strong as in such conditions, genotypic variation for tolerance will be small.

Table 4 contains the mean yield, variances and yield range of 25 bean varieties at 7 levels of phosphorus application. From the results, large yield variation among the bean entries occured at 0 and 120 kg/ha P. At zero level of P application, bean yields ranged from 0.67 t/ha to 3.8 t/ha with mean value of 1.0 t/ha while at 120 kgP/ha, yield ranged from 0.98 t/ha to 4.3 t/ha with mean value of 2.4 t/ha. Although from these results screening could be done at either of the two P levels, application of 120 kgP/ha is probably too high for bean varieties to express genuine differences in their efficiency in P use. Even if some cultivars are not likely to find a place in low P soils in the region with limited capital to fertilizer input. Moreover large applications of P are known to induce Zn deficiency and other soil nutrient disorders which may confuse the interpretation of crop responses.

These considerations justify the Zero level of P application as the optimal stress level for evaluation of bean varieties at Mulama for tolerance to P stress condition. This stress level is not too high as all bean entries completed their life cycle and differed greatly in yield.

SCREENING RESULTS

One hundred and fourteen out of 242 entries planted in 1992 were selected for further screening in 1993. Due to very low yield recorded per plot, the yield

TABLE 3: **Selected physical and chemical properties of soils at Mulama Estate-field.**

Properties		Soil Layer	
		Top soil 0-20cm	Sub-soil20-40cm
pH	1: 2.5 H20	6.0	6.0
	1: 2.5 KCI	4.7	4.5
Exchangeable	Na	0.6	0.5
Cations	K	3.5	3.2
(me/l00g)	Mg	1.4	1.4
	Ca	5.4	7.1
CEC(me/l00g)		11.2	12.4
Total N%		0.34	0.27
Organic C%		4.6	3.6
Available P (Bray) (ppm)		3	1
Exchangeable Al (me/l00g)		0.10	0.10
Exchangeable H (me/l00g)		0.15	0.05
Textural class		loam	loam

TABLE 3: **Effect of bean genotypes (entries) and P levels on agronomic, and disease reaction.**

Variable	Rep	P	Entry (E)	PxE
Stand at harvest	ns	ns	***	ns
Problem Y	ns	ns	ns	ns
Angular leaf spot	**	ns	ns	ns
Common bacterial blight	ns	ns	ns	ns
Floury leaf spot	ns	ns	ns	ns
Vigor	**	ns	***	ns
Pods/plant	***	ns	***	ns
Seeds/pod	*	ns	***	ns
100 Seed wt.	ns	ns	***	ns
Seed Yield (g/plant)	ns	*	***	ns
Seed Yield (kg/ha)	ns	*	**	ns

*,**,*** Indicate significant difference among means at p= 0.05,
0.01 and 0.001 respectively.
ns = not significant,
P = Phosphorus,
E= Entries
Problem Y = Yellowing of leaf margin which spreads interveinally and develops into deep browning of the whole leaf. In severe cases the leaf blackens and drops. The cause and cure is unknown.

data is reported per plant (Table 5-6). The selection criteria was based on good seed yield. The best high yielding entries for non climbers in unfertilized plots were A 321, PYT-1-4, PYT-LS-5, Muhinga, RIYT 43, and Kairaguju (Table 5). For climbers best entries in unfertilized plots were DRK 3, AND 61, EM 73, and Urubonobono (Table 6). In fertilized plots high yielding non climbers were PYT-LS-5, BAT 25, RAYT 5, PAI 112 and PYT-1-4 where as high yielding climbers were EM 2/7, 433, EM 73 and G 2333 (Table 5-6).

In 1993 best 50 entries (40 bush and 10 climbers) were selected and screened in 1994 season. The seed yield at none stress and stress P condition is presented in Tables 7,8,9 and 10. Phosphorus application significantly (P= 0.05) increased seed yield. The response to P application were expected since Mulama soil had low extractable P (Table 1.)

Yield in fertilized plots ranged from 188-1092g/plot. Urubonobono was the best yielder (1092 g/plot) and it was followed by PYT-MS-40 (1089 g/plot). The poorest entry (AND 863) gave 188 g/plot.In unfertilized plots seed yield ranged from 139 g/plot - 801 g/plot Table. The best two entries were RAYT 19 (801 g/plot) and A 321 (732 g/plot). The poorest entry was PYT-LS-4 (139 g/plot).

From these results twelve entries (Table 11) have been advanced for further screening in 1995.

TABLE 4: Mean yield; variances and yield range of 25 bean varieties at 7 levels of applied Phosphorus.

P-level (kg/ha)	Mean Yield (kg/ha)	Variance	Yield range (kg/ha)
0	1047	677,776	67-3822
20	1657	523,789	533-2711
40	1080	282,7S7	267-2222
60	2109	456,018	644-3289
80	1348	319,659	311-2400
100	1640	423,585	249-2604
120	2449	999,464	978-4288

TABLE 6: Climbers under both stress and non-stress in 1993.

Entry name	Ranking unfert. plots	Ranking fert. plots	Yield unfert. plots g/plant	Yield fert. plots g/plant
1. DRK 3	1	7	7.2	11.5
2. AND 61	2	15	6.5	6.1
3. EM 73	3	2	6.4	14.6
4. URUBONOBONO	4	13	6.0	7.4
5. ACV 22	5	5	5.8	12.6
6. EM 2/7	6	1	5.7	15.8
7. 433	7	2	5.7	14.6
8. G 2333	8	4	5.3	12.7
9. RWK 3	9	10	4.9	10.0
10. PYT-MS-40	10	8	4.5	10.6
11. PUT-ms-121	13	6	3.4	12.2

TABLE 5: **Best 50% non climbers under both stress and non-stress.**

Entry name	Ranking unfert. plots	Ranking fert. plots	Yield unfert. plots g/ plant	Yield fert. plots g/plant
1. PYT-LS-5	3	2	7.8	12.4
2. BAT 25	10	3	6.0	11.9
3. RAYT G	20	4	4.8	11.3
4. PAI G	32	5	3.3	11.1
5. PYT-1-4	2	6	7.8	10.8
6. NEPA 29	14	7	5.5	10.6
7. KAIRAGUJU	6	8	6.5	10.5
8. RAYT 8	16	9	5.2	10.4
9. BLACK DESSIE	28	10	3.8	10.2
10. MUYAGA	5	11	6.6	10.1
11. RITY 11	14	12	5.5	10.0
12. RWK 5	31	13	3.5	9.8
13. RIYT 43	6	14	6.5	9.6
14. RIYT 15	22	15	4.6	9.4
15. BRU 22	19	16	4.9	9.3
16. PYT-LS-4	5	18	6.6	9.0
17. TZ 0201473	8	19	6.2	8.9
18. EM 24/10	30	19	3.6	8.9
19. RWR 982	27	20	4.0	8.8
20. RIYT 33	9	22	6.1	8.5
21. RAYT 31	13	22	5.6	8.5
22. CALIMA	20	23	4.8	8.4
23. LYAMUNGU 90	25	23	4.2	8.4
24. RIYT 40	12	23	5.7	8.4
25. BAT 85 VEF 7	18	23	5.0	8.4
26. RAYT 14	13	24	5.6	8.3
27. A 321	1	25	8.2	8.2
28. RUBONA	29	25	3.7	8.2
29. VIDAC ROJO	22	26	4.6	8.1
30. EMP 84	25	26	4.2	8.1
31. PYT-1-4	24	26	4.3	8.0
32. RAYT 11	21	27	4.7	7.9
33. MSHORO	20	28	4.8	7.6
34. AND 863	33	29	3.2	7.5
35. AFR 5	30	30	3.6	7.5
36. PYT-LS-17	35	30	3.0	7.4
37. RAYT 19	34	31	3.1	7.2
38. OBA	29	32	3.7	7.2
39. PYT-LS-8	32	32	3.3	7.1
40. RAYT 150	29	33	3.7	7.0
41. MUYONJA	16	34	5.2	6.8
42. RWR 971	17	35	5.1	6.8
43. PYT - LS - 7	34	35	3.1	6.8
44. AFR 478	28	35	3.8	6.8
45. RAYT 27	30	35	3.6	6.8

TABLE 7: Performance of entries screened at 26 kg P/ ha in 1994.

Entry	Yield	Entry	Yield
1 . RWK 5	712	46. URUBONOBONO	1092
2. RAYT II	451	47. DRK 3	883
3. PYT-1-4	498	48. EM 73	414
4. CARIOCA	561	49. RWK K	806
5. RAYT 31	688	50. EM 217	702
6. MAYUGA	991	51. AND 61	729
7. RIYT 40	457		
8. RIYT 40	647		
9. AFR 516	449		
10. RIYT 43	642		
11. RAYT 14	581		
12 RAYT 8	477		
13 RUBONA	889		
14. PYT-LS-4	510		
15. RAYT 9	808		
16. EMP 84	737		
17 EM 24/10	855		
18 TZ 0201473	590		
19. RIYT II	751		
20. VIDAC ROSO	531		
21. PYT-LS-S	538		
22 PYT-LS-S	442		
23 NSHORO	476		
24. LY 9O	852		
25. PYT-1-4	782		
26. PAI 112	827		
27. OBA	633		
28. KAIRAGUJU	525		
29 RAYT 150	371		
30 CALIMA	536		
31. RWK 982	957		
32 BAT 85	761		
33 AND 863	188		
34. BRU 22	486		
35. BLACK DESSIE	635		
36. RIYT 31	1051		
37. RAYT L9	896		
38 NEPA	693		
39 BAT 25	800		
40. A 321	755		
41. PYT-LS-L	729		
42. ACV 22	734		
43. 433	982		
44 2333	593		
45 PYT-MS-40	1089		

TABLE:8 **Performance of entries screened without applying Phosphorus in 1994.**

Entry	Yield Per plot	Entry	Yield Per plot
1. RWKS	398	46. URUBONOBONO	376
2. RAYT II	278	47. DRK 3	457
3. PYT-1-4	404	48. EM 73	325
4. CARIOCA	427	49. RWK K	261
5. RAYT 31	436	50. AND 61	207
6. MAYUGA	474		
7. RIYT 40	349		
8. RIYT 40	417		
9. AFR 516	416		
10. RIYT 43	431		
11. RAYT 14	479		
12. RAYT 8	222		
13. RUBONA	343		
14. PYT-LS-4	139		
15. RAYT 9	438		
16 EMP 84	332		
17. EM 24/10	528		
18. TZ 0201473	292		
19. RIYT II	471		
20 VIDAC ROSO	354		
21. PYT-LS-5	326		
22. PYT-LS-8	371		
23. NSHORO	248		
24. LY 90	620		
25. PYT-1-4	357		
26. PAI 112	576		
27. OBA	587		
28. KAIRAGUJU	516		
29. RAYT 150	280		
30. CALIMA	566		
31. RWK 982	372		
32. BAT 85	276		
33. AND 863	227		
34. BRU 22	215		
35. BLACK DESS	437		
36. RIYT 31	599		
37. RAYT 19	801		
38. NEPA	166		
39. BAT 25	575		
40 A 321	733		
41 PYT-LS-17	586		
42. ACV 22	332		
43. 433	442		
44. 2333	648		
45. PYT-MS-40	718		

TABLE 9: **Best twelve lines in unfertilized plots in 1994.**

Entry name	Yield g/plot
1. RAYT 19	801
2. A 321	732
3. PYT - MS-40	718
4. CARIOCA	692
5. G 2333	648
6. L 90	620
7. KAIRAGUJU	615
8. RYT 31	599
9. PYT-IS-17	585
10. PAI 112	576
11. BAT 25	575
12. CALIMA	565

TABLE 10: **Best twelve lines in fertilized plots in 1994.**

Entry	Yield g/plot
1. URUBONOBONO	1092
2. PYT-MS-40	1089
3. RIYT 31	1051
4. MAYUGA	991
5. 433	982
6. RWR 982	957
7. RAYT 19	896
8. RUBONA	889
9. DRK 3	883
10. EM 24/10	855
11. L 90	852
12. PAI 112	827

CV = 36. 2%

SE = 23.7

TABLE 11: **Selected entries for further screening in 1995 by neighbor analysis.**

	Yield g/plot	Tolerance level to low phosphorus*
1. PYT-MS-40	949	NA
2. PAI 112	874	T
3. RAYT 19	817	NA
4. OBA	785	T
5. URUBONOBONO	770	S
6. CARIOCA	742	T
7. EM 24/10	741	NA
8. RIYT 31	733	NA
9. MUYUGA	720	T
10. LYAMUNGU 90	692	NA
11. 433	680	MT
12. G 2333	679	NA
13. RAYT 9	678	NA

*Source: Wortman 1995.

NA= Not available, T= Tolerant, S= Susceptible, MT= Moderately Tolerant

DISCUSSION

The ability of some of these entries to grow on soils with low phosphorus status is associated with their high capacity to absorb phosphorus at low levels of supply and/or low internal reguirement for optimum growth. Many factors may be associated with tolerance to low phosphorus soils. These may include large root systems, fine roots with large root hairs and hence high rate of phosphorus absorption per unit root weight. Results obtained from this study and that reported by Wortman (1995) in Uganda suggest that majority of entries selected were performing similarly across the two environments. Five out of best 12 lines selected for further screening in Tanzania were also rated by Wortman (1995) as tolerant to low P (Table 11) Some of the entries found to be tolerant to low phosphorus eg. RAYT 19 and A 21 gave small response to applied phosphorus implying that the least responsive entries are able to grow better on low phosphorus soils than the more responsive lines. Such results are encouraging for use by the small scale farmers who cannot afford expensive chemical fertilizers.

CONCLUSION

This screening work has provided entries which in future will be used by breeders to incorporate tolerant genes to low phosphorus into our adopted varieties for final use by our farmers.

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Q: Allan Femi Lana

Why have you vertricted your experimental sites to Tanzania?

A: PA Ndakidemi

In the SADC countries Tanzania was leading this project. The primary site was located in Tanzania. At advanced stages of screening, it was planned to send the materials for further screening at secondary sites in Malawi, Zambia and other countries suffering from low P problem.

INTERCROPPING OF MAIZE AND DRY BEANS IN THE VULINDLELA DISTRICT OF KWAZULU-NATAL

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ABSTRACT

An intercropping trial with maize and dry beans was conducted in the Vulindlela district (20 km east of Pietermaritzburg) in KwaZulu-Natal during the 1992/93 summer season. Due to uncontrolled grazing of cattle, cropping is limited to small areas of land close to the homesteads. Land and other agricultural inputs are limiting for most families. The possibility of increasing land productivity under a low-input situation, needed investigation. In this area maize has lost its traditional place as the most important crop, it was rated only third after potatoes and dry beans. A high dry bean yield of good quality was desired. Two maize and two bean cultivars at three bean densities were used. The maize was grown at 50% of the common sole crop density of 41 500 p/ha. Maize rows were rearranged to have two rows 40 cm apart and then 2,2m open to grow beans in. Beans were grown at 75, 100 & 125 percent of the common sole crop density of 250 000 p/ha. Maize cultivars used were the hybrid SR 52 and open pollinated cultivar Kalahari Early Pearl. Bean cultivars used were Mkuzi and Umlazi. The maize was planted mid November and the beans at the beginning of January (to miss the summer rains at harvesting to produce good quality beans). There were no significant yield differences between maize cultivars or different bean densities. Bean cultivars did not give significantly different yields, but Mkuzi tended to give higher yields but an unknown disease came in at the end of the growing season shortening Mkuzi's lifespan, while not affecting Umlazi which is a short season cultivar. Maize proved to be too dominant for the beans, despite the lower maize density and changed row arrangement, and depressed bean yields by an unacceptable 50%. The seven week growth advantage that the maize had over the beans proved to be too overwhelming. Sole cropping of beans and maize seems to provide more desirable yield and land productivity for the progressive farmer due to their specific demands. However for the subsistence farmer intercropping can holed certain advantages.

INTRODUCTION

This whole study in intercropping was brought about as a result of a study done on the state of agriculture in the Vulindlela area of rural KwaZulu-Natal lying about 20 km east of Pietermaritzburg.

The following constraints were identified (Liebenberg, 1993):

1. Small land size due to high population pressure, uncontrolled grazing and lack of land ownership,
2. Limited agricultural inputs,
3. Limited manpower due to limited labour saving devices and absenteeism of migrant workers.

Due to the fact that there is a preference for refined maize meal, maize is no longer the most important crop grown. It was rated only third after potatoes and dry beans. Green maize, however, was still very popular. Due to the high value attached to beans, high yields of good quality are desirable.

MATERIALS AND METHODS

Two maize and two bean cultivars at three bean densities were used. The maize planting density was halved from the common sole crop density to 20750 p/ha to reduce maize competition. Maize rows were rearranged to have two rows 40 cm apart thus giving a corridor 2,8 m wide to grow beans in. Bean densities were 75, 100 & 125 percent of the common sole crop density of 250 000 p/ha. This gave 3, 4 and 5 rows respectively. The maize cultivars were the Zimbabwian hybrid SR 52 (M2) and the open pollinated cultivar Kalahari Early Pearl (M1). Bean cultivars were the indeterminant carioca Mkuzi (B1) and the bush speckled sugar bean, Umlazi (B2). Maize was planted mid November and beans beginning of January the following year. This was done to miss the summer rains at harvesting thus producing good quality beans. Maize plants harvested for green maize were removed to prevent further competition.

The statistical design was a split-split block design with cultivars as the main block and split for densities and green maize harvest. Sole crop controls of each cultivar were also included.

RESULTS

Bean yield

Intercropping reduced the seed yield significantly (P=0.01). For B1 a reduction of 48.3% (i.e. from 1.556 to 0.805 t/ha) was experienced, and for B2 a reduction of 42.1% (i.e. from 0.900 to 0.521 t/ha). This gave LER's of 0.517 and 0.579 for B1 and B2 respectively, but if the highest bean yield is used, then B2 only gave a LER of 0.335. due to the fact that B1 and B2 fetch the same price, the LER needs to be used. Under sole cropping, cultivar B1 produced significantly more than B2 (P=0.01). The cultivar differences were not significant in the intercropping treatments. The only other point of significance was a linear tendency (P=0.05) for higher yields with increasing density. The rows closer to the maize yielded significantly (P<0.01) less than the other rows.

Yield components

The total number of pods was significantly (P<0.01) decreased by intercropping by 70.7% and 56.4% for B1 and B2 respectively. Rows next to M2 produced significantly less pods than other rows. Increased density also had a significantly (P=0.04) linear decreasing effect on the number of pods in the outer rows.

The number of seeds per pod was only significantly decreased by intercropping at the highest density (P=0.05). Rows next to the maize also produced significantly (P=0.01) less seeds per pods than the other rows.

Hundred seed mass was significantly (P=0.05) decreased by intercropping for B1 but not for B2. Furthermore M2 also had a significant (P=0.01) reducing effect on hundred seed mass.

Intercropping significantly (P<0.01) reduced plant size by 41.7% for B1 and 37.5% for B2. B1 had a significantly (P=0.02) linear tendency to decrease in size with increasing density. Rows bordering maize had much smaller (P<0.01) plants than other rows.

Maize yields

Green maize yields were decreased by 42.4% and 36.1% (land equivalent ratios of 0.576 and 0.639) for M1 and M2 respectively by intercropping. When M2 intercrop yield was compared with the higher M1 sole crop yield a LER off 0.559 was obtained. Removal of maize plants had no influence on beans what so ever. There was also no significant difference between maize cultivars.

Maize grain yields for M1 were reduced by 53.0% from 5.442 to 2.558 t/ha. For M2 yields were reduced by 49.4% from 5.912 to 2.991 t/ha. LER for M1 was 0.470 and for M2 was 0.506. When M1 intercrop yield was compared with the M2 sole crop yield a LER of 0.433 was obtained.

DISCUSSION AND CONCLUSIONS

Reduction in bean yields was disappointingly high and showed that rearrangements in maize rows was not sufficient. Yield components indicated competition right through the season. Simultaneous planting of maize and beans can contribute to higher yields and it must be asked if the improvement in seed quality due to later planting can compensate for loss of yield.

The highest LER of 1.093 was obtained from the B2 M1 green maize treatment, but this was not significantly higher than the rest, some being below 1.000. There was therefore no significant advantages due to intercropping. But this was only one season and intercropping trials are prone to high statistical error. In real terms I would have said that a B1 M2 combination would have given a meaningful yield advantage, especially for subsistence farmers for whom high seed quality is not so important, therefore crops can be planted together. Added to this is the possible benefits of reduced disease and insect damage that suggested itself very strongly in the trial but failed to have any real influence due to my constant movement between treatments to do water use readings.

Intercropping research in South Africa is still only done on a very small scale and researchers are in great need of help from our more experienced colleagues in other countries. I ask you all here today to assist us as we try to aim our research more towards the needs of the small scale and subsistence farmers. The theory is in the books, but we need to apply it practically to our situation.

POTENTIAL HERBICIDES FOR WEED CONTROL IN COMMON BEANS (*PHASEOLUS VULGARIS* L.) IN NORTHERN TANZANIA.

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ABSTRACT

The importance of beans in Tanzania cannot be over emphasized in terms of production, consumption, and marketing aboard. Weed free bean fields would be an ideal crop husbandry but not practical. Growing beans without adequate weed control is a major constraint in bean production. High bean seed yield has been related with minimum weed competition. Herbicides were screened against grass and broad-leaf weeds in volcanic soils receiving over 1000mm of rain and elevation ranging from 1020 to 1390 masl. in Northern Tanzania. The trial was arranged in RCB design in four replications.

Data showed that bean plants were tolerant to herbicides except Flex which injured bean leaves temporarily. Fusillade and unweeded control correspondingly reduced bean seed yield by 52 and 61 percent. Pre-emergence herbicides controlled grass and broad-leaf weeds for at least 30 days after germination. Broad-leaf weeds predominated the sites and suppressed bean seed yield. Unfortunately, these herbicides were not effective against Argemone mexicana, Tagetes minuta, Oxygonum, Commelina, Cyperus, Portulaca and Nicandra spp. Pursuit Plus was identified as a potential herbicide for Northern Tanzania but like Stomp 500EC was weak against Bidens pilosa. In addition, it was not economical for weed control since its costs increased with decreased net benefit. Galex 500EC and Stomp 500EC were economically beneficial in controlling weeds in bean fields. Persistence of some common weeds against the tested herbicides was noted and necessitated further screening of newly manufactured herbicides to benefit bean producers.

INTRODUCTION

The importance of beans in Northern Tanzania cannot be over emphasized in terms of production, consumption and marketing abroad. Weed-free bean fields would be an ideal crop husbandry but not practical. Growing beans without adequate weed control is a major constraint facing bean producer.

Common bean (*Phaseolus vulgaris L.*) is the most widely grown grain legume with 18-34 percent protein content (Allen, 1986). Common bean is a good source of cash income and famous for its palatability and hence daily component of the human diets. Bean play a major role in human nutrition in rural and urban Communities. Small scale farmers are the principal producers of beans in Africa in complex associations with other crop species, notably maize. African bean production exceeds 2.5 million tons annually with 85 percent of the total coming in a declining order from Kenya, Uganda, Rwanda, Burundi, Tanzania and the Kivu province of Zaire (Allen, 1986). About 443,000 tons of dry bean seed are produced from SADC countries in which Tanzania produces about 230,000 tons or 52 percent of SADC production (Mushi *et al*; 1993). Within Tanzania the major regions of bean production are highlands of the Northern regions of Arusha, Kilimanjaro and Tanga, the Western regions of Kigoma and Kagera; the Southern highland regions of Mbeya, Ruvuma, Rukwa and Iringa and the Uluguru and Ukaguru mountain region of Morogoro. Bean seed yields range from 200 to 700kg/ha due probably to biotic (weed competition), abiotic (soil infertility) and socio - economic constraints (Marketing systems). Indeed, yields are quite low as compared with yields of up to 2 and 4 tons/ha in associated and in monoculture, respectively, obtained under experimental conditions (CIAT, 1975; Francis *et al*; 1977).

Beans are sensitive to early weed competition and with full competition bean yield losses were reported to range from 40 (de Groot *et al*; 1979, Mbuya *et al*; 1987 and Sibuga, 1986) to 92 percent (Nieto *et al*; 1968). The critical period during which beans must be kept weed free to realize optimum yields was indicated to be 40 days for Tropical Central America (Nieto *et al*; 1968) and 20 to 40 days in Kenya (de Groot et al; 1979). There is evidence to suggest higher dry matter yields of weeds per unit area compared to crop dry matter yields (Senesar and Mantelty, 1978; Chambles *et al*: 1982). To increase crop yield Roberts (1982) suggested increase in plant density. High crop densities increased not only the number of crop plant per unit area but also reduced weed competition (Rao and Shelty, 1974). Wortmann (1993) indicated that the ability of bean to suppress weeds was independent of bean growth habit but was related to leaf size, leaf area index and plant growth rate.In a closely planted bean Sepasgozarian and Mirkamali (1977) pointed out a single weeding about two weeks after germination may be necessary to obtain near optimum yields. Uncontrolling weeds reduced bean seed yields by 77 and 87 percent during long and short rains, respectively (Ariga, 1991).

The increasing labour costs and the unavailability of labour at critical stage of bean growth and development are rapidly causing the use of herbicides to become more economical than manual labour (Moody, 1975). Use of herbicide will be on the rise due to rising manual labour cost, urban migration of young people and more labour intensive in dairy, coffee and horticultural activities in Northern Tanzania. Moody (1975) reported that in Western Nigeria at least 50 percent of the farmers working time is spent on weeding while in Kenya, the range is between 50 to 70 percent (Zoebl 1984), hence this experiment.The objectives of the experiment were to evaluate the effectiveness of pre-and post - emergence herbicides and to screen new herbicides for weed control in bean fields.

MATERIALS AND METHODS

The experiment was conducted at Selian Arusha region (1390 masl) Lambo Estate (1020 masl), and Lyamumgu Agric. Research Institute, (1268 masl) in Kilimanjaro region during the 1991-1993 long rainy season. Several herbicides were screened against grass and broad-leaf weeds in beans grown in well drained volcanic soils with over 1000mm of rain and good water holding capacity.

TABLE 1: Experimental treatment combinations.

Treatment		Pre-op Post Emergence	Rate (litres/ha)
1.	Weed free up to 35 DAP	Post	Two hand weeding
2.	Galex 500 EC	Pre -	5.0
3.	Stomp 500 EC	Pre -	3.0
4.	Pursuit Plus	Pre -	3.0
5.	Flex	Post -	1.5
6.	Fusilade	Post -	2.0
7.	Fusilade (1.0l/ha) 14 DAP + Flex(1.0l)21DAP	Post -	1:1
8.	Unweeded control	-	None

TABLE 2: Herbicide specifications.

Common Name	Trade Name	Formulation	Manufacturer/ Distributor
1. Metalachlor + Metabrumuron	Galex 500 EC	250g/litre metalachlor 250g/litre metabrumurow	Ciba. Geigy
2. Pendimethalin	Stomp 500 EC	500g/litre pendimethalin	Rhone-Poulenc
3. Imazethapyr + Pendimethalin	Pursuit Plus	22.5g/litre imazethapyr 322.4g/litre pendimethalin	Rhone Poulenc
4. Fomesafen	Flex	250g/litre Fomesafen	Twiga
5. Fluazifap	Fusilade	125g/litre Fluazifap - P-butyl	Twiga

The plot size was 8 rows x 8m long and the net plot was 4 rows x 6m long. Bean seed variety Lyamungu 85 was sown in April at a spacing of 0.5 m x 0.2m x 2 seeds/hill between and within row respectively. Calcium ammonium nitrate (CAN) and Triple superphosphate (TSP) were applied at planting at the rate of 30 and 26 kg/ha N and P, respectively. Other recommended agronomic practices of the Northern Tanzania were practised.

Pre - emergence herbicides were applied on a moist soil and post - emergence herbicides were applied 14 and 21 days after planting (DAP). The herbicides were applied by using a solo sprayer fitted with a herbicide nozzle at manufacturer's recommended rates (Table 1) and were mixed with water at 200l/ha. The weed free treatment was first weeded 15 DAP and second weeding was carried out 30 to 35 DAP.

Observations were made on weed cover, bean tolerance to herbicides, pods/plant, plant height, hundred seed weight, comparative economic gains and bean seed yield. The weed cover and tolerance of beans to the applied herbicides were visually rated two weeks after application of each treatment on a 1-5 scale where 1 = complete crop tolerance and weed - free (20 percent weed cover/ tolerance) while 5 = highly susceptible to applied herbicides and complete weed cover (100 %). The scoring was then converted to percentages. The experimental design was a randomized complete block design with four replications. A factorial analysis of variance was conducted for appropriate data interpretation involving sites and treatments combined over three years as replication.

RESULTS AND DISCUSSION

The results on the effect of the herbicides on weeds and bean seed yield are summarized in Table 3-6. The most common weeds observed in the three experimental sites were *Bidens pilosa, Galinsoga parviflora, Tagetes minuta, Datura stramonium, Nicandra physalodes, Oxygonum* spp. *Argemone mixicana, Portulaca oleracea, Tricbodesma* spp and *Commelina* spp. representing broad-leaf weeds. *Setaria, Digitaria,* Panicum and Sorghum spp. were commonly observed grass weeds and *Cyperus* spp was predominant in the Selian experimental site. Pre-emergence herbicide treatments controlled broad-leaf and grass weeds at least for 30 days after germination. The performance of unweeded control was similar to herbicide treatments and weed free plots in plant height, pods per plant and hundred seed weight (Table 3 and 6). Plant height and pods per plant were only significantly affected by treatment combinations at Lambo and Lyamungu (Table 4 and 5).

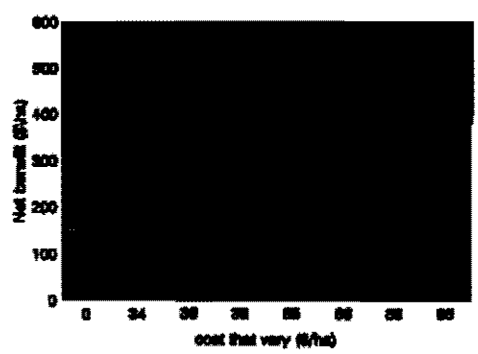
Percent weed cover, bean tolerance to herbicides and bean seed yield were significantly affected by treatment combinations (Table 3-6). Weed free up to 35 DAP had the lowest percent weed cover and was reflected in high bean seed yield. The significance in yield differences could be explained by 99 percent weed cover recorded from unweeded control as compared to 20 percent weed cover from weed free plots. The highest bean seed yield therefore was realized when plots were kept weed free up to 35 DAP. Herbicides and weed free treatments significantly outyielded the unweeded control in bean seed yield with exception of Fusilade. Data on pods per plant demonstrated that the yield component was not affected significantly by weed density. There was no significant relationship between weed density and pods per plant although high weed density produced low pods per plant as observed in Fusilade and unweeded control treatments. However, bean seed yield significantly corresponded with weed density. Fusilade and unweeded control reduced bean seed yield by 52 and 61 percent, respectively, as compared to weed free up to 35 DAP possibly due to high weed density and/ or competition as supported by de Groot *et al*; (1979); Nieto *et al*; (1968) and Ariga (1991).

However, bean seed yields obtained from Galex 500 EC, Stomp 500 EC, Pursuit Plus (Pre-emergence) and Fusilade + Flex combination (Post - emergence) were comparable with weed free up to 35 DAP but significantly higher than unweeded control (Table 6). Similar results were reported by Muthamia (1991) and Gondwe (1989). The three pre-emergence herbicides effectively controlled grass and broad- leaf weeds and produced similar bean seed yield as weed free up to 35 DAP but were weak against *Cyperus* spp, *Oxygonum, Argemone mexican, Tagetes minuta,* *Commelina* spp, *Portulaca* spp *and Nicandra* spp. In addition, Stomp 500 EC and Pursuit Plus did not effectively control *Bidens pilosa*, an observation supported by Muthamia in (1989).Flex a broad-leaf weed killer suppressed weeds more than Fusilade, a grass weed killer showing that broad-leaf weeds predominated the sites and had more suppressive effect on bean seed yield than grass weeds as demonstrated by seed yield recorded from Fusilade plots. Specific herbicides either for grass or broad-leaf weeds are not economically viable for resource-poor farmers unless such weeds are predominant in the location. Fusilade treatment did not suppress broad-leaf weeds and scored 79 percent weed cover as compared to 44 percent score for Flex treatment indicating that control of grass weeds in a situation where broad-leaf weeds predominate is a waste of herbicide, money and time. Flex, on the other hand, controlled broad-leaf weeds and suppressed grass weeds temporarily and hence low weed cover and increased bean seed yield similar to pre-emergence herbicides. Bean plants were tolerant to tested herbicides except Flex which caused brown spots on the leaf but grew out of it. A combination of Fusilade and Flex effectively controlled grass and broad-leaf weeds resulting in increased seed yield similar to weed free plots hence supporting findings by Muthamia (1991) and Mburu (1991). The performance of Pursuit Plus, a test material was comparable to the recommended herbicides like Galex 500 EC and Stomp 500 EC and weed free up to 35 DAP and was consequently identified as a potential pre-emergence herbicide for Northern Tanzania. Significant site x treatment interactions were observed in plant height, pods per plant and bean seed yield.

Differences were observed at Lyamungu where plants were significantly shorter than plant height at the other sites and Selian recorded significantly higher pods per plant and consequently produced significantly higher mean seed yield than Lambo and Lyamungu. Further screening of newly manufactured herbicides from different companies is necessary to control some of the common weeds which persisted against the tested herbicides in order to minimize weed competition, increase bean seed yield and benefit future bean producers.

It is important to pay attention to economic benefit of the varying treatments in addition to yields. Increase in yield may not be enough to compensate for the increased costs of production. Judging from Dominance and marginal analyses it is clear that farmers are economically benefiting by controlling weeds through the spray of Galex 500EC or stomp 500EC rather than by weeding twice (table 7, 8 and Figure 1.)

Figure 1:
Net Benefit for herbicide screening experiment on beans



For every dollar invested in purchasing and spraying Galex 500 EC or Stomp 500EC will generate U$ 17.5 and U$ 6.8 respectively (Table 8): Weed free up to 35 DAP will only generate U$ 0.81 due to high labour cost for labour intensive commo- duties like dairy cattle, coffee and horticultural crops. On the other hand Pursuit plus, Flex, Fusilade and their combinations were not economical for weed control since their costs increased with decreased net benefits.

CONCLUSION

Weed free bean fields would be an ideal crop husbandry but not practical. Growing beans without adequate weed control is a major constraint in bean production. High bean seed yield was related with minimum weed competition. Bean plants were tolerant to herbicides except Flex which caused brown spots on the bean leaves but beans recovered shortly. Flex controlled broad-leaf weeds and suppressed grass weeds temporarily resulting in increased bean seed yields similar to pre-emergence herbicides.

The most common weeds observed in the three experimental sites were *Bidens pilosa, Galinsoga parviflora, Tagetes minuta, Datura stramonium, Nicandra physalodes, Argemone mexicana, Portulaca oleracea, Oxygonum, Trichodesma and Commelina* spp representig broad-leaf weeds. *Setaria, Digitaria, Panicum* and *Sorghum* spp were common grass weeds and *Cyperus* spp was predominant in the Selian site.

Pre emergence herbicide treatments controlled broad leaf and grass weeds for at least 30 days after germination. Weed cover, bean tolerance to herbicides and bean seed yield were significantly affected by treatment combination. Unweeded control recorded 99 percent weed cover and produced only 766 kg/ha or 61 percent yield reduction compared to weed free plots. Bean seed yield obtained from Galex 500 EC, Stomp 500 EC, Pursuit Plus and Fusilade + Flex combination were comparable to weed free up to 35 DAP but significantly higher than Fusilade and unweeded control. For every dollar invested in Galex 500 EC or Stomp 500 EC a farmer was able to US$ 17.5 and US$ 6.8, respectively as compared to US$ 0.81 for the two hand weeding treatment. Pursuit Plus performance was comparable to Galex 500 EC and Stomp 500 EC, standard herbicides and hence a potential herbicide for use in Northern Tanzania but was weak against *Bidens pilosa* and not economically beneficial to farmers. It appeared that some weeds resisted the tested herbicides hence necessitating further screening of new herbicides to minimize weed competition, increase bean seed yield and benefit future bean researchers.

TABLE 3: Effect of herbicides on weeds and bean seed yield at Selian - Arusha

Treatment Combination	Weed Cover (%)	Bean Tolerance (%)	Plant Height (cm)	Pods/ Plant	100seed Weight (g)	Seed yield (kg/ha)
1. Weed free up to 35 DAP	20^{d}	20^{c}	44	10	52	2213^{a}
2. Galex 500EC	26^{d}	20^{c}	45	12	53	2271^{a}
3. Stomp 500 EC	40^{c}	28^{b}	42	9	54	1869^{ab}
4. Pursuit Plus	46^{c}	32^{b}	41	10	51	1880^{a}
5. Flex	40^{c}	64^{a}	43	12	49	1640^{ab}
6. Fusilade	78^{b}	20^{c}	41	10	53	878^{c}
7. Fusilade + Flex	44^{c}	66^{a}	40	12	54	1887^{a}
8. Unweeded control	100^{a}	20^{c}	41	9	54	1138^{bc}
Mean	48	34	42	1	52	1722
LSD (0.05)	12	9	NS	NS	NS	733
C.V (%)	14	15	5	16	4	24

TABLE 4: Effect of herbicides on weeds and bean seed yield at Lambo - Kilimanjaro.

Treatment Combination	Weed Cover (%)	Bean Tolerance (%)	Plant Height (cm)	Pods/ Plant	100/seed Weight (g)	Seed yield (kg/ha)
1. Weed free up to35 DAP	20^{d}	20^{d}	51^{a}	9^{a}	53	1733^{a}
2. Galex 500EC	24^{d}	22^{d}	50^{ab}	9^{a}	52	1600^{a}
3. Stomp 500 EC	46^{c}	24^{c}	48^{bc}	8^{a}	51	1610^{a}
4. Pursuit Plus	50^{d}	40^{b}	49^{ab}	8^{a}	52	1491^{ab}
5. Flex	46^{c}	64^{a}	48^{bc}	7^{b}	50	1376^{ab}
6. Fusilade	84^{b}	20^{d}	49^{ab}	6^{b}	46	1084^{b}
7. Fusilade + Flex	46^{c}	62^{a}	46^{c}	8^{a}	48	1284^{ab}
8. Unweeded control	100^{a}	20^{d}	49^{ab}	5^{c}	50	393^{c}
Mean	52	34	49	7	50	1321
LSD (0.05)	9	5	3	2	NS	508
C.V (%)	10	8	3	16	7	22

TABLE 5: Effect of herbicides on weeds and bean seed yield at Lyamungu - Kilimanjaro

Treatment Combination	Weed Cover (%)	Bean Tolerance (%)	Plant Height (cm)	Pods/ Plant	100seed Weight (g)	Seed yield (kg/ha)
1. Weed free up to 35 DAP	20e	20^{c}	51^{a}	10^{a}	50	1955^{a}
2. Galex 500EC	28de	22^{c}	48^{b}	8^{bc}	50	1491^{bc}
3. Stomp 500 EC	42^{cd}	40^{b}	46^{b}	9a^{b}	50	1505^{bc}
4. Pursuit Plus	54^{c}	38^{b}	47^{b}	8^{bc}	50	1256^{cd}
5. Flex	46^{c}	72^{a}	42^{c}	9^{ab}	50	1438^{bc}
6. Fusilade	76^{b}	20^{c}	47^{b}	7^{c}	49	855de
7. Fusilade+Flex	44^{cd}	70^{a}	43^{c}	8^{bc}	51	1701^{ab}
8. Unweeded control	96^{a}	20^{c}	52^{a}	7^{c}	48	766^{e}
Mean	50	38	47	8	50	1371
LSD	18	14	3	2	NS	411
C.V. (%)	21	22	4	12	3	7

TABLE 6: Effect of herbicides on weeds and bean seed yield in Northern Tanzania combined over sites and seasons.

Treatment Combination	Weed Cover (%)	Bean Tolerance (%)	Plant Height (cm)	Pods/ Plant	100seed Weight (g)	Seed yield (kg/ha)
1. Weed free up to 35 DAP	20^{d}	20^{c}	49	9.5	51	1967^{a}
2. Galex 500EC	25^{d}	21^{c}	47	9.7	52	1787^{ab}
3. Stomp 500 EC	43^{c}	34^{b}	45	8.8	52	1661^{ab}
4. Pursuit Plus	50^{c}	37^{b}	45	8.8	52	1661^{ab}
5. Flex	44^{c}	66^{a}	44	9.5	50	1485^{b}
6. Fusilade	79^{b}	20^{c}	45	7.5	49	939^{c}
7. Fusilade+Flex	44^{c}	66^{a}	43	9.4	51	1624^{ab}
8. Unweeded control	99^{a}	20^{c}	47	6.8	50	766^{c}
Mean	50	36	46	8.8	51	1471
LSD	8	6	NS	NS	NS	437
C.V. (%)	16	18	10	36	10	32

TABLE 7: **Dominance analysis for herbicide screening experiment on beans.**

Treatment No.	Treatment Name	Total cost that varies (US $/ha)	Net Benefit (US $/ha)
8	Unweeded control	0	226
3	Stomp 500EC (3l/ha)	34	456
2	Galex 500EC (5l/ha)	36	491
4	Pursuit plus (3l/ha)	38	417^{D}
6	Flex (1.5l/ha)	65	373^{D}1
1	Weed-free up to 35DAP (Two Hand Weedings)	66	514
5	Fusilade (2l/ha)	86	393^{D}
7	Fusilade + Flex (1+1l/ha)	86	393^{D}

TABLE 8: **Marginal analysis for herbicide screening experiment on beans.**

Treatments	Cost that vary(U$/ha)	Marginal Costs(U$/ha)	Net Benefits (US$/ha)	Marginal Net benefits	Marginal Rate of Return
Unweeded control	0		226		
Stomp 500EC	34	34	456	230	6.8
Galex 500EC	36	2	491	35	17.5
Weed-free up 35 DAP	66	30	514	25	0.8

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APPENDIX: PARTIAL BUDGET FOR HERBICIDE SCREENING EXPERIMENT ON BEANS

TREATMENTS

	1	2	3	4	5	6	7	8
Average yield (kg/ha)	1967	1787	1661	1542	939	1485	1624	766
Adjusted yield (kg/ha) (10%)	1770	1608	1495	1388	845	1337	1462	689
Gross field benefits (US $/ha)	580	527	490	455	277	438	479	226
Cost of Treatment (US $ /ha)	66	32	30	34	82	61	82	0
Total costs that vary (US $ /ha)	0	4	4	4	4	4	4	0
Net benefits (US $/ha)	66	36	34	38	86	65	86	0
	514	491	456	417	191	373	393	226

NB: Market price. US$ 0.33 per kg of beans

US$ = 610 T.Shs

POTENTIAL OF CLIMBING BEANS IN NORTHERN ZAMBIA

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ABSTRACT

Beans constitute an important source of vegetable protein in Zambia and is consumed as a popular relish in both rural and urban households.

Beans produced in Zambia is dominated by dwarf types which are adapted to a wide range of soil and climatic conditions. Despite a wide adaptation, over 60% of beans produced comes from Northern Zambia with rather low yields of around 300 kg/ha. Semi climbing types which are slightly higher yielding are often grown intercropped with maize as a minor early season crop. True climbing types which are higher yielding and take longer to mature are not common.

Introductions of true climbing types from CIAT were first evaluated in Eastern Zambia in 1987 where they performed poorly by averaging 292 kg/ha as a result of a short season. In Northern Zambia where the growing season is longer but grown on an infertile site gave mean yields of 710 and 786 kg/ha in 1993 and 1994 respectively. Future research is expected to lead to a better production and management strategy beneficial to small holder farmers who mostly cultivate beans in Zambia.

INTRODUCTION

Dry beans in Zambia constitute an important source of vegetable protein and is consumed as a popular relish in both rural and urban households.

The crop is adapted to a wide range of soil and climatic conditions and is grown for sale and domestic consumption by many smallholder farmers. The dwarf types are the most predominant in the country for both production and consumption (Kannaiyan *et al* 1987, Reddy *et al* 1989).

Bean production in Zambia is most successful in areas of cool weather with a longer period of rainfall and the main bean crop is planted relatively late in the rainy season: in January or February when the rains begin in November. Most areas of Northern Zambia have this type of environment and accounts for over 64% of production with rather low yields of around 300 kg/ha(Kannaiyan *et al* 1989).

The breeding program has had a considerable progress in identifying dwarf bean varieties adapted to Zambian conditions. The variety Carioca from Brazil which is distinctly high yielding gives more than a tonne/ha against 200-300 kg/ha by local varieties was released in 1984. The variety has however, not been accepted by consumers on account of taste.

Zambian consumers have very difficult tastes. While it is difficult to clearly determine bean types acceptable to consumers, certain types can be automatically excluded as they are not liked such as black and small dark red. For popular types in addition to speed of cooking, large mixed white and yellow kidney, large cream/pale brown kidney seed with and without red or purple speckling are preferred(Kannaiyan *et al* 1987). When Carioca is being rejected, one of the reasons given for rejection is that it tastes like Cowpeas (*Vigna unguiculata*) which suggests flavour as one of the criteria for acceptance. Efforts are being put in replacing Carioca and A197 with many acceptable characteristics which has been identified and pre-released.

Since most farmers grow maize as their major crop and some even intercrop it with semi climbing beans, an attempt is being made to introduce true climbing types. An earlier attempt to evaluate introductions of climbing beans from CIAT in Eastern Zambia in 1987 was not very successful. The area where the evaluations were conducted has a short rainy season which contributed to the low average yields of 292 kg/ha(Reddy *et al* 1989).

This paper has results of another attempt to evaluate climbing beans and their effect on maize but this time in Northern Zambia where conditions seem ideal.

MATERIALS AND METHODS

A field experiment on Climbing Beans was conducted at Misamfu Research Center from 22 December 1992 to 15 May 1993 and 21 December 1993 to 12 May 1994. Misamfu Research Center (10^0 10' S and 31^0 10' E altitude 1384m) is located 7 km away from Kasama town a Provincial Center of Northern Province.

Soil type at the experimental site is deep, strongly leached, acid (pH 4.2 - 4.4 ($CaCl_2$)) and a low mineral content through out the profile. The area has subtropical climate with average annual rainfall of 1360mm (Van Sleen 1976). Total rainfall throughout the experimental period was 1344mm in 1993 and 1255mm in 1994. Pan evaporation for two seasons was less than the rainfall. Temperature and solar radiation were generally favorable during the course of the experiment.

Nine climbing bean varieties (VRA 81054, ZAV 83052, ACV 55, ACV 8312, ACV 84029, ACV 84032, ACV 84034, ZAV 8313, LOCAL) and one maize variety(MM604) were used in the experiment in 1993 and six climbing bean varieties(VRA 81054, ACV 8312, ACV 84029, ACV 55, ZAV 8313, LOCAL) and the same maize variety were used in 1994. The varieties were planted in plots measuring 4m x 3m arranged in randomized complete block design with 4 replications. In each plot 4 rows were used spaced 0.75m apart with seed planted 0.30m at the same time and in the same hole as maize within the row. An extra plot of sole maize was included in 1994 to assist in estimating the effects of climbing beans on maize. A path way of 1.0m was used to separate the blocks.

Disc ploughing and harrowing was performed on the experimental site and D compound fertilizer (10%N, 20%P,10%K, 9%S) in 1993 and (10%N, 20%P,10%K) in 1994 at the rate of 200 kg/ha was broadcast by hand before making ridges and planting. Top dressing using ùrea (46%N) was applied at the rate of 200 kg/ha when maize had reached 30cm height. No other cultural practices were performed after top dressing.

RESULTS AND DISCUSSION

Climbing beans perform well when provided with a support on which to climb. In Zambia, maize is the major cereal and provided the best candidate for supporting climbing beans in the experiment.

The majority of soils found in Northern Zambia are acid with very poor nutrient and base status. It has however, been found that acidity or low pH per se does not directly affect crop growth. Poor plant growth on these soils has been found to be caused by aluminium and/or manganese toxicity and/or by the deficiencies of plant nutrients (Mapiki and Phiri 1994).

The crops of 1993 were planted on a site that looked ideal at the time of land preparation but later turned out to be infertile and water logged. Low fertility and water logging did not just affect the crop but also hindered other field operations which resulted in higher infestation of weeds.

In the climbing beans trial, low fertility and most probably aluminium/manganese toxicities affected the maize crop most whose yields were insufficient to record but the stalks provided the much needed support for the climbing beans. The dwarf beans were also affected by the same conditions. The weeds and water logging are manifested in the high Coefficient of Variation and also not very good yields as shown in Table 1 and 2.

During the following season, the number of climbing bean entries was reduced and a provision was made for the evaluation of maize. In the dwarf beans only two entries including the two check entries A197 and ZPV 292 were retained the rest were replaced. Although site selection was improved upon, the results of both the dwarf and the climbing beans were not very good. The poor nutrient status of Misamfu soils necessitates use of inorganic fertilizers.

The analysis of the Zambian manufactured compound D fertilizer normally used in legumes contain: 10% Nitrogen, 20% Phosphorus, 10% Potassium and at least 9% Sulphur. This combination has been found to also work well in most other crops(Mapiki and

Phiri 1994). The foreign or imported fertilizers contains only NPK. This was the type of fertilizer which was used in the last experiment and resulted in poor maize and bean performance (Table 3 and 4)

The yields of climbing beans appear to be much better than those exhibited by dwarf beans probably due to nitrogen meant for maize. Apart from the nitrogen, the other stress conditions affected both crops equally and the good performance of climbingbeans indicates potential. Perhaps at better sites and good management climbing beans may yield even higher than what is shown.

TABLE 1: Yield of Climbing Beans in 1993.

Variety	Days to 50% Flowering	Grain Yield (Kg/Ha)	100 Seed Weight (g)
VRA 81054	49	584	32
ZAV 83052	46	627	36
ACV 55	51	704	35
ACV 8312	48	861	30
ACV 84029	48	773	32
ACV 84032	48	701	34
ACV 84034	50	722	31
ZAV 8313	50	691	37
LOCAL 43	732	32	
Mean	48	710	33
C.V %	3.11	27.10	8.7

TABLE 2: Yield of Large Seeded Dwarf Beans in 1993.

Variety	Days to 50% Flowering	Grain Yield (Kg/Ha)	100 Seed Weight (g)
A197	39	463	45
T23	40	356	40
CIFEM 87033	37	421	46
AFR 385	40	321	34
AFR 344	40	307	33
AND 71	38	264	33
DRK 24	39	414	42
NIC 138	41	531	18
RWR 129	38	312	32
SUG 56	40	232	37
ZPV 292	40	192	28
Mean	39	340	35
C.V %	2.0	32.46	6.22

TABLE 3: Yield of Climbing Beans and Effect on Maize in 1994.

Variety Flowering	Beans 50% (Kg/Ha)	Bean Yield Seed Wt (g)	Bean 100 LS*	Bean Disease Pod	Scab	Maize Yield (Kg/Ha)
VRA 81054	45	760	34.4	3	3	2767
ACV 8312	44	780	27.9	3	3	2616
ACV 84029	46	716	33.2	2	2	2717
ACV 55	52	820	34.5	3	3	2717
ZAV 8313	47	799	41.8	5	5	2850
LOCAL BEAN	45	841	33.9	4	3	2783
SOLE MAIZE	-	-	-	-	-	4189
Mean	46.1	786	34.1	3.0	2.8	2949
C.V %	1.7	16.5	5.4	41.9	44.5	22.7

LS* = Leaf Spot Disease (Scores: 1-9 Scale)

TABLE 4: Yield of Large Seeded Dwarf Beans in 1994.

Variety Flowering	Days to 50% (Kg/Ha)	Grain Yield Seed Wt (g)	100 LS*	Disease Score Pod	Scab
A197	42	430	53.8	4	3
A321	50	469	33.5	4	2
AFR 344	43	350	37.0	4	4
CAL 98	43	219	45.1	3	5
CIFEM 87033	44	242	47.8	4	5
GLP 1004	42	194	37.3	7	9
IKINIMBA	40	345	33.3	3	5
LYAMUNGU 90	43	239	43.3	3	7
PEF 14	40	213	36.2	7	7
ZPV 292	41	303	30.0	7	9
Mean	42.3	300.0	39.7	4.3	5.5
C.V %	1.7	61.3	11.6	23.9	32.1

LS* = Leaf Spot Disease (Scores: 1-9 Scale)

The effect of climbing beans on maize may be compensated by the higher yields of beans which in terms of money is better priced than maize.

Future research is therefore expected to be directed at achieving higher yields and also on how to reduce the effect of climbing beans on the maize.

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Q: RA Buruchara

1. Which are the names of climbing beans you used.

2. Did you consider alternative firms of stakes?

3. Are the types you used the vigorous or less vigorous?

A: JC Musanya

Eight climbing bean varieties from CIAT identified as VRA 81054, ZAV 83052, ACV 55, ACV 8312, ACV 84029, ACV 84032, ACV 84034 and ZAV 8313 plus one local entry from bala was used. These climbing bean types did not come with botanical descriptions from CIAT for us to know how vigorous they are. This is the reason why they are being evaluated on station first before exposing them to farmers. Alternative forms of stakes is being considered through a trial entitled evaluation of climbing beans using live support (maize) and dead support stakes. This trial is currently being evaluated at Nesamfu.

CRITERIA TO DEVELOP A SCREENING TECHNIQUE FOR A LOW-pH, LOW-P SOIL IN MALAWI: EFFECT OF PHOSPHOROUS ON GROWTH AND YIELD OF BEANS

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ABSTRACT

Beans are an important crop in Malawi and soils where they are grown are increasingly becoming infertile due to continuous cultivation and lack of restoration of fertility. Over a period of time these soils are also becoming more acidic due to leaching, thus reducing the availability of essential elements like phosphorous (P) to the crop. The problem of soil fertility can be corrected by use of chemical fertilizers, but few small scale farmers who grow this crop can afford them.

To overcome this problem the bean project in Malawi initiated a programme in the 1992-93 crop season to identify varieties tolerant to low soil fertility, particularly to a low pH-low P complex at Bembeke in Central Malawi situated at an altitude of about 1650m above mean sea level. This site had a pH varying between 4.6 to 5.0, low levels of available P (< 16ppm) and a high amount of aluminium. P was assumed to be tied to aluminium, thus making its levels low in the soil. Because of this the screening in the beginning was centred around the use of lime to release the tied P to aluminum. The use of liming, however, did not produce any significant response, but when P treatment was introduced, an immediate significant response to yield and other characters was observed.

The 1994-95 experiment whose results are being discussed here, had no liming treatment but had four P treatments of 0,20,40 and 60 kg/ha P. Six varieties were used. The trial was planted as a factorial design with four replications. Data was recorded on grain yield, nodule number, nodule weight, shoot dry weight and root dry weight.

A significant response was observed between 0P and 20P, where the grain yield increased by 56.3%, nodule number by 184.1%, nodule weight by 154.0%, shoot dry weight by 50.3% and root dry weight by 32.2%. Additional application of P produced additional increases but the increases were less dramatic, indicating that the soil was inherently low in available P. Since the response of P on nodulation was also significant and nodulation in turn was significantly correlated with yield, the study suggested that P probably might have caused a significant increase in nitrogen fixation, resulting in high yields. This made P to be an important factor in screening beans for tolerance to low soil fertility.

INTRODUCTION

Beans are an important crop in Malawi and soils where they are grown are increasingly becoming less fertile due to continuous cultivation and lack of restoration of soil fertility. Over period of time they are also becoming more acidic due to leaching, and thus reducing availability of essential elements like phosphorous (P) which gets tied up with aluminium in such soils. This problem can be corrected by use of chemical fertilizers but few small scale farmers who generally grow this crop can afford them. Growing of tolerant varieties can be another possibility if such varieties can be found or developed. They can particularly be of great help to the resource poor farmers, majority of whom are women. But the most important factor in identifying such varieties is availability of a suitable screening technique which is reliable and easy to use, particularly when the soils are known to be highly heterogeneous in their physical and chemical properties.

Considering this problem, the bean programme in Malawi started screening bean genotypes a few years ago under a low pH soil at Bembeke in central Malawi, initially using lime to raise the soil pH. This was based on the assumption that aluminium toxicity probably was the only main limiting factor in acid soils, and that this problem could be corrected by using lime. When this work was started in 1992-93, no fertilizer treatments other than lime, therefore, were applied. This caused a severe fertility stress that drastically reduced the plant growth and yields, resulting in a situation where it became difficult to distinguish among the varieties. However, in spite of poor growth, a limited linear response to liming was observed, which could not be fully explained. It was assumed that probably lack of other nutrients such as nitrogen, zinc and boron, which are usually low in the Bembeke soils, might have caused this response (Aggarwal *et al*, 1994). It could also have been caused by the possibility that the amount of P in the soil to start with was so limited and even if all of it was tied to aluminium, it could only have produced a limited response when released by liming.

In the following year, 1993-94, the experimental treatments were modified. Two levels of P (0 and 20 kg ha^{-1}) and four levels of liming (0, 25, 50 and 100% neutralisation levels) were selected and were applied in a split-plot design where P treatments were in the main plots and liming in the sub-plots. In addition, a basal dose consisting of N (30 kg ha^{-1}), K (30 kg ha^{-1}), Zn (Zinc Oxide 5.0kg ha^{-1}) and B (Borate 0.5kg ha^{-1}) was applied to the soil before planting to raise the fertility to a more realistic level generally found at the farm level (MCT and SCT, 1993-95). Unfortunately liming again did not produce any real response. P, on the other hand, produced a significant effect, indicating that it could be the most limiting factor at the experimental site (Aggarwal et al, 1994). Based on these results, 1994-95 work, details and results of which are discussed in this paper, was again modified.

MATERIALS AND METHODS

Considering the significant response observed to added P in the 1993-94 experiment, the liming treatment was completely removed in the 1994-95 experiment. The basal dose was maintained as applied in the 1993-94 experiment, but doses of P were increased from two to four (0, 20, 40 and 60 kg ha^{-1}). The number of varieties used were six. The experiment was conducted at the same site at Bembeke where previous years' trials were conducted. The field design was a factorial with four replications, where P treatments and varieties within each P treatment were completely randomized. The plot size was four rows, 4m long with a distance between and within the rows of 0.60m and 0.10m, respectively. Central two rows were reserved for measuring the grain yield. Ten plants from the border rows were harvested at mid flowering to measure shoot dry weight, root dry weight, nodule number and nodule weight. Averages were used in the statistical analysis done using the MSTAT software on a PC.

RESULTS AND DISCUSSION

A significant increase ($p < 0.001$) was observed in all the five characters with the initial 20 kg ha^{-1} of P application. Grain yield increased by 56.3%, shoot dry weight by 50.5%, root dry weight by 32.3%, nodule number by 184.1% and nodule weight by 154.0%. Although all characters increased with additional P up to 60 kg ha^{-1}, the amount of increase was relatively small (Table 1). Regression analysis to look at the incremental affect of the added P on yield and other characters, showed that adding one kg of P ha^{-1} increased grain yield by 12 kg ha^{-1}; nodule number by 1.2 $plant^{-1}$; nodule weight by 0.002 g $plant^{-1}$; root weight by 0.006 g $plant^{-1}$; and shoot weight by 0.03 g $plant^{-1}$. The results obtained in this study indicated that the trial site was inherently very low in P such that a limited initial dose of P was able to induce such a significant response. Grain yield was also positively and highly significantly correlated with both root and shoot weight (Table 2).

Another interesting observation was that P application not only increased the grain yield, but it also increased the nodulation, both in terms of nodule number and weight. The increased nodulation appeared to have greatly influenced the yield as indicated by a highly significant positive correlation between yield and these two characters; nodule number ($r = 0.53$) and nodule weight ($r = 0.54$). It also showed that probably P played a much greater role in nitrogen fixation. Poor nodulation in beans is quite common, and a starter dose of N is usually recommended to give an initial boost to growth. But the results obtained in this study indicated that increased availability of P in the soil appeared to be an important factor to increase nodulation (Beck, 1994), which in return might have improved the nitrogen fixation.

The results of this and the previous years' trials have shown clearly that P was the limiting factor in the low pH soils at the Bembeke Experimental Site. The low level of P at this site did not seem to be tied to aluminium as assumed earlier or the amount tied was extremely low, because liming in the previous two years had failed to bring any significant difference in yield and other characters. When the P treatment was first introduced in 1993-94, it produced a significant response the very first time, clearly indicating that it was the most important limiting element in the soil. This year's results have further confirmed this observation. Similar observations have been made by other researchers where significant increases in yield have been obtained by adding P in the soil (Whiteaker *et al*, 1976; CIAT, 1982). Based on these results it can now be reasonably concluded that while selecting varieties tolerant to low fertility P should be given priority in the selection process.

The low pH soils at Bembeke Experimental Site might be extremely stressed in fertility as compared to farmers' fields, but they do represent a common problem of low fertility found at the smallholder farm level, particularly with those farmers who have limited land for rotation and do not use chemical fertilizers. For such farmers growing of tolerant varieties can be an attractive option. Selection of such varieties can be successfully done at the research stations, but the soils at these places are generally not similar to those at the farmers' fields. For the varieties to be better adapted to the low fertility conditions existing at the farmers' fields, it might be advisable to locate part of the testing at the farm level at an earlier stage. This might help to improve the overall efficiency of the selection process.

A large number of germplasm lines (about 720) originating from various sources were screened at the same site where this trial was conducted using two P treatments i.e. 0P and 30 kg P/ha, respectively. The mean yields increased significantly in all cases when P was applied (Table 3) irrespective of the nature of the germplasm evaluated, further suggesting the importance of P in the Bembeke soils. This screening also helped to identify several germplasm lines which did quite well under 0P (Annual Report, Malawi Bean Research Programme, 1994-95). These lines are expected to be tolerant to the low pH-low P complex found at the Bembeke Research Station. But these results need to be further verified.

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Q: AJ Liebenberg

Did you add Mo to the P treatment to enhance the BNF? (At Cedara Mo had a positive effect).

A: Vas Aggarwal

No

Q: S Koch

Whether Rhizobium inoculants was used.

A: V Aggarwal

No - relide on natural populations of Rhizobium.

Comments by Koch:

We do not have a natural *Rhizobium* for beans in our soil in Africa. Rhizobium is also sensitive for Al^{+++} toxicity and this must be taken into consi-deration. Nodulation must also be taken in consideration in breeding.

TABLE 1: Response of selected bean varieties to different levels of phosphorous in a low fertility, low pH soil at Bembeke, Malawi, 1994-95.

Variety	Yield kg ha^{-1}				Shoot dry wt g plant^{-1}				Root dry wt g plant^{-1}				Nodule number plant^{-1}				Nodule wt g plant^{-1}			
	0 P	20 P	40 P	60 P	0 P	20 P	40 P	60 P	0 P	20 P	40 P	60 P	0 P	20 P	40 P	60 P	0 P	20 P	40 P	60 P
AND 873	672	979	1212	1214	1.87	3.44	3.56	3.52	0.57	1.13	1.05	1.00	14.0	46.3	80.4	51.0	0.03	0.09	0.17	0.11
RWR 221	724	932	1037	1521	2.90	2.97	4.12	4.36	0.65	0.55	0.81	0.94	30.6	52.3	76.2	94.5	0.10	0.17	0.18	0.21
DRK 57	537	1047	1167	1526	1.45	2.86	3.06	4.37	0.63	0.80	0.94	1.00	9.6	85.1	84.1	115.7	0.04	0.18	0.17	0.31
RIO TIBAJI	547	943	1000	1338	1.64	2.48	2.46	4.12	0.58	0.76	0.86	1.07	16.7	34.1	41.0	88.1	0.04	0.06	0.09	0.15
CAL 143	745	1026	1120	1453	1.72	2.68	3.15	2.89	0.55	0.68	0.76	0.81	35.0	75.9	97.5	73.7	0.06	0.14	0.13	0.17
PHALOMBE	453	818	672	1115	1.98	2.93	3.40	4.36	0.59	0.79	0.86	1.01	11.3	38.8	83.1	136.5	0.03	0.13	0.23	0.22
Mean	631	958	1035	1361	1.92	2.89	3.29	3.93	0.59	0.78	0.88	0.97	19.5	55.4	77.0	93.2	0.05	0.13	0.17	0.20
SE var.	47.8				0.19				0.04				9.15				0.02			
SE fert.	59.0				0.20				0.03				7.01				0.01			
SE F x V	95.7	56.3			0.38				0.08				18.3				0.03			
CV%	19.3				25.8				20.7				59.7				46.3			
% increase			8.1	31.5		50.5	13.8	19.5		32.2	12.8	10.2		184.1	39.0	21.0		160	30	17

TABLE 2: Correlations regression of various plant characteristics in a low fertility, low pH, soil at Bembeke, 1994-95.

	Correlations						Regression
	Yield kg ha^{-1}	Nodule no.	Nodule wt.(g)	Root wt.(g)	Shoot wt.(g)	Fertilizer Level	Fertilizer Level
Yield kg ha^{-1}	-	0.536^{***}	0.544^{***}	0.517^{***}	0.632^{***}	0.77^{***}	12.0
Nodule no.		-	0.737^{***}	0.390^{***}	0.581^{***}	0.58^{***}	1.2
Nodule wt (g)			-	0.411^{***}	0.616^{***}	0.59^{***}	0.002
Root wt (g)				-	0.724^{***}	0.60^{***}	0.006
Shoot wt (g)					-	0.64^{***}	0.030

*** = $P < 0.001$

TABLE 3: Effect of 'P' on yield of bean germplasm evaluated at a low 'P' soil in Bembeke, Malawi, 1994-95.

		Mean yield (kg/ha)			
Germplasm Material	Entries	0 P	30 P	% Increase	Significance
BILFA	158	688	1030	49.7	***
CIAT Core Collection I	370	583	1344	130.7	***
Rwanda Germplasm	193	775	1373	77.2	***

SESSION 5

TECHNOLOGY TRANSFER AND SEED DISSEMINATION

CHAIRMAN : O.T. EDJE

FARMER EVALUATION OF EARLY GENERATION BEAN LINES IN TANZANIA: COMPARISONS OF FARMERS' AND SCIENTISTS' TRAIT PREFERENCES.

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ABSTRACT

The Washington State University - University of Idaho - Sokoine University of Agriculture Bean/Cowpea Collaborative Research Support Programme (CRPS) has been developing more effective methods for involving farmers in the evaluation of improved bean varieties. This has added to the breeder's understanding of farmer and consumer preferences. Until recently, farmers assessed the qualities of six generation plants and seeds. In 1994 the modelwas modified to compare the preferences of both farmers and scientists in third generation populations. The paper will discuss the rationale underlying the early evaluation model and present some of the findings we have documented to date.

INTRODUCTION

The Washington State University (WSU) - University of Idaho (UI) - Sokoine University of Agriculture (SUA) Bean Collaborative Research Support Program (B/C CRSP) was initiated in 1982. It began as a bean breeding program focused primarily on the development of multiple disease and insect resistant cultivars for smallholder farm families in the low - mid altitude regions of Tanzania. In these bean growing areas, approximately 20,000 ha are devoted to production of common beans (Wortmann and Allen, 1994). Beans are an important source of dietary protein for rural families. With the relaxation of the Tanzanian economy, and the growth of the urban population, they are rapidly becoming a source of cash for small holders as well.

In 1990, the B/C CRSP was modified to include a participatory research component to strengthen the breeding program. Our assumption was that increased involvement of smallholder farmers, particularly women farmers, in the evaluation and testing of promising cultivars, would result in varieties that were more acceptable to, and more widely used by, smallholder farmers and their families. Now, SUA B/C CRSP scientists actively engage smallholder bean farmers in the development and evaluation of improved bean lines.

For the first few years we concentrated on understanding farmers' preference criteria so that breeders could incorporate preferred qualities into selection decisions. We also looked to farmers' evaluations of improved lines in the F_6 generation in order to decide which of these lines were ready for release. For example, EP 4-4, was submitted for release in 1994 based on three years of farmer approval. This particular line is popular with farmers and consumers because of its red color which makes it more marketable than our earlier variety, SUA 90, which is tan in color. Otherwise both varieties have similar qualities that are well recognized by farmers: high yield, early maturation, drought tolerance, resistance to disease and insect pests, fast cooking and pleasing taste. When improved lines such as these are released, we hope that they will be adopted by smallholder farmers and combined into farmers' existing farming systems. We are not looking for a "wonder bean." Rather, we hope to generate varieties that farmers will mix with their own local varieties and crop combinations, thus achieving greater overall risk aversion.

Conventional plant breeding typically does not involve users in early phases of the breeding process. In developing countries, this is particularly problematic because of the heterogeneous, risk-prone farming environments encountered by smallholder farmers. As a result, improved varieties may be ill-suited to farmers' own farming systems and to their families' needs. Involvement of the customer in product development and improvement makes good marketing sense.

Recently we began to involve farmers and scientists jointly in evaluating early generation breeding materials. Three main factors prompted us to have both of these groups evaluate early generation materials. One was that we wanted to determine if farmers would identify and select variation not normally present in indigenous bean varieties. Second, additional knowledge of those traits emphasized by farmers compared to researchers should help in the breeding process. Third, do farmers and scientists say and do the same thing when selecting desirable lines?

This paper will describe the early evaluation approach being used and some of the preliminary findings which contrast and compare farmers' trait preferences with those of scientists and collaborating extension personnel. The purpose is not to show that one group is right and the other wrong; rather it is to illustrate some of the differences between the two groups, perhaps based on a differing set of goals, and to stress the usefulness of collaboration between the two in generating a better over-all product. We conclude with a few reflections and suggestions on the early evaluation methodology based on our experiences with participatory research in the B/C CRSP bean breeding program.

RATIONALE FOR EARLY EVALUATION

In order to better understand farmers' preference criteria, smallholder farmers have evaluated for the past five years promising F_6 bean lines developed by B/C CRSP scientists. This has been done using an informal interview process whereby we listen to, and document, exactly what both men and women farmers tell us as they observe, test and use the improved varieties at home. After three years we feel fairly confident that we have approximately 40 criteria (positive and negative) used by lowland area farmers to assess bean varieties (Table 1). We are now using these criteria in a more structured way to document farmers' and scientists' reasons for selecting early generation breeding materials.

In this earlier model, farmers did not become involved in breeding decisions until a much later stage -- perhaps after useful qualities were lost because they were not recognized by the breeder, and perhaps after selection decisions had been made that overlooked farmers' priorities, for example, seed color, seed shape, quality of cooked broth, and so on.

Farmers and scientists, particularly plant breeders, probably make selections based on different goals. Compared to a scientist's selections, a farmer's selections are more likely to be associated with potential adaptability of the material to his/her own farm, available local genetic materials, random outcrossing and mutations, less need for uniformity and a desire for long-term product generation. A breeder's choices, on the other hand, are more likely to be based on the need for broader adaptability, the desire for more uniformity, availability of worldwide genetic resources, more controlled crossing, need for many lines for evaluation per generation and long-term product generation.

The decision about whether to utilize findings from early generation selection or not may depend upon screening and evaluation procedures, heritability of traits, anticipated gain from selection, number of plant populations and families, seed availability, research facilities and logistical resources.

Table 1: Farmer evaluation criteria for common beans.

	Positives (+)	Negatives (-)
Leaves	1. Few leaves (allow pods to grow)	1. Many leaves (causes few pods)
	2. Leaf color good (dark green)	2. Leaf color bad (pale green, yellowish)
	3. Uniform leaf color	3. Spotted/mottled leaf color
	4. Leaves not hurt by disease	4. Leaves hurt by disease
	5. Leaves not damaged by insects	5. Leaves damaged by insects
	6. Leaves resistant to rain	6. Leaves damaged by rain
	7. Leave not skrinking/shriveled	7. Leaves skrinking/shriveled
Branches, Stems and Plants	8. Many branches	8 Few branches
	9. Strong stem (standing straight up)	9. Weak stem (falling over)
	10. Upright plants	10. Crawling plants (climbing)
	11. Small size plants	11. Large size plants
	12. Large size plants	12. Small size plants
	13. Plants tolerant to sun (drought tolerant	13. Plants not tolerant to sun (not drought tolerant
	14. Many flowers	14. Few flowers
	15. Flowers stay on plant	15. Flowers dropping
	16. Early maturing	16. Late maturing
	17. Continuous podding	17. No continuous podding
	18. No continuous podding	18. Continuous podding
	19. Tolerant to standing water	19. Not tolerant to standing water
Pods	20. Many pods	20. Few pods
	21. Pods high on plant (not touching the ground)	21. Pods touching the ground
	22. Thick pods	22. Thin pods
	23. Long pods	23. Short pods
	24. Pods not skrunken	24. Skrunken pods
Seeds	25. Many seeds in pods	25. Few seeds in pods
	26. Large seed size	26. Small seed size
	27. Small seed size	27. Large seed size
	28. Thick seeds (round)	28. Thin seeds (round)
	29. Thin seeds (flat)	29. Thick seeds (flat)
	30. Thin seed coat	30. Thick seed coat
	31. Color of seed good	31. Color of seed bad
	32. High yield	32. Low yield
	33. Seed not damaged (shriveled, wrinkled, insects)	33. Seed damaged (shriveled, wrinkled, insects)
Cooking Qualities	34. Broth thick	34. Broth thin
	35. Broth dark color	35. Broth light color
	35. Broth light color	35. Broth dark color
	37. Taste sweet	37. Taste not be sweet
	38. Cooks quickly	38. Takes long to cook
	39. Keeps well	39. Spoils quickly

Typically, early generation evaluation and selection is done by plant breeders, sometimes in cooperation with plant pathologists, entomologists, or other biological scientists. Involving the customer (e.g. consumers, farmers, vendors), and scientists from other disciplines, in early generation selection has a number of advantages. Some of these are:

- Materials are evaluated before breeder selection has been imposed, thereby increasing the likelihood that identified qualities will reflect customers' priorities, rather than only those of breeders.

- Qualities that are liked by customers, may be identified and this increases the likelihood of adoption.

- When we make an effort to listen to customers, and those who know a lot about these customers, we learn more about customers' knowledge of the product, their experience with the product (e.g. growing, selling, use), and this can lead to future use of the product.

- By bringing farmers into the early selection of materials, the wide range of choices offers the possibility of identifying variations not found in indigenous landraces. Compared to those varieties to which farmers may have access, this may be a great advantage to smallholder farmers. If customers' preferences are discarded by the breeder in the third or fourth generation, they are lost to customers later on.

- The usual breeding process could feasibly take anywhere from six to twelve growing seasons before the product reaches consumers. By bringing customers in earlier, we may eliminate unacceptable qualities at an earlier point, and could reduce generation time.

On the other hand, without careful planning, involving farmers and scientists in early generation evaluation can add to the cost in terms of time and money, especially if the assessment includes large breeding populations, and frequent evaluations each generation. It is therefore important to limit the size of the population to be evaluated. This must be balanced against the need for large populations in order to find individual plants with desirable gene combinations. Careful consideration must be given to the traits to be selected. First, trait heritablity dictates the method of selection. Heritability patterns are important in that they underlie each factor's potential to contribute to particular varietal qualities. For example, if low heritability traits are selected in an early generation, it is unlikely that the trait will be fixed in the future; whereas, when a high heritability trait is selected, the breeder can be more certain that the quality will be present in later generations. For some traits such as yield, selection will be ineffective in early generations on a single plant basis, and must be done in later generations on lines replicated over locations and years. Other traits such as maturity, some disease resistances, and seed color, have high heritabilities, and may be selected on a single plant basis in early generations (Singh, 1992). The second issue is that of visual selection versus the need for direct measurement of a trait. Yield has not been amenable to visual selection even on a replicated plot basis, but many other traits can be discriminated visually without resorting to direct measurement. In farmer evaluations, trait assessment must be done visually. As a consequence of these two constraints, traits should possess medium to high heritability, and should be amenable to visual evaluation. Other potential problems are associated with the amount of data organization and analysis, the increased planning and logistical arrangements required, and the possible difficulty that evaluators may have in identifying certain traits, for example disease and insect resistance.

PURPOSE OF STUDY

Our purposes in carrying out early generation evaluation were to compare scientists' and smallholder farmers' breeding selections in order to 1) determine what traits, if any, are emphasized by both groups, and 2) determine if novel traits or phenotypes have been identified. Ultimately, we are striving for a better blend between farmers' more gradual adaptive systems of crop improvement and scientists' more purposive and sophisticated approaches to crop improvement.

METHODS

Common bean (*Phaseolus vulgaris* L.), is typically a self-pollinating species. Breeding methods employed for self pollinators rely on making crosses to achieve recombination followed by self-pollination for 6 - 8 generations to produce homozygous lines. Lines may be derived by bulk, pedigree, or single seed descent selection from early generations. Selections may be made in any generation after the F_1, with high heritability traits such as growth habit, seed color, and some diseases resistances being selected early, and lower heritability traits, such as yield, being selected in later generations. In addition to this process, early generation testing can identify hybrid populations that are likely to contain a greater frequency of superior inbred lines. This may involve conducting replicated trials of the segregating plant populations in the F_2 or F_3 generations. Selected populations can then be inbred by any of the methods mentioned above.

This paper reports on the early evaluation of two relatively small populations. The evaluations took place during the F_3 and F_5 generations. Each session involved approximately the same number of farmers and scientists. Since the complete set of data has not yet been fully analyzed, findings should be viewed as tentative. Because the evaluation model is still being adapted and improved, and the team is still learning about the process, observations are preliminary. This process should tell us more about the differences between farmers' and scientists' preferences, and about appropriate methodologies for early generation evaluations.

THE BREEDING LINES

F_1 seeds were planted in the screen house and at Morning Side (a higher altitude site used to accommodate two plantings per year) to obtain F_2 seeds. The F_2 seed was planted at Morning Side, and each F_2 plant was harvested separately to obtain F_3 seed. One hundred F_3 lines and 36 F_3 lines of the crosses SUA 90 x *Kablanketi* and EP 4-4 x *Kablanketi*, respectively, were grown in 10 plant rows at the Mafiga farm. Initially they were grown 20 cm within a row, and 50 cm between rows, later increasing the distance between rows and plants to give more space to evaluators for inspection. Recommended lowland cultural practices were applied. At the time of evaluation, the F_3 plants were still segregating for various traits including plant type, reaction to diseases and others. A heavy virus infestation was noted in the F_3. The F_4 and F_5 lines were planted at Mafiga and Morning Side.

EVALUATION PROCEDURES

Preceding the first evaluation of F_3 materials, members of the B/C CRSP team (breeders, extension agents and specialists, graduate students) developed and modified the interview form, and planned field methods. With some exceptions, the evaluator teams consisted of 12 farmers who were experienced in bean plant/seed evaluation, and 12 scientists from biological and social science disciplines (including plant breeders and extension specialists). Both men and women were included on each team. Three sets of selections occurred: random from the population, scientist selections, and farmer selections. In the F_3 generation, single plants were assessed. Each plant and line was numbered in the field in advance. Evaluators considered specific traits as well as overall plant qualities. In F_5, plants were assessed by line, again including trait assessment. Farmers were brought to the research plots early in the morning, and their task was completed by noon. Following instructions, they examined the populations in order to identify the best 5 lines, the worst 5 lines, and within the best line, 5 of the best plants. "Best" and "worst" lines were identified by placing colored flags beside the respective rows. Then farmers were asked to give specific reasons for each of their choices. This was recorded by interviewers. Scientists' evaluations followed the farmers' session using similar procedures. Codes were assigned to criteria categories (Table 1) and these were used by interviewers to document what farmers said, and to capture scientists' assessments. No restriction was placed on the number of reasons that could be given by either group. F_3 seed evaluation took place in the field, however we moved F_4 and subsequent seed evaluations to a SUA lab (for scientists), and to the village (for farmers).

DATA ANALYSIS

Traits were grouped by investigators according to the perceived linkages among them. Figure 1 illustrates relationships among traits used in early generation evaluation, with arrows showing how one trait is linked to another. Based on this model, and the frequency of farmers' preferences noted at F_5 (Table 2), 6 trait categories were used for analysis: yield components, abiotic stresses, biotic stresses, maturity, plant architecture and seed characteristics (Table 3). The frequency of reasons given for the "best" 5 varieties was tabulated within the 6 categories. Farmers' reasons were compared to scientists' reasons. Individual traits were examined for their tendencies toward high, medium or low heritability (Table 4) (Singh, 1992).

FINDINGS

F_3 Generation Evaluations

Farmers' and scientists' reasons for selecting the best F_3 plants were compared (Table 5). While scientists provided more reasons than did the farmers for explaining their selections, there was general agreement that many pods, probably reflective of both groups' interests in high yield, was considered the most important trait. Farmers placed second priority on dark green leaves, third priority on upright plants, and fourth priority on large plants. Scientists placed second priority on upright plants, third priority on dark green leaves and large plants, fourth priority on pods not shrunken, and fifth priority on leaves not shriveled. Other than the difference in the number of reasons presented, there appeared to be considerable agreement across the two groups.

At this early stage of selection, heritability factors provide important signals for the likelihood of achieving certain future product qualities. Dark green leaves, and upright plants have medium - high heritabilities, and many pods have low heritability. The two traits that seemed to be more important to scientists than farmers, leaves not shriveled and pods not shrunken, have medium - high heritability. These may represent selection for resistance to viruses.

The F_3 seed evaluation tended to reflect some farmer - scientist agreement on the importance of two traits even though scientists indicated many more preferences than did farmers. Both groups placed first priority on seed color, and second priority on high yield. Of the two, only seed color has a high heritability. Unlike scientists, farmers also liked thick round seeds, and taste was a consideration. Scientists, on the other hand, expressed interest in undamaged seed and large seeds (Table 6).

F_5 Generation Evaluations

The F_5 plant evaluation also revealed some similarity in farmer - scientist trait preferences. Both groups gave top priority to many pods (low heritability). Scientists placed second priority on upright plants (medium-high heritability). While the frequency of responses was small, farmers had a tendency to place a similar preference on three different traits, all of which fell into second priority: thick pods (high heritability), upright plants (medium-high heritability), and strong stems (medium-high heritability) (Table 7).

Comparing farmers' and scientists' F_5 seed preferences (Table 8), there was considerable difference between the two groups' selections. Farmers gave high yield their top vote, followed by seed color, thick broth and thick seed. Scientists placed first priority on seed color and second priority on undamaged seed. High yield and thick broth were tied for third priority, followed by large seeds in fourth priority.

COMPARISONS OF FARMERS' AND SCIENTISTS' PREFERENCES

Scientists usually provided more reasons than did farmers for explaining their selections. Generally, farmers seemed to prefer strong stems, uniform leaf color, leaves not damaged by insects, and leaves not injured by diseases. Scientists tended to prefer many seeds per pod, long pods, many branches, large plant size, pods not shriveled, and leaves not shriveled.

Those traits where farmers and scientists tended to show some similarity in their preferences included many pods, thick pods, upright plants, and high placement of pods on plant. Both farmers and scientists seemed to be looking for a large seeded, upright bush plant.

Table 2: Farmers' F_5 trait preferences within analytical categories (Refer to Figure 1).

Traits and Analytical Categories	F	S	Traits and Analytical Categories	F	S
2.1 Yield Component			2.4 Maturity		
Many seeds in pods	3	8	Early maturing	2	3
Many pods	12	19			
High yield	1	3	Total	2	3
Total	16	30			
2.2 Seed Characteristics			2.5 Biotic Stresses		
Thick pods	4	8	Uniform leaf color	1	1
Large seed size	1	2	Pods not skrunken/shriveled	1	5
Long pods	1	6	Leaves not skrunken/shriveled	0	3
			Leaves not damaged by insects	3	5
Total	6	16	Leaves not damaged by disease	2	2
			Seed not damaged	0	1
			Total	7	17
2.3 Architecture			2.6 Abiotic Stresses		
Pods high on plant	3	8	Plants tolerant to sun (drought tolerant)	1	2
Upright plants	4	14	Tolerant to standing water		
Strong stem (stands straight up)	4	4	Leaf color good (dark green)	0	1
				0	1
Many branches	1	8	Total		
Continuous podding	0	1		1	4
Large size plants	0	4			
Small size plants	1	2			
Few leaves (allow plant to grow)	1	2			
Total	14	43			

F = Farmers

S = Scientists

Table 3: Analytical categories based on interrelationships among traits.

1. Yield component Many seeds in pods Many pods High yield	4. Maturity Early maturing
2. Seed characteristics Thick pods Large seed size Long pods	5. Biotic Stresses Uniform leaf color Pods not skrunken/shriveled Leaves not skrunken/shriveled Leaves not damaged by insects Leaves not damaged by diseases Seed not damaged
3. Architecture Pods high on plant Upright plants Strong stem (stands straight up) Many branches Continuous podding Large size plants Small size plants Few leaves (allow plant to grow)	6. Abiotic Stresses Plants tolerant to sun (drought tolerant) Tolerant to standing water Leaf color good (dark green)

Table 4: Heritability factors of F_6 plant and seed traits.

Trait	Heritability	Explanation
Yield		
Many seeds in pods	Low	Yield component
Many pods	Low	Yield compontnt
High yield	Low	
Seed Characteristics		
Thick pods	High	Related to seed size and shape
Large seed size	High	
Long pods	Medium	Related to number of seeds/pod & seed size
Architecture		
Pods high on plant	Medium-High	
Upright plants	Medium-High	Related to plant architecture
Strong stem (stands straight up)	Medium-High	Related to lodging resistance
Many branches		
Continuous podding	Medium	
Plant size (large or small)	High	Related to bush (determinate) or vine (indeterminate) growth habit
Few leaves	Low	
Maturity		
Early maturing	High	
Biotic Stresses		
Uniform leaf color	Medium-High	Could be related to virus infection &/or leaf hopper burn
Pods not skrunken/shriveled	Medium-High	ditto
Leaves not skrunken/shriveled		
Leaves not damaged by insects	Medium-High	
Leaves not damaged by diseases		
Seed not damaged	Low-Medium	
	Low-Medium	Bacterial or fungal diseases, excluding virusses
		Disease or insect damage
Abiotic Stresses		
Plants tolerant to sun	Low-Medium	Related to drought tolerance
Little flower drop	Low-Medium	Related to heat tolerance
Tolerant to standing water	Low?	
Leaf color good (dark green)		Maybe related to nutrient use efficiency
	Medium-High	

Table 5: Comparison of farmers' and scientists' preferred bean plant traits at F_3 (Population 100).

Trait	Farmers (Frequency of Reasons)	Scientists (Frequency of Reasons)
Many pods*	62	59
Upright plants**	11	36
Dark green leaves**	13	25
Leaves not shriveled***	0	20
Large plants*	7	25
Pods not skrunken**	3	23
	Heritability: * Low	** Medium *** High

Table 6: Comparisons of farmers' and scientists' F_3 seed preferences.

Farmers' Preferences	No. of Reasons	Scientists' Preferences	No. of Reasons
Seed Color	8	Seed Color	19
High Yield	8	High Yield	14
Thick Seeds (round)	5	Undamaged Seed	13
Taste (sweet)	4	Large Seeds	11

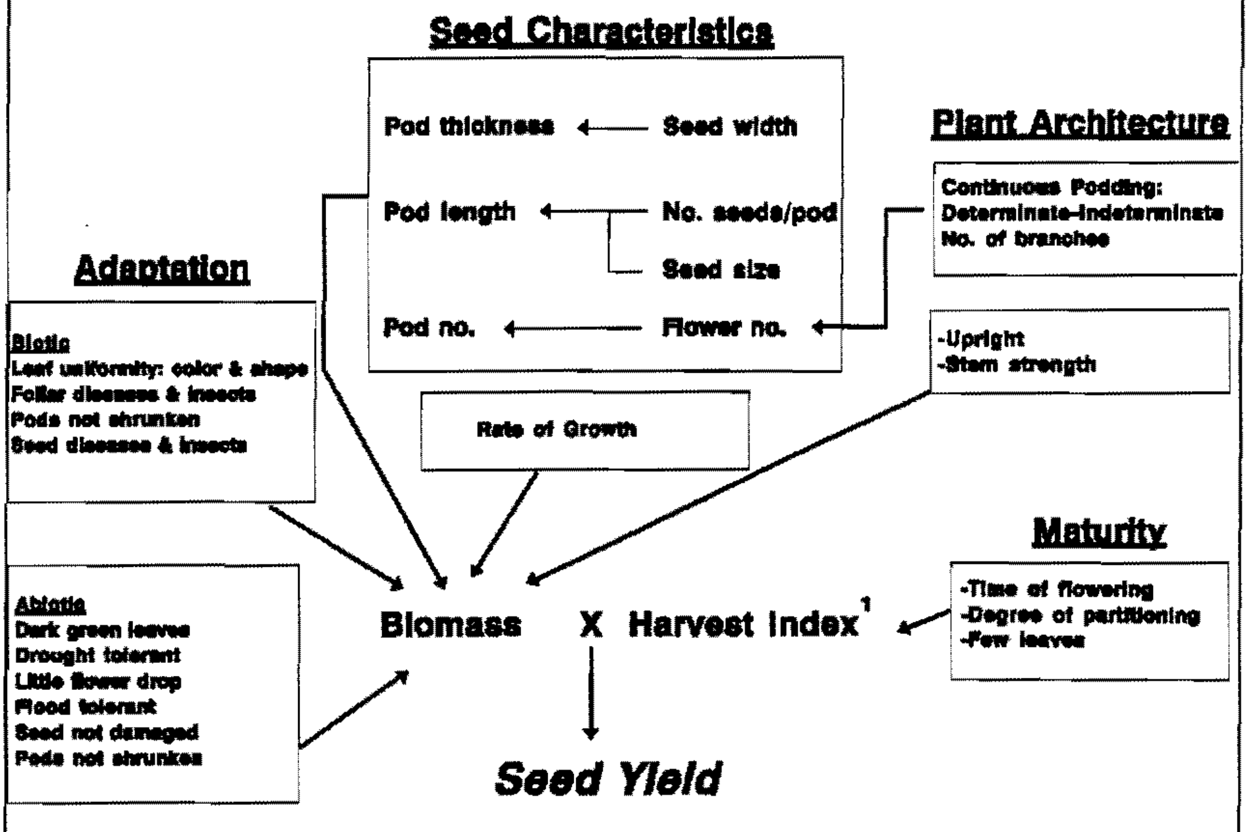
Table 7: **Evaluation of early generation bean lines at SUA - Mafiga farm (Morogoro, Tanzania): Preferred F_5 characteristics of farmers and scientists (June 1995).**

Characteristic	Farmer Frequency	Scientist Frequency
Many seeds in pods	3	8
Many pods	12	19
High yield	1	3
Thick pods	4	8
Large seed size	1	2
Long pods	1	6
Pods high on plant	3	8
Upright plants	4	14
Strong stem (stands straight up)	4	4
Many branches	1	8
Continuous podding	0	1
Large size plants	0	4
Small size plants	1	2
Few leaves (allow plant to grow)	1	2
Early maturing	2	3
Uniform leaf color	1	1
Pods not skrunken/shriveled	1	6
Leaves not skrunken/shriveled	0	3
Leaves not damaged by insects	3	5
Leaves not hurt by disease	2	2
Seed not damaged	0	1
Plants tolerant to sun (drought tolerant)	1	2
Tolerant to standing water	0	1
Leaf color good (dark green)	0	1

Table 8: **Comparisons of farmers' and scientists' F_5 seed preferences.**

Farmers' Preferences	No. of Reasons	Scientists' Preferences	No. of Reasons
High Yield	49	Seed Color	34
Seed Color	35	Undamaged Seed	24
Thick Broth	26	High Yield	17
Thick Seed	17	Thick Broth	17
		Large Seeds	12

Figure 1. Interrelationships Among Traits Used in Farmer Evaluation



[1] Harvest index is proportion (%) of total biomass made up of seed

DISCUSSION

Findings

Farmers appeared more interested in foliar diseases and insects, although scientists did seem to feel these were moderately important. As one might expect, scientists seemed to recognize and place more emphasis on virus diseases (e.g. shriveled leaves). Farmers liked uniform foliage color. This may imply that farmers were selecting against viruses and leafhopper damage as well as for nutrient use deficiency. By selecting for large vigorous plants without disease symptoms, both farmers and scientists were choosing a range of low to high heritable characteristics.

Scientists seemed to look more at individual yield components, some of which (e.g. long pods) may contradict other traits (e.g. architecture). Scientists' preferences for many branches could feasibly lead to higher yields, but also to more foliar diseases and insects. For viral diseases, farmers' materials may be tolerant, while scientists' materials may be resistant. Since this is purely speculation, and written from a scientist perspective, several more generations of testing and evaluation would tell us whether our predictions have merit.

Methodologies

Based on our knowledge of heritability factors, it would seem preferable to confine plant type evaluation to F_3 and F_4 generations. While it is important to select vigorous, disease free plants, emphasis should not be placed on yield. It would seem more productive to conduct seed evaluation in F_4 and F_5 generations since seed qualities are fairly set after F_3. Begin with individual plant assessment at F_3 and F_4, then to avoid the complexity of high numbers of plants, switch to line assessment at F_5. Farmer evaluation at early generations entails a lot of field organization and logistical arrangements -- much more than doing 20-30 F_6 lines. There appears to be some value in limiting farmer evaluations to early and later generations, and having researchers conduct disease and yield testing in between these periods. It would also be beneficial to have farmers and scientists collaborate more closely in at least one evaluation session, and to include a joint farmer-scientist discussion of preferred traits, plants, seeds, etc. It may also be worthwhile to restrict the number of reasons given by both farmers and scientists to two or three, thus generating the most central reasons.

CONCLUSIONS

Our reasons for involving farmers and scientists jointly in the evaluation of early generation breeding materials were associated with the potential that some traits might be mutually appreciated, and that novel traits might be identified which would give breeders new insights about preferences. Because we assumed that farmers and breeders make their trait selections based on different goals, we felt it was entirely possible that some unique qualities and some similarities might emerge. We also felt there was value in testing a collaborative farmer - scientist evaluation model in order to encourage a stronger working partnership between the two. Each group has a unique but complimentary set of experiences and knowledge -- the farmer who takes a more dynamic, adaptive, innovative approach to crop improvement, and the scientist who takes a more purposive, systematic, commodity-oriented approach to crop improvement. The more formal, institutionally-driven approach of the scientist carries with it the risk of overlooking the larger environment of which bean growing, and agriculture, is only one of many parts (Amanor, 1993; Hardon and de Boef, 1993; van Dusseldorp and Box, 1993).

While it may still too soon to draw definite conclusions, in the early breeding stages there does seem to be general agreement among farmers and scientists on the importance of yield, however this does not seem to carry through to later generation selections. Therefore, it may not be advisable to put too much emphasis on yield qualities because of the low heritability of this quality, and because farmers' and scientists' priorities seem to diverge in later generation selections. In early generation evaluation it seems preferable to concentrate on plant selection, concentrating more on seed evaluation in later generations.

Early generation evaluation by farmers is worthwhile but requires a higher level of field organization than when carried out at later stages. It also requires prompt attention to documentation and analysis of data because of the amount of detailed information accumulated, and to the need for continuing interaction among scientists and farmers to understand the meaning and usefulness of the data. With attention to these factors, both scientists and farmers stand to benefit.

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Q: V Aggarwal

In your knowledge, do you know if similar involvement of farmers in variety selection has been done outside Africa. If yes, where and or what crop; if no, why do you think it needs to be done in Africa?

A: LM Butler

It is nice to bring farmers to breeder's plots. But it appears you are over doing it by farmers over taking the breeding activities where their selections are actually limited only to individual personal preferences. This is creating a situation which can be more innovative and which can bring a major change in bean production by adopting something new and more productive which farmers initially may not like but over period of time might accept it.

Social scientists should play a role not just looking at the short term needs of the farmers, but they should also bring to their attention and convince them about the merit of new technology that might increase yields and overall production. If it will inquire extra efforts and little bit of inputs.

Q: MM Liebenberg

Why were non-breeder included in the group of scientists who evaluated breeding lines?

A: LM Butler

The breeder is a very specialised individual with definite goals. The farmer (customer) has a complex system and a variety of biological and socio-economic problems to solve as he/she integrates new or improved technologies into his/her system. By involving scientists of different disciplines, all of whom work on bean improvement, we feel there is a more practical approach to meeting farmers' whole farm needs. Most bean/cowpea CRSP research is conducted first on interdisciplinary perspectives in order to address the needs of the smallholder farm family. In addition, we also see the value of exposing scientists (and extremists) to our farmer participating research methods in order to enhance their understanding and use of these approaches.

LM Butler

Comment:

We are observing a changing market situation in Tanzania (and neighbouring countries). Smallholders are producing seed for cash and for home use. Our design of variety evaluation methods needs to look at changing market classes - eg. preferences of farmers, vendours, urban consumers, etc.

CIAT SUPPORT FOR NATIONAL RESEARCH STRATEGIES IN AFRICATHAT ADDRESS BEAN TECHNOLOGY NEEDS OF SMALL FARMERS

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ABSTRACT

Small farmers the world over typically differ from large commercial producers in their needs for technology, for both environmental and socioeconomic reasons. Each country needs a research strategy, reviewed periodically, based on an understanding of these needs and their variation. Strategic plans developed by selected bean research programmes in Africa are reviewed here, and their utility in research planning and monitoring is discussed.

Some of these plans were originally developed with assistance from CIAT in diagnostic surveys and trials, assessment of suitability of existing technology, and methods for setting priorities. Many other countries have been exposed to participatory planning procedures in part through involvement in a regional bean network.

Now that the regional networks are graduating to regional or national leadership following some ten years of intensive training, CIAT's role in them is shifting further towards provision of technical support, while continuing to catalyse pan-African interaction among bean networks. Support to the development of new varieties by national programmes includes the generation of a wider genetic base for selection, leading to the provision of segregating populations and nurseries, the contribution of entries in regional trials, and the making of custom crosses. Several regional staff focus on identifying and incorporating resistance or tolerance to selected insect, disease and edaphic problems, and combining them with sources of high yield potential.

Other strategic research aims to develop low-cost or more efficient ways of raising soil productivity through integrated soil/crop/pest management, and sustainable approaches to seed dissemination and the achievement of impact. Examples are given of the importance of working in a collegial manner with small farmers. CIAT's staffing profile aims to maintain a close working relationship with a good number of NARS, and to encourage and complement human resources and research sub-projects within the networks.

INTRODUCTION

Small farmers the world over typically differ from large commercial producers in their needs for technology, for both environmental and socio-economic reasons. The bean research literature from Africa now abounds in examples of decisions of resource-poor farmers that have been influenced by need to manage production on poor soils (Wortmann and Allen, 1994) or under high incidence of diseases, insects, or weeds (e.g. Georgis, 1990) with minimal use of external inputs, to reduce risks of total crop failure by compromising on potential yields (e.g. Kisakye *et al*, 1987), and to satisfy multiple objectives that may include traditional diets and market preferences (Voss, 1992).

A high-input, high-yield approach to technology development is much less likely to be successful in achieving impact with small-scale farmers than with commercial producers in the same country. The appropriate research strategy may vary according to national technical or political objectives but, if it is to be realistic, should be designed with a local focus.

STRATEGIC PLANNING

Each national bean research programme needs to develop a set of research strategies based on an understanding of farmers' needs and their diversity. Certainly most of the larger bean programmes in Africa, and each of the regional networks, have done this (Table 1). Their strategic plans generally have been revised after an interval of about four years, and are available as published network documents.

The planning methods used in these national and regional exercises were proposed in most cases by CIAT, based on the techniques of participatory planning by objectives introduced by the Swiss Development Cooperation, our first donor in Africa. Some refinements have been introduced with experience. The method has proven particularly useful in planning interdisciplinary interventions which are to be carried out by several actors or teams, and its application to bean research is described by Scheidegger and Buruchara (1993). The principles employed are:

* participation by a broadly based group of institutions and disciplines;
* democratic discussion, where all ideas are considered important, often with an independent moderator;
* consensus through discussion and reformulation;
* continuous visualisation through use of cards posted on a board, rather than verbally.

Over the course of an intensive one-week workshop, this group lists and checks all problems related to the subject; ranks the problems and organises them into cause-effect chains and thence into a problem tree; converts the problem tree into a set of priority objectives; devises and ranks potential strategies that respond to the objectives; and quantifies resources needed and attributes responsibilities for implementation.

A factor limiting the effectiveness of some early planning workshops was a lack of participants' detailed understanding of farmers' real problems. Workshops in Ethiopia and Kenya were therefore preceded by commissioned diagnostic surveys in distant production zones; in Uganda an adequate start was achieved by inviting a farming system report from each production zone. In several instances CIAT assisted in diagnostic surveys and trials, in assessments of suitability of existing technology, as well as in methods for setting priorities.

Also, as some national agricultural research systems (NARS) still overlook potential partnership with development agencies, a careful review of planning participants usually pays off. The most successful workshops have been those that included senior (but not necessarily all) researchers representing a wide range of relevant disciplines drawn from several institutions, extension subject matter specialists and field staff of non-governmental organisations in bean-growing areas, traders, and so on. In Ethiopia it was important to include exporters of navy beans; data on informal cross-border trade in beans would be useful in Tanzania.

Agreement on zoning for better adaptive research is important. Ethiopian participants recognised four zones (Girma and Kirkby, 1990), and since then have progressed a good way towards decentralising variety selection as human resources permitted this. Kenya (Wabule *et al*, 1991) has at least five bean research zones; resources permit active research in four of these, with almost completely decentralisation. Tanzania has long defined three zones by elevation, with separate institutional responsibilities for serving them (Mushi and Youngquist, 1992). Uganda distinguished three important zones by rainfall/vegetation criteria (Grisley, 1991) and now addresses their distinct needs from a central programme and satellite testing sites, making good use of NGO collaborators in the zones.

In recent years some emphasis in most programmes has shifted from breeding for disease resistance to a more balanced attention to integrated pest/disease management including use of resistant varieties, selection for specific soil constraints and research on soil amendments, and strategies for improving the availability of seed of new varieties. The last objective is increasingly being implemented in association with NGOs. These changes can be attributed, at least in part, to these planning workshops. Meanwhile, countries that started strategic planning several years ago, such as Ethiopia, are now embarking on revisions of their plans; as an iterative process, it is to be expected that the next round may be more sophisticated in its use of zonal data and farmer feedback. In several cases bean research plans have been used as models for the development of NARS-wide programme planning that is increasingly required by government and external donors.

Kenya, Tanzania and Uganda have made use of national strategic plans for guiding the design of annual bean research plans and/or for monitoring implementation by collaborating institutions. While this aspect appears to have been particularly helpful to national research coordinators in large or decentralised programmes, the use of a strategic plan for justifying individual research projects should have considerable utility for smaller programmes; under conditions of restricted funding and staffing, the forging of a coalition among institutional partners becomes even more important to achieve real benefits for the clients of research. Most programmes have had some exposure to strategic planning methods through involvement in the regional network -- participatory methods have also been used extensively by some of the pan African specialist working groups (Table 1). CIAT would like to encourage the development of strategic plans in all countries that have not yet attempted to do this, and we suggest that the Steering Committee review the demand and assess the capacity of the network to assist the process.

RESEARCH IN SUPPORT OF REGIONAL NETWORKS

Now that all three African regional bean networks are graduating to regional or national leadership following nearly ten years of intensive training, CIAT's role in them is shifting further towards provision of technical support, while continuing to catalyze pan-African interaction among bean networks. Support to the development of new varieties by national programmes includes the generation of a wider genetic base for selection, leading to the provision of segregating populations and nurseries, the contribution of entries in regional trials, and the making of custom crosses. Several regional staff focus on identifying and incorporating resistance or tolerance to selected insect, disease and edaphic problems, and combining them with sources of high yield potential.

Principal research themes currently being undertaken by CIAT in support of regional bean networks in Africa are the following:

Continuing assessment of priorities for bean research

* Catalyzing setting of priorities at regional and pan-African levels
* Mapping agro-ecological zones (e.g. Wortmann and Allen, 1994)

Bean germplasm improvement for Africa

* Characterization of pathogenic variation of angular leaf spot and anthracnose in Africa
* Development of populations resistance to angular leafspot, bean common mosaic virus, root rots and bean stem maggot (problems that can be inadequately addressed in Colombia)
* Bean Improvement under Low Fertility in Africa (BILFA)
* Distribution and analysis of pan-Africa resistance nurseries
* Screening World "Core Collection" in Africa

Participatory research on integrated crop/soil fertility management (methodology and pilot studies)

* Management of root rots through soil amendments
* Integrated management of bean stem maggot
* Farmer-participatory methods for crop/soil fertility management
* Improving cost-effectiveness in use of local and imported fertilizer (e.g. Wortmann *et al*, 1992)
* Low-cost on-farm methods for variety testing (e.g. Sperling *et al*, 1993)

Achieving adoption and measuring impact

* Study of effectiveness of non-formal seed channels, and farmer seed-producer groups, for variety multiplication and dissemination.

* Adoption and impact surveys (e.g. Sperling *et al*, 1994)

CIAT's staffing profile -- interdisciplinary, with bases in three national programmes in Eastern and Southern Africa -- aims to maintain a close working relationship with a good number of NARS, and to encourage and complement human resources and research sub-projects within the networks.

Recent published output from some CIAT supporting research is indicated against research themes shown above. Other outputs include the following:

* Development of low-cost seed storage, obviating need for a cold room at every station (Fischler, 1993)

* Publication of an annotated list of bean diseases, to facilitate logical decisions on quarantine clearance (Allen, 1995)

* A compendium of research methods for bean stem maggot (Ampofo, 1991)

* Identification of research sites where bean varieties perform in a similar manner (Smithson and Grisley, 1992)

* Implications of farmer management of varietal mixtures for research strategy (Voss, 1992)

* Demonstration of effectiveness of incorporating farmer bean experts into the research programme (Sperling *et al*, 1993)

* Bean morphological characters that could be used in selecting for ability to suppress weeds (Wortmann, 1993)

REGIONAL COLLABORATION

CIAT welcomes the advent of self-managing regional bean networks in the SADC and Great Lakes (RESAPAC) regions. At the same time we all lament the continuing lack of financial support in SADC for collaborative research sub-projects; CIAT's publication of the magnitude of bean crop losses by country, ecological zones and constraints in Africa may assist in justifying new sources of financial support (Wortmann and Allen, 1994). However, the reality may be that networks generally will need increasingly to survive on the shared resources of their members -- financial resources as well as those of skilled personnel.

In that sense, the SADC Bean Network may become once more a forerunner of the future, placed in the position of developing new, workable modes of operation. The regional research sub-project mechanism should become even more the centre of the Network if the objective is to seek efficient use of scarce resources through pooling of problems and sharing of responsibilities. Sub-projects should not require external funding, although of course collaboration is nicely lubricated when some additional funds are present.

Much more advantage might also be taken of opportunities for direct bilateral collaboration between research groups in neighbouring countries which share agro-ecological conditions. Central Malawi and Eastern Zambia, and the Northern parts of both countries with Southern Highlands of Tanzania, might form natural research complexes that economise on everyone's expenses. The Steering Committee might wish to consider ways in which SACCAR's network communications funds could be employed to catalyze these and similar interactions.

Pan-African collaboration

Collaboration among regional bean networks has been focussed on technical planning and information exchange: pan-African specialist working groups (Table 1) and three publications series. Working groups generally meet about once in three years to review research advances and priorities for Africa, and are advisory to regional steering committees in areas where no individual committee is likely to have extensive expertise.

In future, inter-regional collaboration is likely to become more important as greater efficiency is sought through shared research and more specialised needs for training and information exchange. The other two networks, EABRN and RESAPAC, are in the process of merging to save on administrative costs and capitalise on research opportunities, although they plan to maintain internal working groups to address common problems of the existing sub-regions.

Members of the SADC Network may wish to know of the following activities planned by EABRN and RESAPAC, and to which SADC is invited to participate at its own cost:

* Use of Crop Growth Models: Egerton, January 1996
* Survey Data Analysis: Egerton, 12-23 February 1996
* Bean Market Opportunities: Arusha, 1996
* Scientific Writing Retreat, Egerton, 17 Feb-2 March 1996

Until now, collaboration among regional bean networks has been mediated by CIAT, often in response to an initiative from one of the networks. This role is likely to continue, but CIAT proposes to strengthen the links by forming a pan-African steering committee that would more directly represent the regional networks in identifying opportunities for common activities or sharing of information. Separate funding is being sought for pan-African activities.

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Table 1: STRATEGIC PLANNING WORKSHOPS SUPPORTED BY REGIONAL BEAN NETWORKS

	1989	1990	1991	1992	1993	1994	1995
Great Lakes	Regional multidisc.		Breeding	Regional multidisc.			
Eastern Africa		Ethiopia	Kenya Uganda	Soil fertility		Uganda Breeding	Ethiopia Regional multidisc.
Southern Africa			Regional multidisc.	Malawi Tanzania		Breeding	
Pan-African	Insect pests	Viral diseases Soil fertility/ cropping systems		Drought Fungal diseases	Insect pests	Bacterial/viral diseases Improvement for low fertility soils Seed dissemination	Fungal diseases

THE PRODUCTION OF DISEASE FREE DRY BEAN SEED THROUGH MERISTEM TIP CULTURE

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ABSTRACT

Seeds of leguminous crops like dry beans carry viruses and bacteria internally. Spread of these plant pathogens within a growing crop usually results in both extensive seed quality and yield losses. Plant pathogens pose a particular problem in economically important cultivars such as "white kidney bean", sugarbeans and white canned beans. Conventional methods can't be used to eliminate these pathogens. Meristem tip cultures have proven to be a handy tool in eliminating these diseases from crop plants. The aim of this study is thus the production of disease free dry bean seed on small scale followed by the multiplication of disease free seed. Three phases are important in apical meristem cultures, namely establishment, multiplication and root regeneration. Each of these phases has particular requirements in regard to growth factors in the agar medium. In this project all three phases have been successfully completed. The last phase, namely root regeneration, is being standardized for all the cultivars to find a universal agar medium. These phases include the following: After the seed was left for a predetermined germination period, the meristem was isolated from the growth tip. These meristems were placed on an initiation medium which has been formulated to stimulate shoot formation. Strong shoots were placed on a transitional medium formulated to stimulate root regeneration. Different hormones (BA, NAA and IBA) were added to the transitional medium in various concentrations. In all the cultivars studied, high concentrations of IBA (10-25 µM) stimulated root regeneration. Plants (±5 cm) were planted in vermiculite and then in soil with the necessary humidity adaptions. Plants of various cultivars were successfully cultured and seed was harvested for disease analysis.

INTRODUCTION

Seeds of leguminous crops like dry bean carry viruses and bacteria internally. Spread of these plant pathogens within a growing crop usually results in both extensive seed quality and yield losses. Plant pathogens pose a particular problem in economically important cultivars such as "white kidney bean", sugarbeans and small white beans. Conventional methods are inadequate and can't be used to totally eliminate these pathogens.

Meristem tip culture has proven to be a handy tool in eliminating these diseases from crop plants. Three phases are important in meristem tip culture. These phases are establishment of the isolated meristems, multiplication of the meristems and root regeneration. Each of these phases has particular requirements regarding growth factors in the agar medium.

AIM

This study has two main aims. In the first place, we want to produce disease free dry bean seed on small scale. The other aim is to use a seed multiplication system to multiply these disease free seeds.

APPROACH

Since this technique is cultivar specific, we started with three diverse cultivars. We thus ensured that if there does exist a universal medium, we would find it. The three different cultivars we used to standardise the technique, were white kidney bean, a sugarbean - Kranskop and a small white bean - Teebus.

EXPERIMENTAL DETAILS

1. The dry bean seeds were surface sterilised in 70% ethanol for one minute followed by 20 minutes in 40% commercial bleach and three rinses with water.

2. The sterilised seeds were germinated in the dark on water-agar for 4 to 5 days. After 5 days, the hypocotyl has grown out of the cotyledons while the young leaves and the apical meristem are still between the two cotyledons.

3. The apical meristems were isolated under a dissection microscope. The different steps in the isolation of the apical meristems are as follows: -

   The dry bean seed is germinated for 5 days. The hypocotyl has grown out of the cotyledons, while the two young leaves with the meristem are located between the cotyledons. In the next step, the hypocotyl and the cotyledons are removed. The remaining leaves are dissected away in the next step and the apical meristem is exposed. All excessive tissues are removed. The exposed apical meristem is situated between the petioles of the young leaves. This apical meristem is isolated. The apical meristem is half a millimetre in diameter.

4. This isolated meristem is then cultured *in vitro* on a medium that initiates leaf formation. The meristem develops strong leaves and is ready for the next step.

5. In the next step, the developing meristem is placed on a medium, specially formulated to stimulate root regeneration. The plantlet is left in the culture tube, containing the root regeneration medium, until it reaches a height of about 10 cm.

6. The fully developed plant is then planted in vermiculite.

7. The plants are then planted in soil.

8. After the plants are planted in soil, it is hardened by gradually adjusting the relative humidity.

9. Seed is harvested from mature plants.

10. The seed will be tested to ensure that it is disease free.

RESULTS

Hormones that regulate shoot and root formation

Development of shoots and roots in plants depends on the presence of different plant hormones in the plant. Two of the classes of plant hormones are auxins and cytokinins. The development of shoots and roots depends on the concentration of these hormones in the medium. Figure 1 gives a schematic representation of the ratio of auxin to cytokinin that is necessary for the development of various tissues in the plant. Shoot formation on cuttings needs low auxin and high cytokinin concentrations. The reason for this is that roots are the principle site of cytokinin biosynthesis. It is unlikely that the meristem has sufficient endogenous cytokinin to support growth and development. Cytokinin at high concentrations must be added to the medium. Auxin is also required for shoot growth, but as it is synthesised in the shoot apex, only low concentrations is needed in the medium.

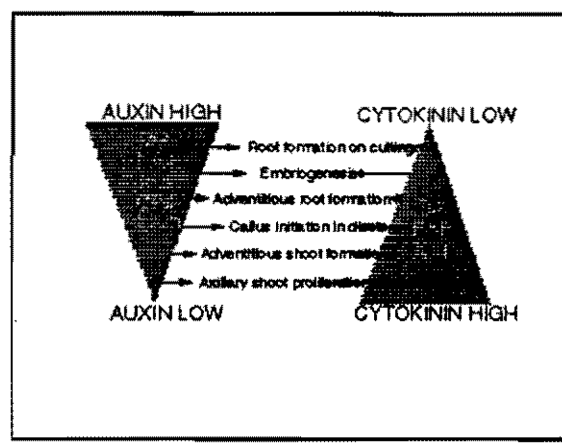

Fig. 1. The influence of growth factors on tissue culture development

On the other hand, axillary shoot proliferation needs low auxin and high cytokinin concentrations. Callus initiation in dicots needs an intermediate concentration of both auxin and cytokinin. A few examples of different auxins and cytokinins are given here.

Tested mediums for root formation

The histogram in Figure 2 represents the different mediums tested for root formation. The percentage root formation and mature plants are plotted against the different mediums. As mentioned earlier, root formation depends on high auxin concentrations.

Mediums 1 to 9 represent different auxin concentrations in the medium. The auxin concentration increases from medium 1 to 9. This shows that root formation increased with increased auxin concentration. However, if the auxin

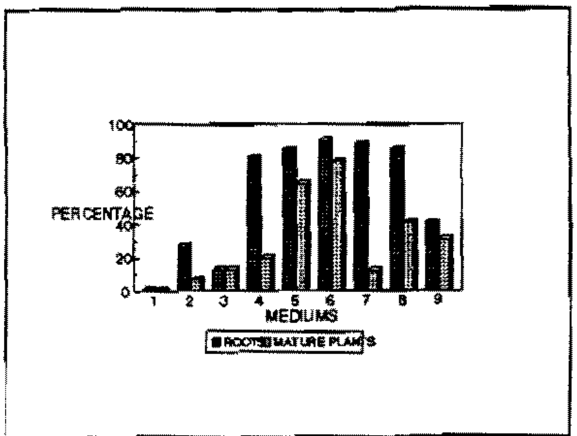

Fig. 2. Different mediums tested for root formation.

concentration is too high, it leads to the formation of callus. Mediums 5 and 6 gave the best results, with both root formation and mature plants. Although mediums 7 and 8 gave many roots, it also stimulated callus growth. Mature plants didn't form in the presence of callus.

Thus, the results can be summarised as follows:

1. Roots formed in the presence of very high concentrations of auxin.

2. Callus formed when the auxin concentration was too high.

3. No mature plants formed in the presence of callus.

4. Root formation in dry beans depends on the type of auxin.

5. The differences in the mediums for leaf and root formation are as follows:

   1x MS salts versus 0,5x MS salts

   Both mediums have 1x B5 vitamins, 3% sucrose and 0.9% agar

   Low auxin and high cytokinin for leaf formation versus high auxin and no cytokinin for root formation.

   Low concentrations of gibberellic acid was added to the leaf formation medium. Gibberellic acid stimulates cell division and/or elongation.

SUCCESS

We had the following successes with the technique:

- 90% survival of the meristems on the leaf formation medium
- 90% survival of leaves on the optimal root formation medium
- 78% survival of the young plants after transferring them to soil
- We found an average of 5 pods per plant and 2,5 seeds per pod.

CONCLUSIONS

We found an universal medium for leaf formation and for root formation. All three tested cultivars gave an optimal response on the same mediums. The technique was successfully standardised.

RECOMMENDATIONS

- We shall test the technique on a wide spectrum of other cultivars.
- The development of a biological procedure to detect whether the seeds are disease free.

Q: AJ Liebenberg

What is the need of the procedure of making plant disease free?

A: L Herselman

This method is intended to replace the present method of making plants disease free. This seed will be fed into the seed production programme.

TECHNOLOGY TRANSFER AND POTENTIAL FOR INFORMAL BEAN SEED MULTIPLICATION IN THE SOUTHERN HIGHLANDS OF TANZANIA.

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ABSTRACT

On-farm variety evaluation and bean production trials have been conducted in the Southern Highlands, (SH) of Tanzania since 1975. The trials did not serve as an effective means of technology transfer or source of seed for new varieties. The formal seed company also has not been able to produce sufficient seed for the farmers. It, therefore, became necessary to intensify on-farm technology transfer, demonstration and variety evaluation as well as to initiate informal seed multiplication.

A pilot project, "Village Bean Saturation", involving about 50 farmers per village was started in 1993 and 1994 in Ilembo/Usafwa and Iyawaya villages in Mbeya rural district. Currently the project covers over 20 villages in Mbeya, and Iringa regions of the SH. The primary objective includes evaluation and introduction of new varieties, the necessary production technology packages and initiation of informal seed multiplication.

The work is executed by research and the extension staff and the farmers. The plots are solely managed by the farmers but with the necessary guidance from research and extension staff. Important biological data, yields and farmers' opinion data are collected from planting to harvest. Observations showed that farmers keep seed of their choice, sell seed to other farmers or share with relatives and friends.

The bean research programme is now planning to organize groups, particularly female groups to produce bean seed within the village. The would-be producers will be given basic knowledge about seed production and marketing.

INTRODUCTION

Bean is an important crop in the Southern Highlands (SH) of Tanzania. It is grown as cash and a food crop. Despite its importance bean production is low ranging from 300 - 500kg/ha (ASSP 1991). The low yields are attributed to low yielding varieties diseases, insect pests, poor soils, weather, poor production technologies. Improved varieties and production technologies are available from research and lack of seed of improved varieties Attempts have been made to transfer the technologies to farmers but unfortunately, there has been less success in adoption by farmers.

On-farm trials and demonstrations have been used as a way of collecting data from farmers' fields, introducing the technology to farmers. On-farm trials were also used as sources of seed for the improved varieties.

After many years of on-farm research since 1974/75 - 1992/93 seasons (UAC 1974/75 - 1992/93) it has been realized that the impact of the work in terms of adoption of new varieties and production technologies is below our expectations.

In the past the on-farm trials and demonstration were big and complicated hence the farmers may not have understood them. Few farmers in few locations were involved. Sometimes, the trials were conducted on the community farm and probably individual farmers did not take interest in the work. Many farmers may have not seen the new varieties. There were also no seed available in case the farmers liked the varieties.

In is hypothesized that some of the reasons for slow adoption were limited exposure of technology to farmers because few farmers in few locations were involved. Farmers may not have understood the technologies because the treatments were complicated. The technologies were also demonstrated or given to farmers without properly discussing with them.

Farmers were not sensitized about the importance of the new technologies and the maintenance of the seed. There were also no programmes for seed multiplication.

OBJECTIVES

The objectives of the current work are:

1. To rapidly introduce improved bean varieties and bean production technologies by involving many farmers in more locations in on-farm trials.

2. To use simple demonstrations for bean on-farm work.

3. To introduce bean seed multiplication in the village for sustainable bean production. To encourage groups, particularly female groups to grow bean seed for sale in the villages.

4. To produce back-up seed at the research station.

MATERIALS AND METHODS

Work Area

Our work involved (a) variety evaluation; (b) technology transfer/demonstration in farmers' fields; (c) provision of initial seed to farmers and; (d) multiplication of back-up seed at the research station.

Field work

We came into contact with the farmers through: (a) other activities like surveys; (b) direct request from the farmers; (c) request from the Extension and; (d) sometimes villages are randomly picked by the research through the extension service.

About 20 villages, mainly in Mbeya and Iringa regions, are involvement in the programme for rapid technology transfer. The work is done in collaboration with Kilimo/Sassakawa Global 2OOO, who funded the project and KILIMO/Extension.

The programme started in Ilembo/Usafwa village in Mbeya rural district in 1992/93 season with 43 farmers involving 4 varieties. The work was extended to Iyawaya village in 1993/94 season where over 1OO farmers were involved with new bean varieties. More villages were included in 1994/95 season (App I).

Farmers and the Extension Officers (EO) in the villages are informed of our intended work. In villages where there is no EO the village government is used as our link. After the necessary discussion the work of farmer selection is left to the village government and the EO. We normally request the village to nominate not less than 2O-30 farmers to participate in the work. Farmers then prepare the land ready for planting. Planting for all the variety evaluation trials is done by the farmers, research staff and E0. Planting for demonstration and technology transfer and seed multiplication is demonstrated for few farmers in the presence of others and the rest of the work is done by the farmers and the EO. Instructions are given to farmers and EO throughout the process of land preparation, lanting and other field management, harvesting, seed processing and seed storage.

Necessary data such as diseases, insects, plant population and pod load are taken from plant germination to harvesting. Farmers are instructed on how to harvest and keep seed until they are weighed. Farmers are educated and encouraged to keep their seed and assisted in seed storage techniques.

Necessary inputs are provided by research for the first season as teaching materials and demonstration. Farmers are advised to buy their inputs for the following seasons.

Seed Sources

Initial seed were purchased from seed farm and from individual producers. Basic seed for back-up is produced at the research station to enable continuous availability of initial seed.

RESULTS AND DISCUSSIONS

Variety Evaluation

Variety evaluation trial is a one way of technology transfer. It is also conducted for new or elite varieties in new areas where the available data cannot be extrapolated. Data from some villages is summarized below.

Ilembo/Usafwa Village

This village is in high altitude of about 2000 m.a.s.l in Mbeya rural district. Five varieties were evaluated by 4 farmers in 1994 and the data is presented in Table 1.

The best variety in this trial is Njano in terms of yield and disease tolerance. Njano has now become popular in the village. The other varieties although high yielding, are susceptible to halo blight and angular leaf spot (ALS). It, therefore, became necessary to evaluate other varieties that may fit in such high altitudes. Results are reported in Table 2.Bean lines 91/92 and LB465-1 showed good yields with no diseases. Ilomba also has better yields than Kabanima. LB465-1 and Ilomha has been reported as palatable. Uyole-94, however, is susceptible to halo blight thus not suitable for high altitudes. Results of farmer evaluation for 91/92 will be included in other report.

Table 1: Mean yields and total yields of 5 bean varieties evaluated by 4 farmers in Ilembo/Usafwa village, 1994.

Varieties	Kabanima	OQG 379	UACG 161	UAC 160	Njano
Mean Yield (kg/ha)	1685	1763	2275	1938	3563
Total Yield (kg)	6.7	7.1	9.1	7.8	14.3

Table 2: Mean yields and total yields of 4 bean varieties evaluated by 4 farmers in Ilembo/Usafwa village, 1995.

Varieties	Kabanima	OQG 379	UACG 161	UAC160	Njano
Mean Yield (kg/ha)	1075	1700	2475	1650	2425
Total Yield (kg)	4.3	5.1	9.9	6.6	9.7

Table 3: **Mean yields and total yields of 6 bean varieties evaluated by farmers in Iyawaya village, 1995.**

Varieties	Kablanketi	Kabanima	DRK-4	UACG 161	Kablanketi-2	Uyole-94
Yield kg/ha)	976	1397	1065	1642	1002	1602
Total Yield (kg)	3.9	5.6	4.26	6.6	4.0	6.4

Table 4: Mean yield of 8 bean varieties evaluated in Shibolya during December planting, 1994/95.

Varieties	Kabanima	UACG-161	PBABL-226	UAC-160	EGERM-74	LB465-1	PBABL-142	KABLANKETI
Yield kg/ha	1250	650	1125	875	1100	2525	625	1000

Iyawaya Village:

New varieties were evaluated by 5 farmers in this village which lies across medium - low altitude in Mbeya rural district. The results of the variety performance are summarised in Table 3.

Varieties Uyole-94 and UACG 161 had better performance and this area has less problem of halo blight. The preferred variety in this area is Kabanima but farmers interviewed indicated that Uyole-94 is within their preference too.

Shibolya Village:

This village is on the same altitude as Ilembo/Usafwa but the farmers prefer to plant in December where rainfall is very high during the bean growing period. It, therefore, became necessary to evaluate for varieties which can tolerate the high rainfall conditions. The yield data is recorded in Table 4.

The best line which was almost free of diseases was LB465-1. This line is however, late maturing. The variety has also been evaluated in Ilembo/Usafwa village under March planting and it yielded high. Similar work was carried out in 5 villages in Rukwa region and in 5 villages in Chunya district of Mbeya region. The data has not been processed yet.

Technology transfer and demonstrations:

Technology transfer in this work means the technology (varieties) are directly given to many farmers with instructions. This method is used for those varieties which are familiar to farmers but they did not have seed. Demonstration in this work means that one or two improved varieties are grown by farmers in comparison to a known improved variety like Kabanima or a local variety. This work aims to rapidly transfer the technologies and "saturate" the villages with beans.

Several villages are involved in this work (App. I) and the data is given for the representative ones.

Ilembo/Usafwa:

This is a pilot village in the programme of rapid technology transfer with an aim to saturate the village

with beans through growing of improved and local varieties by using proper technologies.
Our involvement is this village started in 1991/92 season when the EO was supplied with varieties Uyole 84, Kabanima and Lyamungo 85 to demonstrate to farmers. As a response farmers requested for more seed which was supplied as shown in Table 5.

Table 5: List of varieties and the number of farmers supplied with seed in Ilembo/Usafwa, 1993.

Varieties	Seed Quantity (kg)	Numher of Farmers
Kabanima	62.0	11
Red Kabanima	20.5	10
Uyole 84	49.5	15
Uyole 90	26.0	7
TOTAL 4	158.0	43

After harvest the beans were weighed and the data is given in separate report. Attempts were made to recover the seed and redistributed to other farmers as shown in Table 6. The process of seed recovery was found to be complicated and it was, therefore, abandoned.

Table 6: List of beans and their quantities and the recipient farmers in Ilembo/Usafwa, 1994.

Varieties Recovered	Seed Quantity (kg)	Recipient Farmers
Kabanima	14.0	8
Red Kabanima	6.5	13
Uyole 84	34.0	21
Uyole 90	18.0	11
TOTAL 4	75	55

During 1993/94 and 1994/95 seasons various varieties and seed quantities were provided to a female group of 66 members (Table 7).

A good progress in this village has been made in a sense that the village has made a by-low that the seed produced should be sold within the village. Another group for producing beans is in the process of being made. Most of the farmers claim that they have been exposed to and have the new varieties.

Iyawaya Village:

Our work started in 1993/94 and continued in 1994/95 seasons. Thirty farmers planted maize/beans intercropping involving bean varieties Uyole-84 and Kabanima. Uyole 84 produced 1940-3130 kg/ha and 1042 kg/ha and no fertilizer was needed in maize bean intercropping. This data confirmed our earlier finldings (Madata 1994). Maize yields were 2-3 tons/ha.

About 100 other farmers were provided with seed of 7 varieties in 1993/94 season. Farmers produced the second bean crop under irrigation. More farmers were involved with seed in 1994/95 season (App. I). Most farmers now claim that they have Uyole seed. Most farmers in this village are now planting Kabanima in Usangu valley under irrigation. One farmer who received Uyole 94 has also gone to Usangu to it.

Shibolya Village:

Four varieties were given to 27 farmers during 1994/95 season for observations and production. Farmers were responsible for inputs and field management. 22 farmers planted the beans during December and the other 5 farmers planted during March. Some of the farmers who planted their beans in December also replanted them in March. Three farmers recorded very poor yields and their data was discarded. The yield data is shown in Table 8.

Mayale village Female Group:

Seven varieties including a local sheck were demonstrated to an already established group comprising of 30 members. The group normally operates in 10 subgroups of 3 members. Two different varieties plus a local check were assigned to each subgroups. The village had no EO at the time of field ork but satisfactory results were obtained (Table 9). The female chose varieties Uyole 94, Kablanketi-2, YC-2 and DRK-4 in the order of

Table 7: **Bean seed provided to female group and the seed they produced during 1993/94 and 1994/95 seasons in Ilembo/Usafwa.**

Seasons	Varieties provided	Seed (kg)	Beans produced
	Kabanima	10	105
1993/94	Uyole 84	10	160
	Njano	5	168
	Total	25	433
	UAC 160	11.2	85.6
	Njano	14.5	209.4
1994/95	Ilomba	14.5	141.9
	Selection-8	5.5	86.1
	Total	45.7	553

Table 8: **Mean yield (kg/ha) and total seed yields (kg) of 4 bean varieties planted in Shibolya village December 1994.**

Varieties	Number of Farmers	Seed planted (2kg/Farmer)	Mean Yield (kg/ha)	Total Seed harvested (kg)
Kabanima	5	10	1680	240
Uyole 90	5	10	1035	230
Njano	7	14	2475	690
Selection 8	2	4	600	60
Total	19	38	-	1120

Table 9: **Yield performance of bean varieties at Mayale female group in Makambako, 1995.**

Varieties	Number of subgroups	Mean Yield (kg/ha)	Seed Produced (kg)
Uyole 94	3	1321	39.6
GO5476	5	622	31.1
Local mixtures	4	650	30.4
DRK-4	4	730	29.2
Kablanketi-2	3	1113	33.4
YC-2	4	671	50.6
UACG 161	2	1120	23.6

preference. Their choice was based on yield, marketability and culinary factors. The female have retained the seed of their choice for further multiplication for the following season. The seed they retained have been seed-dressed with Actellic Super D against the storage insects. Apart from successfully exposing the female to new varieties, a group of female from a neighbouring village is considering to join the programme of bean demonstration and seed multiplication.

Other villages:

The other villages which successfully completed the work and have maintained the seed are Shamwengo, Iduda, Ituha, Iwindi, Njelenje and Mshewe. This Work will be summarised in another report.

Other villages whose data is being completed are Imalinyi, Sadani, Kitelewasi, Kapelekesi and Ibungo villages. Beans are at pod filling stage in Iponjora and Kinyala villages. The reports for these villages will also be summarised in another report.

Back-up Seed multiplication:

Sufficient seed have been produced at Uyole for selling to limited farmers in the project for their initial seed. The bean programme will buy more seed for reinforcement of the village bean programme when necessary. More multiplication is planned when funds are available.

CONCLUSIONS

Important results have been obtained from this programme. Many farmers had a chance to evaluate the varieties and made concrete choices. For example different varieties are selected for different uses such as Kabanima is being selected for market and high yields. Uyole 94 for yield and market Uyole 84 for yield and good leaves and Njano for yield and disease resistance. Recently Ilomba, a small-seeded variety with coffee-coloured seed is appreciated for its culinary factors. These observations show the importance introducing many varieties. Different varieties are also been found suitable for different locations and planting times as shown above. Many farmers have also been exposed to prodution technologies.

It seem easy to work with groups in seed multiplication such as Female groups in Ilembo, Usafwa and Mayale Makambako. A second group in Ilembo/Usafwa is organising itselves to join the programme. The bean programme will educate the groups on production technologies, seed processing and seed storage.

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Q: S David

You mentioned that initially trials were too complicated, how were they changed? What do you think about using multiple distribution strategies, beside the use of female's groups?

A: C Madata

Complicated trials: Many treatments and treatment combinations involved.

Changes: Few treatments.

Every person are involved.

There are only 2 female groups each in 2 villages.

Q: PA Ndakidemi

Why men groups were not given seed despite the fact they are the major active practising farming in Tanzania?

A: C Madata

Everybody is encouraged but there are only 2 female groups. However, female are more serious in collaboration than men.

Q: LM Butler

How do you test your varieties for palatability and cookability?

A: C Madata

During earlier generations the horticulture research workers, who are primarily woman are given small samples of 3 lots (for cooking 3 times) to take home to cook using their own methods. They are given 2-3 weeks to test them, then they bring us the data on their preferences. During later generations, when varieties are almost ready for release, the varieties are given to villagers to test. We do not attempt to influence the way they cook them. They are free to do as they which, then provide us with feedback.

CS Madata

Comment:

Farmers like to plant beans and maize on the same hill so that beans can benefit from fertilizer to maize. BNF is complisted many factors are involved.

R Kirkby

Comment:

Producing adequate seed to feed into dissemination schemes for new varieties is a common problem in countries where seed companies not interested or ineffective in beans. The extension project "Sasakwa Global 2000" has started training small shop keepers to become more effective local stockists of inputs such as maize seed. Understand they could welcome discussion with bean specialist on the idea of including new bean varieties in this activity selling the seed would then regenerate the funds for further seed production.

APPENDIX 1:

LIST OF VILLAGES INVOLVED IN BEANS/KILIMO SASSAKWA GLORAT 2000 ON FARM TECHNOLOGY TRANSFER PROGRAMME IN MBEYA AND IRINGA REGIONS, 1995.

Villages (Districts)	Activities	No. of farmers	Varieties
Iyawaya (Mbeya R)	Technology transfer, DEMO Seed Multiplication	115	Uy-84, Kabaninsa Lyamungo-85
	Variety Evaluation	5	5 New + 1 local
Ituha (Mbeva R)	Technology Transfer, DEMO, Seed Multiplication	71 +PS	Uy-84, Njano Uy-9O, Kabanima Uy-9O, Kabanima
Ilembo/ Usafwa (Mbeya R)	Technology Transfer, DEMO Seed Multiplication	66 (FG)	UAC 16O, Njano Sel-8, Ilomba
	Variety Evaluation	4	4 New + 1 local
Mshewe (Mneya R)	Evaluation DEMO Seed Multiplication	17 +PS	8 Varieties (New, old, local)
Njelenje (Mbeya R)	Evaluation, DEMO, Seed multiplication	25 +PS	1O varieties (New, old, local)
Shibolya (Mbeya)	Technology Transfer, DEMO Seed multiplication	27	6 varieties
	Variety Evaluation	Village	7 new + 1 local
Idunda (Mbeya R)	Technology Transfer, DEMO Seed Multiplication	Village	Uy-84, Uy-9O Njano, Ilomba, Kabanima, Kablanketi
Iwindi (Mbeya R)	Technology Transfer, DEMO Seed multiplication	12	Uy-84, Njano, DRK-4 Kabanima, UACG 161
Shamwengo (Mbeya R)	Technology Transfer, DEMO, Seed multiplication Variety Evaluation	5O	1O Varieties
Kapeleksi (Ileje)	Technology Transfer, DEMO Seed multiplication	8	5 Varieties Uy-84, Njano Kabanima, Sel-8, Uy-94
Ibungo (Illeje)	Technology Transfer, DEM Seed multiplication	26	Sel-8 CG76-1 Lyamungo 85, Njano,

			Uy-84, Ilomba
Mayale (Njombe)	Technology Transfer, DEMO Seed Multiplication	3O FG	6 New varieties + 1 Local
Imalinyi (Njombe)	Technology Transfer, DEMO Seed multiplication	2O	6 New varieties + local varieties
Kitelewasi (Mufindi)	Technology Transfer, DEMO Seed multiplication	12	7 new varieties + Local varieties
Sadani (Mufindi)	Technology Transfer, DEMO Seed Multiplication	2O	7 new varieties + Local varieties
Iponjole (May planting) (Rungwe)	Technology Transfer, DEMO Seed multiplication	15	3 New varieties
5 Villages (Chunya)	Variety evaluation Technology Transfer, DEMO Seed multiplication	3O	10 varieties

PS = Primary School FG = Female Group

CULTIVAR EVALUATION AND ITS ROLE IN SEED PRODUCTION IN SOUTH AFRICA.

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ABSTRACT

In South Africa a national cultivar evaluation programme is run by the Agricultural Research Council in collaboration with the Department of Agriculture, the seed industry and farmers' cooperatives. It is financed by the dry bean producers. A total of 30 cultivars are planted annually at 34 localities. The lowest yield of a cultivar at different yield targets in nine out of ten years is calculated by means of a regression analysis. This is called it's yield reliability. All the cultivars are characterised for disease resistance, quality and agronomic traits. The results are published in an annual report which is widely distributed among extension officers and producers. Farmers are able to select cultivars with a high yield potential, a low disease risk or some other trait of particular importance such as canning quality. Producers can then order seed well in advance. This enables seed companies to plan for the production of enough disease free certified seed. The disease free seed scheme originated as an extension of the cultivar trials and it ensures the availability of high quality seed of the best cultivars.

INTRODUCTION

Dry beans are an important crop in South Africa. The local consumption is 108 000 ton and plays an important role in the diet of a large segment of the population. The area under commercial production varies between 50 000 and 80 000 ha. Annual seed requirements are about 3 000 ton. At the current price of R6-00/kg the potential value of the seed produced in South Africa is at least R18 000 000 annually.

In most countries in Southern Africa the value of a breeding programme and the subsequent release of cultivars are impaired by a number of factors. In many cases these cultivars do not reach the producers soon enough or seed is not available when needed. In other cases cultivars are not maintained with the result that farmers are compelled to retain their own seed even if they are willing to buy seed (Banda, 1994; Madata, 1994). In South Africa this was also the case up to about 1980. During the past 15 years dramatic progress in the area of dry bean breeding, cultivar evaluation, seed certification and production has changed the whole dry bean industry (Liebenberg, 1994). My talk will concentrate on those factors which were instrumental in changing the dry bean scene. It is hoped that the lessons learned from our experiences in South Africa would be of some value to other countries in the region.

BREEDING

The first dry bean breeding programme was started in 1970 by the Department of Agriculture. For many years it was the only programme of its kind in South Africa due to a lack of interest from the seed industry. Farmers kept there own seed and showed very little interest in buying seed of this self pollinated, and therefore pure breeding crop. When the first lines were ready for release in 1976, there was a serious need to evaluate them (Liebenberg, 1994). An organisation also had to be found that would be interested in producing seed of these public cultivars. The Dry Bean Board was willing to fulfil this role. Presently cultivars produced by the Grain Crops Institute (GCI) are released to all interested seed companies and royalties are paid.

CULTIVAR EVALUATION

For many years the South African bean research programme consisted of a breeder and an agronomist assisted by two technicians. The breeder did not have the infrastructure or the time to compare his best breeding lines with the commercial cultivars. A national dry bean cultivar evaluation programme was started in 1975/76. Initially it consisted of 20 cultivars and breeding lines planted at 10 sites. During the years these trials have expanded to 30 entries and 34 sites in 1995.

Initially these trials were mostly conducted at research stations. Presently our Institute is directly responsible for only 11 of the trials. Gradually more seed companies and farmers' cooperatives have became interested and they are now responsible for 15 trials. The remainder are conducted by the Department of Agriculture and by interested farmers. At the moment the main function of our Institute is to coordinate the programme by obtaining seed of the most important cultivars from seed companies and by compiling and distributing the trials to the different cooperators. The trials are planted according to a standard procedure and are visited by the coordinator at least once during the season. A report is published and distributed amongst cooperators and all interested extension staff. The dry bean producers consider these trials of such great importance that they are willing to provide the running cost of the project.

The report supplies information on a whole series of observations on aspects such as susceptibility to a number of diseases, length of growing season, seed size, lodging and shattering as well as canning and cooking quality. As far as yield is concerned the mean yield as well as the yield reliability are taken into consideration. The mean yield of a cultivar is to a large extent determined by the highest yielding localities. Some cultivars, however, are better adapted to stress conditions. To overcome the bias in favour of high potential cultivars our Institute has introduced the yield reliability analysis as a standard procedure. This is derived from the regression analysis of the yield of individual cultivars against trial mean yields. It calculates the lowest yield which a cultivar is likely to achieve in nine out of ten seasons (Liebenberg, *et al.*, 1995). More reliable predictions are obtained if the data of more than one season are used.

The results of these trials are discussed at the annual meeting of the cultivar evaluation committee and no cultivar is recommended unless it was evaluated in these trials. The results of the cultivar trails have been the guiding force in determining which cultivars are grown in South Africa. Because the information is widely published the producer knows which cultivars have the highest yield potential or best disease resistance. This determines which cultivars he will order for the next season. The result is that no seed company is prepared to invest in the production of seed of a poor cultivar.

VARIETY LIST

Until recently South Africa had an open variety list. As the number of cultivars increased it was decided to close the list. This means that seed of a cultivar may not be sold unless it is on the variety list. In order to qualify for the list and plant breeder's rights, a cultivar must be submitted to the Directorate of Plant and Quality Control to be judged on the basis of whether it is new, uniform and stable. If it qualifies in this respect it can be put on the list. In most cases a cultivar is submitted for variety listing and inclusion in the cultivar trials during the same season. In this way information on its agronomic characteristics and adaptation is available by the time it reaches the variety list.

SEED CERTIFICATION

The production of disease free certified seed has become one of the cornerstones of the South African dry bean seed industry. Disease free breeders seed is produced in the glass house followed by field productions of breeders, basic and certified seed. Each generation is inspected for cultivar purity and the presence of seed borne diseases by inspectors approved by the South African Seed Organisation (SANSOR). A laboratory seed test on a seed sample of each production is done to detect seed borne pathogens. The whole seed certification scheme is privatised. The Department of Agriculture only does spot checks to monitor the standards (Malan, 1994). The success of the scheme lies in the fact that farmers are prepared to come back year after year to buy certified seed because they: a) are sure that it is high quality seed of the best available cultivars, b) see the difference in yield between the certified and uncertified seed. In many cases this means the difference between a good yield and a crop failure.

SEED PRODUCTION

Seed production in South Africa is limited to certain production areas. The normal commercial production regions are not suitable for this purpose, chiefly because of the presence of the three bacterial diseases halo blight, common blight and bacterial brown spot. Anthracnose, scab and bean common mosaic virus (BCMV) are less important largely because they are effectively controlled by the seed scheme. Seed is produced under irrigation in the drier hotter areas during the autumn or winter. Seed is normally ordered one year ahead. This means that seed companies must plan well ahead to decide which cultivars they are going to promote. These promotions are normally based on the results of the cultivar trials because farmers rely on them for their decision making. One of the main constraints in the seed industry in South Africa is the limited area available for seed production. Beans have to compete with other crops, for instance potatoes, for limited water and land. This results in very high seed prices.

At present the combined production of all the seed companies cannot supply in the demand for disease free certified seed.

RESULTS OF A FUNCTIONING SEED INDUSTRY

One of the main results of a well functioning seed industry was that bean seed production has become profitable. This has motivated a number of seed firms to start their own bean breeding programmes. Within recent years a whole series of new speckled sugar cultivars have been released which has increased bean yields by 20 to 30% above that of the standard.

Seed companies were prepared to invest in expensive seed processing plants in order to have seed ready at the beginning of the season.

Seed of all cultivars in demand are produced in large quantities. The main limiting factors at present are limited land and water in the seed production areas.

ESSENTIAL ELEMENTS OF A FUNCTIONAL SEED INDUSTRY

Less important elements:

The presence of a variety list is not important. In a country where farmers produce many different local landraces and mixtures this could have a negative influence on the dry bean industry.

A disease free seed scheme is also something which needs an extensive infrastructure and trained manpower. In most cases this would be too difficult and expensive to implement.

More important elements:

To what extent can the South African model be applied in other countries? Are there some elements which could be identified as essential for success?

a) One of the cornerstones in the whole system is the availability of reliable comparisons between cultivars. There is a good demand for a cultivar with wide adaptation and high yield. It pays to invest in seed production of such a cultivar. A system of national cultivar trials coordinated from a central office could be the first step in establishing a bean seed industry. Wide publication of trial results is essential to create a demand for the best cultivars.

b) The possibility to make money from seed production must exist. Seed prices must be higher than that of commercial seed. The normal tendency of producers is to keep their own seed back. Where the quality of the certified seed or the yield of a cultivar is of such a nature that it ensures higher yields, farmers are encouraged to buy this seed. This provided the stimulus for seed companies in South Africa to invest in seed production and breeding programmes.

c) Quality standards must be guaranteed. Certification of some sort is necessary. The producer must know that acceptable standards of cultivar purity, germination and absence of seed borne diseases are met. This could be done by the government or an independent non government organisation. In South Africa the government fulfilled this role until recently. Seed certification is now privatised and it is now done by the seed industry itself by means of SANSOR.

d) The seed must be available in the quantities needed and at the right time. Seed companies must be able to supply at planting time and they must be prepared to sell in small quantities if necessary. Even in South Africa the normal tendency for most growers is to start looking for seed at planting time. At that stage bean prices are high due to the seasonal bean shortage. If seed of a new cultivar of the right seed type is available at that stage farmers will plant it.

e) An organisation must be willing to take responsibility for the production of seed of cultivars originating from a public breeding programme. Initially the Dry Bean Board was willing to fulfil this role in South Africa. At present, its successor, the Dry Bean Producers Organisation, as well as seed firms, are keen on producing seed of GCI cultivars.

FUTURE PROSPECTS

In South Africa attention will in future be given to cultivar trials and on-farm trials to identify cultivars that are well suited to the needs of small farmers. Additional emphasis on breeding for adaptation to low soil fertility and heat and drought stress as well as early maturity will be important for the needs of resource poor farmers. Seed companies will have to find ways to reach these farmers with high quality seed of the best available cultivars.

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SESSION 6

ON-FARM RESEARCH

CHAIRMAN : C.S. MUSHI

BRIDGING THE RESEARCH-FARMER GAP : EXPERIENCE WITH ON-FARM RESEARCH ON BEANS IN TANZANIA

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ABSTRACT

The SADC/CIAT on-farm research activities in Tanzania reported in this paper covered four regions: Arusha, Kilimanjaro, Tanga and Kagera. The first three are maize-based cropping systems, while Kagera is banana based. The research activities included variety evaluation trials, farmer managed trials, on-farm seed multiplication and distribution, soil fertility and agroforestry. The research programmes were executed in collaboration with farmers, extension workers, national programme scientists and NGOs.

Exploratory trials in Lushoto District, Tanga region, using the modified minus one design, identified variety and soil infertility as the main constraints limiting Phaseolus bean production in the district. Both constraints have been addressed. The involvement of farmers in varietal selection for on-farm trials is now institutionalised. Evaluation techniques that were developed for the assessment of technology included the use of questionnaire, ordinal method and the elicitation of preference using coins.

The nutritional disorder that was once referred to as Usambara mottle was diagnosed as potassium deficiency. Agroforestry trials were initiated in 1988 in Lushoto to address erosion and soil fertility improvement as well as the provision of stakes for climbers. These trials are now yielding encouraging results.

INTRODUCTION

In Eastern and Southern Africa, beans [*Phaseolus vulgaris* L.] are the second most important source of protein and the third most important source of calories. Production is estimated to exceed 2.5 tonnes annually. It was against this background that a regional workshop was held in Malawi in 1980 and the Centro Intrenacional de Agricultura Tropical [CIAT] was invited to collaborate with national agricultural research systems for bean improvement. From the recommendations of the workshop three regional bean programmes were launched between 1984 and 1987. The first region to be served was the Great Lakes region. The second was the Eastern Africa region and the third, the Southern Africa Development Community [SADC] with headquarters in Arusha, Tanzania.

AGRO-ECOLOGICAL ZONES

The Northern Zone [Arusha and Kilimanjaro Regions]

The SADC/CIAT on-farm research activities in Tanzania covered four administrative regions: Arusha, Kilimanjaro [here after referred to as the northern zone], Tanga and Kagera. Geographically, the northern zone is located between 1°44' south latitude and 35°30' and 38°45' east longitude. The northern boundary of the zone is the Tanzanian-Kenya border [Grace and Lyamchai, 1991]. Much of the zone lies in the rift valley. Altitudes range from 610 m above sea level around Lake Natron to 5895 m [Mt. Kilimanjaro]. However, most of the area lies in the floor of the rift valley with elevations of less than 1500m and a flat to gently rolling surface. The population of the zone is 2.5 million [1989 statistics]. It is projected to grow to 10 million by 2025. The rainfall pattern is bimodal. Annual rainfall varies from less than 400 mm in areas of low elevation to excess of 2000 mm in the high rainfall areas of Mount Kilimanjaro and Mount Meru.

Tanga Region [Lushoto District]

The main area where the work was concentrated was in the Usambara Highlands of Lushoto District, one of the six administrative districts of Tanga region. The Usambara Highlands are located in the northeast of Tanzania. They are between latitude 4°24' - 5°00'S and longitude 38°10' - 38°36' E. It is very close to the Kenya border and is about 700 km from the Indian Ocean. They are bordered by the Umba Plains in the north, The Pare mountains in the northwest and the Masai steppe in the south. The Usambara Mountains are divided into a western and an eastern block. Both are separated by the Lwengera valley. The work reported here was done in the Western block. The area occupies about 2600 km^2 although about 1575 km^2 of the area is considered to be arable.

The altitude ranges from 1000 - 2400 m above sea level. But the arable area in the upper plateau ranges from 1200 to 1800 m. There is considerable relief with steep slopes ranging from 10 to 30%, although 75 % of the cultivated land is between 20 and 25%.

The annual varies from 600 to 2000 mm and it is bimodal. The long rains [*Masika* or *Mwaka*] are from March to June. The short rains [*vuli*] are from November to January. There is also an intermediate rainfall [*mlwati*] between May and August. This is confined to the highlands [Smithson, Edje and Giller, 1992].

The geological base of the Western Usambaras is precambrian base rock consisting chiefly of gneiss and granite. Soils derived from these materials are primarily latosols. Most of the soils of the inner mountain slopes are humic latosols and chromic luvisols. On the lower slopes, clays classified as pellic vertisols and chromic cambisols are found. Almost all soils are poor in nutrients, showing particularly pronounced deficiencies in phosphorus and potassium. The latosols are also deficient in calcium, and magnesium [Egger *et al*, 1980].

The population of the district is 286,069 inhabitants with a mean density of 102/km^2 and a peak density exceeding 250/km^2. Over population coupled with overstocking were seen as the two main constraints that threatened the sustainability of the existing farming systems in Lushoto district, where the farm size is about one to two hectares and most of steep slopes [Dobson, 1940 and Mitchell, 1984].

Kagera Region

The region consists of Bukoba, Karagwe, Biharamulo and Ngara districts. Collectively, they occupy an area 39, 370 km^2. It is situated between longitude 30°30' E and 32°00' east of Greenwich and between latitude 1°00' south of the equator and 3°30 ' S of the equator. The predominant geomorphological features of the region are the low broad mountain ridges. The altitude of the area varies from 1135 to 1600 m asl. The highest peak is in Karagwe with an altitude of 1800 to 1850 m.

The average annual rainfall varies tremendously. The rainfall is highest, above 2000 mm annually in the north western part of the region and decreases towards the south and the west where it levels to 800 -900 mm The rainfall in the region is quite reliable.

ON-FARM RESEARCH

An on-farm research survey was conducted by Due *et al.* in 1985. The survey was part of the research activities of the Bean/Cowpea Collaborative Support Programme [CRSP] of which Sokoine University [SUA] , Morogoro, Tanzania was the host institution. The objective of the survey was to study the place of beans in the farming systems of Tanga region. In 1987, the SADC/CIAT Regional Programme on Beans in Southern Africa with headquarters in Arusha, Tanzania initiated a series of on-farm trials. These were in collaboration with the scientists of the national bean programme and the extension workers in the district. The SADC/CIAT bean programme also worked very closely with the Soil Erosion Control and Agroforestry Project [SECAP] in Lushoto. Through these linkages we were able to establish a clear sequence of on-farm trials proceeding from the diagnosis to the determination and verification stages as exemplified by exploratory, on-farm variety trial and farmer managed trial.

Bean on-Farm Exploratory trials

An exploratory trial was initiated during the *masika* of 1988 using the modified minus one design. The objectives of the design were to quantify the factors limiting bean production and to detect interactions between them. In 1988, this researcher managed trial consisted of eight treatments [see Table 1]. The full package [FP] consisted of an improved variety, Lyamungu 85, insect control [I] which was seed dressing with endosulphan and forthnightly sprays with insecticides; seed dressing with Derasol as well as regular spray to control diseases [D]; and fertilizer [F] at the rate of 45 kg/ ha of N and 26 kg/ha P. One or more inputs were omitted in turn to determine the effects of those factors.

Plot sizes varied from 12 to 16 m^2 and each treatment was replicated three or four times per site. The number of sites per region varied from ten to fifteen per cropping season.

The results in Lushoto showed that varieties and soil infertility were the two main factors limiting bean production. For example, the yield of full package was 1143 compared to 738 for full package minus variety and 802 kg/ha for full package minus fertilizer , respectively [Table 2]. The use of the minus one design was not effective in detecting the main factors limiting yield in Arusha and Kilimanjaro regions . Nevertheless, it was obvious in most cases that lack of variety was the main factor limiting bean production in these regions. Soil fertility was not a major constraint presumably due to the inherent nature of the soils which are of volcanic origin.

The exploratory trial was not conducted in Kagera region. Farmers refused the use of agrochemicals, including inorganic fertilizer, on their banana fields. They preferred instead to rely on mulch as a source of plant nutrient. Their refusal was due to the fact that, a few years before the trials were initiated, some farmers had lost some of their livestock from chemicals [Furadan] applied to banana for the control of banana weevils.

On-Farm Variety Trial

Based on the results of the exploratory trial, on-farm variety trials were initiated in Lushoto district. Prior to this there had not been any systematic evaluation of bean varieties for the area. Sixteen each of promising dwarf and climbing lines from the national bean programme were evaluated in Lushoto to provide a wider choice of entries for future on-farm trials. From these trials, entries for on-farm trials were selected with the assistance of farmers.

Farmer Participatory Research

The national bean programme in Tanzania has a well structured breeding programme ranging from germplasm collection and evaluation, uniform cultivar trial, national yield trial and finally to on-farm trial.

In the above scheme, farmers were given entries to test. These entries were usually selected by the breeders without input from the farmers. In some cases this approach resulted in the testing of materials with low farmer acceptance. In order to integrate farmers in the variety development process, farmers were invited to the research station to assist the breeders and the agronomists in the selection of materials that could be tested on-farm. In this connection, ten farmers [both men and women] who had considerable experience and knowledge on bean production and who were collaborating in on-farm research were selected. These were invited to research stations at Selian Agricultural Research and Training Institute, Arusha; Lambo Estate, near Moshi and at Mabughai, Lushoto. For this purpose, the entries for the national yield trial were planted in one replicate. The plots were 10 m long and 6 m wide, large enough for the farmers to visualise the differences in the entries. The farmers were invited to the research station twice during the season. First during the early reproductive growth stage. At this stage they assessed the crop for production characteristics: crop management, vigour, and reaction to diseases and insect pests. The second visit was at harvest maturity. The farmers assessed the crop for pod load, yield and seed characteristics. At each stage, the farmers were assigned enumerators to record their assessment.

During each visit, the farmers used three forms of assessment. First, they used an ordinal method where the entries were rated on a scale. Second, they were given a questionnaire with positive and negative attributes. The attributes on the questionnaire reflected the growth stage of the crop [see Table 3]. Along with these attributes was a set of reasons from which the farmer could choose for rating an entry as excellent, good, average, fair or poor. The second method of assessment was to assist the breeder rather than the farmer *per se* [see Table 4].

The third method was the use of coin, homogenous physical objects with identifiable value. Each farmer was given fifty one shilling Tanzania coins for the quantification of their preferences. The allocation of more [less] coins to a variety implied that the farmer had a stronger [weaker] preference for that variety [Table 5]. At the end of the exercise, the data were summarised and discussed with the farmers. At the harvest stage, farmers were given one

Table 1: Treatment component for bean exploratory trial.

Trt No	Description	V	D	I	F
1	Full package	+	+	+	+
2	Full package minus variety	-	+	+	+
3	Full package minus disease control	+	-	+	+
4	Full package minus insecticide	+	+	-	+
5	Full package minus fertilizer	+	+	+	-
6	Full package minus variety minus disease control	-	-	+	+
7	Full package minus insecticide minus fertilizer	+	+	-	-
8	Farmer's practice	-	-	-	-

Table 2: Assessment of factors limiting bean production in Lushoto district.

Trt No	Description	Seed yield [kg/ha]
1	Full package	1143
2	Full package minus variety	738
3	Full package minus disease control	946
4	Full package minus insecticide	920
5	Full package minus fertilizer	802
6	Full package minus variety minus disease control	756
7	Full package minus insecticide minus fertilizer	559
8	Farmer's practice	508
	Mean	797
	L S D [P= 0.05]	699

Table 3: List of positive and negative attributes for assessing variety preferences.

Positive criteria [Better because :]	Negative criteria [Worse because :]
1. Good yield	12. Poor yield
2. Resist sun [drought]	13. Does not resist sun
3. Good architecture	14. Poor architecture
4. Resist rain	15. Does not resist rain
5. Does well on poor soil	16. Does poorly on poor soil
6. Leaves in good health	17. Leaves in poor health
7. Pods in good health	18. Pods in poor health
8. Early maturity	19. Matures late
9. Good seed colour	20. Poor seed colour
10. Good seed size	21. Poor seed size
11. Other: specify	22. Other: specify

kilogramme each of the best three varieties for culinary evaluation. Data were collected from farmers about four to five weeks after they had been given the seed. This was done to allow sufficient time for cooking. Farmers were allowed to use their own recipe. Evaluation was done using all the three assessment methods: ordinal, questionnaire and the preference elicitation method using coins.

Farmer Participatory Trial On -Farm: Variety Assessment

The same procedure that was used on-station was adopted on-farm for further evaluation of the entries. Other farmers, about 10 per farm, were invited from neighbouring farms to assist in the assessment of the entries on-farm. The entries were assessed for production, marketing and consumption characteristics [Tables 6 and 7]. This took the farm of a mini-field day. Data from such evaluations were pooled and shared at the end of the season.

On-Farm Seed Multiplication Scheme

A bean variety, Lyamungu 85 was released by the national bean improvement programme in Tanzania in 1985. Four years after its release, it was not marketed by the national seed company. This is not unique to Tanzania. It has been observed elsewhere that most seed companies are reluctant to promote the seed of self-pollinated crops, presumably on account of low volume of business. It was against this background that we introduced a seed multiplication scheme on-farm. Initially, farmers were loaned 5 to 10 kg of a released variety. The seed was collected from the farmers after harvest. Because of the constraint in timely retrieval of the loan, the scheme was modified to a seed revolving one. This was again modified as the rate of spread of new variety was slow. In its place, a group of women, school children, church groups , etc, were given about 100 to 150 kg to multiply and distribute/sell. Through this process, seed of released varieties was made more readily available than through official seed channels.

Farmer Participatory Trial On-Station: Agronomy Trials

The involvement of the farmers in the selection of varieties for on-farm research was a great success. We observed that farmers had begun to multiply and sell some lines long before they were released officially. This encouraging scenario prompted us to extend farmer participatory research into agronomy trials. In 1990, 10 farmers were invitedto assist in the selection of treatments that they would like to see tested on-farm. The same procedure for the selection of entries for variety trial on-farm was used. Farmers evaluated two trials. The first trial was on the effects of the distance of bean rows from maize rows on the yield of both crops. In the northern zone where this was done, farmers normally grow maize and beans in association. The maize crop is fertilised but not the beans. The hypothesis was that the unfertilised beans would benefit from the fertilised maize and the extent of which would depend on the nearness of the bean row from the maize row.

The treatments were:

1. Maize and beans planted in the same row
2. Beans planted 15 cm from the maize row
3. Beans planted 30 cm from the maize row
4. Beans planted 45 cm from the maize row
5. Beans planted 45 cm from the maize row and another row of beans on the same row as the maize.

In all the treatments, the plant density was the same. Farmers were given coins to quantify their preferences. Their highest preference was treatment number 4 [Table 8]. Reasons given include the ease of planting and weeding. The size of the hoe which was used for weeding was a deciding factor.

The second experiment was on strip intercropping, which was conducted in 1990. Maize was planted in rows 90, 180 and 270 cm apart with one, two or three rows of beans, respectively between the maize rows. Ten farmers were invited to assess the trial at Lambo and at Selian. The most preferred was the 90cm maize row spacing. Farmers felt that the number of bean rows in the other treatments was too few. They recommended that the number of bean rows be increased in subsequent trails. This was done and the trial was evaluated in 1991 and 1992. Bean yields were increased by the increase in the number of bean rows. However, farmers still rated the 90cm row as the best.

Table 4: Questionnaire for the assessment of entries to provide more information for the breeders.

Variety	Evaluation [Circle choices]	Reasons [use code and information in Table 4]
1	a b c d e	
2	a b c d e	
3	a b c d e	
4	a b c d e	
5	a b c d e	
6	a b c d e	
7	a b c d e	
8	a b c d e	
9	a b c d e	
10	a b c d e	
11	a b c d e	
12	a b c d e	
13	a b c d e	
14	a b c d e	
15	a b c d e	
16	a b c d e	

Table 5: **Assessment of 16 bean lines at pod fill and harvest and seed yield at Lushoto, 1988-1989.**

Entries	Assessment at pod fill		Assessment at harvest		Seed yield
	No coins	Rank	No coins	Rank	[kg/ha]
Linea 24	3	15	0	15/16	1032
FB/GP 262	57	3	42	5	826
PVAD 1492	22	7	12	8	1054
LB 87-3	34	6	2	13	919
LB 273	5	14	11	9	1104
TB 79/155	7	13	1	14	918
YVT 111-LB 1974	20	8	102	1	944
LB 72	35	5	8	10	722
LB 110	15	9/10/11	6	11/12	959
FB/GP 270-3	100	2	36	6	1054
G 8664	13	12	62	4	857
LB 282	45	4	0	15/16	997
LB 87	0	16	6	11/12	1270
Lyamungu 85	115	1	101	2	1329
Canadian Wonder	15	9/10/11	91	3	751
Masai Red	15	9/10/11	29	7	754

Table 6: **Production, consumption and marketing characteristics used by farmers for assessing entries for on-farm trials.**

Production	Consumption	Marketing
Early maturity	Seed colour	Seed colour acceptable
Tolerance to drought	Short cooking time	Seed size acceptable
High yield	Cooks into good broth	Heaviness of seed
Resistance to field insect pests	Cooked beans keep well over night	Easy to be mixed with other varieties
Tolerance to heavy rains [i.e. diseases]	Tastes good	Matures evenly
Other [specify]	Other [specify]	Other [specify]

Table 7: **No of coins for various characteristics and yield [kg/ha] of six entries in on-farm trial, Arusha, 1990.**

Entries	Production	Marketing	Consumption	Seed yield
Carioca	2.0	3.8	9.8	676
CWSPS 31-3	19.3	14.9	10.2	828
Lyamungu 90	5.3	7.1	5.2	971
Uyole 84	4.1	2.6	3.4	1139
Lyamungu 85	10.5	11.0	11.1	875
Local check	8.8	10.6	10.3	844

Table 8: **Preference elicitation of treatments in the effects of distance of bean rows from maize rows on production practices.**

Treatments	Locations			
	Lambo	Selian	Mean	Rank
1. Maize and beans same row	118	72	95	4
2. Beans 15 cm from maize row	18	47	32.5	5
3. Beans 30 cm from maize row	118	82	110	3
4. Beans 45 cm from maize row	96	222	159	1
5. Maize and beans same row and also 45 cm from maize row	97	127	112	2

Table 9: **Element composition [micro gram/ gram] of trifoliate leaves of beans with and without Usambara mottle symptoms, 1989.**

Element	Irente UM	Irente no UM	Miegeo UM	Miegeo no UM
Phosphorus	2835	3307	1695	2002
Potassium	4958	16133	2210	6190
Calcium	28572	23137	41169	19247
Magnesium	8346	5678	10303	5775
Sodium	56	31	81	37
Iron	163	120	190	82
Aluminium	113	57	107	30
Zinc	26	29	18	24
Copper	9	7	6	6
Manganese	181	65	139	82
Boron	36	30	32	22

Lessons Learned From Farmer Participation in Varietal Selection On-Station and On-Farm.

1. Farmers appreciated the use of coins for the evaluation of entries. Farmers spent some considerable time in deciding how much to allocate to an entry.

2. Yield was not always the main criterion that farmers used in selecting materials for on-farm testing.

3. Farmers did not always select the same materials that they will like to see tested on-station as on their own farms. They recognised the management and soil fertility requirement differences between entries.

4. Farmer's choice of entry depended on the stage of the crop.

5. Farmers wanted to have larger plots for on-farm trials as they saw this as a rapid means of seed increase of desired varieties.

6. Breeders and agronomists appreciated the role of farmers in the exercise.

SOIL FERTILITY STUDIES

Exploratory Trial

In 1987, poor growth of beans crop on farmers' fields was observed often associated with a distinct interveinal chlorosis, which we called "Usambara

Mottle" [UM]. The following year, these symptoms were again observed in bean crops in farmers' fields and also in on-farm trials. These trials had been initiated as part of a national and regional research programme on *Phaseolus vulgaris* in the Usambaras.

In an attempt to address the problems of soil infertility that was detected during the trials on factors limiting bean production in the district, soil fertility studies were initiated. In the first trials, the response of beans to N and P were investigated. The application of nitrogen and phosphorus fertilizers improved bean growth and yield [sometimes significantly so] but the improvements were small. Thus, there appeared to be other soil nutrients which were limiting, perhaps associated with UM. This symptom was not corrected with the application of N or P and indeed, in some plots, was excercebated by the application of P.

In the *masika* season of 1989, on a farm at Irente, not too far from Lushoto town, bean growth was extremely poor and the chlorosis was very severe in areas where the trial was been conducted for the second season. Again, although both N and P had improved growth, the bean crop grew extremely poorly and the symptoms persisted. Other nutrients applied at Irente in this season included boron, copper, molybdenum and zinc. These affected neither growth, nor yield nor did they correct the Usambara Mottle.

Leaf Tissue and Soil Analysis

In 1989, leaves were sampled from bean plants with UM symptoms. Leaves were also sampled from adjacent healthy plants. The results showed that the concentration of potassium in leaves with UM symptoms was only one third of the potassium of leaves of normal plants [Table 9]. These concentrations were considered deficient [Howler, 1983]. The copper and the zinc levels were also considered deficient. Aluminium, iron, magnesium and manganese contents of leaves with UM symptoms were much greater than those of normal plants. The potassium content of soils from affected plants were severely deficient in K.

Farm Survey of UM Incidence

In the *masika* season of 1990, a survey was conducted to determine the extent of the spread and the severity of the UM. The survey was conducted on 60 farms in six divisions of the district: Bumbuli, Lushoto, Mgwashi, Mlalo, Soni and Umba. Ninety five per cent of the farms surveyed had used neither organic nor inorganic fertilizers. All the 60 farms [100 %] showed symptoms of UM. Sixty five per cent of the farms showed symptoms ranging from severe necrosis to death [Fig. 1].

In view of the importance of the deficiency symptoms, and the results of the tissue analysis, a 2^5 factorial experiment was conducted on a site where the symptoms had been very severe. The treatments were N: 0 and 60 kg/ha, P: 0, and 52 kg/ha; K: 0 and 50 kg/ha . Trace elements: cuppric oxide and zinc sulphate were also applied at 1.5 and 7.8 kg/ha , respectively. Both were applied foliarly. Agricultural lime was also applied at the rate of 4.5 tonnes/ha.

The application of K corrected UM symptoms in all trials. Grain yields were significantly improved by P and K and there was significant PK interaction [Table 10].

In the *masika* of 1990 a series of NPK [4^3] factorial trials was conducted. The treatments were N: 0, 30, 60 and 90 kg/ha; P: 0, 26, 52, and 78 kg/ha and K: 0, 25, 50, and 75 kg/ha. As in the previous trial, K corrected UM symptoms. Grain yields were significantly improved by the application of all nutrients [Table 11]. None of the interactions was significant.

AGROFORESTRY TRIALS

In 1980, the Soil Erosion Control and Agroforestry Project [SECAP] was established in Lushoto to tackle the problem of land deterioration. The project began by promoting an existing technique of planting perennial Guatemala grass [*Tripsacum laxum*] along contour lines 0.7 m wide, to control soil erosion and to provide fodder. The distance between the strips was 5 to 20 m wide depending on the slope. However, a single line of Guatemala grass was insufficient to control erosion and the vegetative strip was diversified by planting creeping legumes, shrubs and trees. These 2-m wide strips were called macrocontour lines.

In 1988, the SADC/CIAT regional bean team SECAP initiated collaborative trials on the effects of different trees, shrubs and grasses and their competitive ability on neighbouring annual crops. The composition of the macrocontour lines [MCL] varied. Some were of a single line or a combination of two or three species in the MCL. Depending on the composition, the species in the macrocontour lines were *Leucaena diversifolia, Calliandra callothyrsus, Pennisetum purpureum* or *Tripsacum laxum*. In cases where there were three species in a line, the grasses were always in the middle.

At Ubiri, it was observed that the competitive ability of *Pennisetum purpureum* when planted alone in the MCL was the highest on neighbouring crops even in the first year of establishment. Bean yields were severely depressed for about 3 to 4 m away from the line. However, with the other grass and legume species, yields were not appreciably reduced beyond 1 m from the MCL.

Because most of the farms in the district are on slopes of 20 - 25 %, some farmers use Guatemala grass to control erosion while others use trash lines of maize stover or weeds across the slope. Some planted on fields with large clods, while others had no control measures.

Table 10: Effects of P and K in NPKLT on UM leaf symptoms, pod/m² and seed yield [kg/ha], Lushoto, 1989.

P levels [kg/ha]	K levels [kg/ha]	UM score [1-9 scale]	Pods/m²	Seed yield
0	0	5.31	286.3	307
	50	2.63	460.4	581
52	0	7.31	302.8	354
	50	2.63	491.6	719
Mean	-	4.47	385.3	490
S. E.	-	0.29	4.20	50.7

Table 11: Effects of N, P and K on bean seed yield [kg/ha] at five locations, Lushoto, 1990.

Fertilizers	Irente	Mabughai	Magamba	Mbuzii	Soni
0 N	910	565	332	300	876
30 N	1010	679	609	400	1228
60 N	1334	776	834	437	1275
90 N	1084	820	771	527	1039
0 P	747	374	274	298	980
26 P	1120	691	701	400	1095
52 P	1123	813	678	479	1090
78 P	1348	962	893	487	1253
0 K	584	461	437	243	817
25 K	1184	781	663	479	1226
50 K	1226	792	748	446	1167
75 K	1346	807	698	496	1208
Mean	1085	710	637	416	1104
S E	68.4	36.6	48.0	27.0	43.9

Table 12: Weight of soil loss [kg/ha] and bean seed yield [kg/ha] with five MCL treatments, Lushoto, 1992.

Composition of macrocontour lines	Soil loss	Seed yield
Control	352	286
Maize stover	106	496
Trisacum laxum	112	450
Leuceana diversifolia	168	400
T. laxum and *L. diversifolia*	236	380

In the *masika* of 1990 the effects of *L. diversifolia*, *T. laxum* . maize stover as trash line in macrocontour lines on erosion control were investigated. A control treatment was also included. The trial was on a 22.3 % slope. Plots were 20 m long and 6 m wide. The distance between macrocontour lines was 10 m. Pits, 0.5 m wide by 0.5 m deep and 1.0 m long were dug at the end of each plot to collect runoff. Runoff between plots was controlled by the construction of clay-rich sub-soils. Pits were lined with perforated plastic. Beans, Lyamungu 90 was planted at random to give a plant density of 20 plants/m^2.

The highest soil loss in 1992 was from the control plots [352 tonnes/ha] compared to 106 tonnes / ha for plots with maize trash, which had the least loss [Table 12]. Bean yields were generally low at the site. However, the highest and the lowest yields were in plots with maize stover and control, respectively. The correlation coefficient between soil loss and yield was r = - 0. 978. The low loss of soil from the trash bund could be explained on the basis of a more solid barrier than those of the grass and the legume with relatively wide intra - plant spacing. Perhaps the inclusion of a creeper in the MCL could have reduced the soil loss considerably. Although the maize trash was most effective in reducing soil loss, it has been known to increase the infestation of stalk borers. In areas where farmers rely on maize stover as fodder for livestock, there could be competition for their use as trash bunds.

ASSESSMENT OF COMPETITIVE ABILITY OF HEDGEROWS OF NEIGH-BOURING CROPS

Agriculture is the mainstay of the economies of most developing nations. Although agriculture is important and has great potential, it remains unproductive for several reasons. This includes the adverse effects of soil erosion , which is now one of the main environmental constraints to agriculture. Following this perception, several measures have been adopted to address soil erosion problems and to stabilise hill slope agriculture [Sheng, 1979; Symle and Magrath, 1990]. Some of these measures that have been adopted include terracing, contour bunds, stone lines, stop-wash lines of straw, grass strips, macrocontour lines, etc. [Hudson, 1987; Mamba, 1992].

While there has been considerable interest in the use of grass and/or legumes in hedgerows for erosion control, their effects on neighbouring crops have been neglected. This may explain their low rate of adoption by farmers [Franzel and van Hounten 1992]. Against this background, the SADC/CIAT Regional Programme on Beans on Southern Africa in collaboration with staff of the Agricultural Research and Training Institute, Selian, Arusha, Tanzania initiated a study. Four legumes and five grasses were studied. The legumes species were: cassia [*Cassia simea*], calliandra [Calliandra callothyrsus], sesbania [*Sesbania sesban*], and leucaena [*Leucaena diversifolia*]. The grass species were: Guatemala grass [*Tripsacum laxum*], vetiver [*Vetiveria zizanioides*], panicum [*Panicum collaratum*], napier grass [*Panicum purpureum*] and a local grass, Olkakola local. Plots were 20 m wide and 8 m long with the hedgerow in the middle. Maize or beans was planted on either side of the hedgerow.

Beans were harvested by row. Data showed that the highest yield reduction by the legume species was by

Sesbania sesban [Table 13]. The competitive ability was conferred on it by its canopy height and width [Table 14]. On the hand, napier grass was the most competitive among the grasses, presumably because of its mass of shallow roots.

Table 13: Effects of species in a hedgerow on the yield of beans.

Species	Treatment mean yield [g/ row]	Yield of 2 adjacent rows from hedgerow [g/row]	Difference in yield [%]: column 3 compared to column 2
Sesbania sesban	792	218	-73
Leucaena diversifilai	910	810	-11
Calliandra callothyrsus	665	725	+9
Pennisetum purpureum	796	495	-38
Tripsacum laxum	898	880	-2
Vetiveria zizannioides	1008	923	-8
Panicum collortum	908	678	-25

Table 14: Canopy width, canopy area and canopy ratio of four legume and four grass species in hedgerows, 1991.

Species	Canopy ht.[cm]	Canopy width[cm]	Canopy area[cm^2]	Canopy ratio [ht:width]
Sesbania sesban	420	270	113400	1.6
Leucaena diversifilai	280	110	30800	2.5
Cassia simea	117	55	6435	2.1
Calliandra callothyrsus	162	67	22194	2.4
Pennisetum purpureum	290	137	39730	2.1
Tripsacum laxum	102	62	6320	1.6
Vetiveria zizannioides	115	80	9200	1.4
Panicum collortum	59	162	3658	0.4
Mean	193	117	28340	1.8
C. V. [%]	6.6	20.2	27.6	19.5
S. E.	7.4	13.7	45.1	0.20

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PARTICIPATORY ON-FARM BEAN TRIALS IN MALAWI

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ABSTRACT

To date, bean research and breeding has focused mainly on trials which are carried out on agricultural researchstations, or have a significant researcher input in terms of management and agronomic practices. This paper outlines the Malawi National Bean Programme's methodology for testing new bean varieties on farm with farmers as the principal researcher. It illustrates how it is possible to incorporate and interalise farmers evaluation and selection criteria into the national breeding and researchprogramme. It is hoped that by enabling farmers to participate in the selection of the characteristics of new beans that they value, future seed multiplication and dissemination processes will cater for client demand much more accurately.

INTRODUCTION

On-farm trials are a relatively new addition to the Malawi National Bean Programme (MNBP). Prior to this year the programme activities have predominantly focussed on the more traditional and classic approach to selecting and multiplying high yielding and disease resistant bean varieties. All these activities were based on research stations with management provided by the Department of Agricultural Research and by the programme itself.

While the importance of key breeding activities on research stations can not be doubted, the objective of this programme was to not only identify potential new and appropriate seed materials within a traditional technical and scientific framework, but crucially to transfer the selection and evaluation processes to the end users, that is, farmers from a range of diverse social and economic backgrounds, to empower them to participate at the earliest stage in selecting appropriate seed materials for dissemination to rural communities. .

The objective of focusing on end users, or clients as a key to selecting appropriate varieties has been influenced by the work done by colleagues on the Bean Cowpea CRSP programme(Bunda Agricultural College), who have identified that "a strong inter-relationship exists among biological diversity in the bean crop, regional ecological variation, and the rich sociocultural diversity that characterises Malawi." (Ferguson *et al* 1992)

Therefore a classic technology transfer approach of selecting one or two varieties that respond well under research conditions and then releasing these into a supposedly homogeneous agro-ecologcial and social environment is seen as inappropriate for Malawi, as has been recognised by CIAT's research in the Great Lakes Region of Central Africa.

"In heterogeneous environments, however, (agro-ecological and social) such narrowing may also represent missed opportunities for breeders; that is her/his varieties, never tested on farm, potentially could find a productive place in farmer micro-niches. The challenge is to identify acceptable (potentially locally adapted) variability early in the selection process."(Sperling, *et al* 1995)

With CIAT's experiences and collaboration, the MNBP has begun to design mechanisms that enable farmers to play an important role in variety selection and breeding. By incorporating farmers criteria through the use of a range of farmer participatory research initiatives, the MNBP will be able to have a greater understanding of the hetrogenity of culture and farming systems within the country, and then MNBP's response to seed needs will be driven by farmers who represent this heterogeneity. Therefore the opportunities for the programme breeders through interactive collaboration with farmers to identify seed materials that find a productive micro-niche are greatly enhanced.

While this move towards farmer participatory research and farmer-researcher interaction is still relatively new, this paper will outline the beginnings of the process and set out some preliminary results from these first initiatives.

Two initiatives have been undertaken since February 1995 as a start to developing an interactive farmer participatory research and breeding programme.

Farmer Participation in Variety Selection and Identification:

Farmer On-Station Selections

The MNBP has three major sites where regional and inter-regional nurseries have been developed, Bembeke and Kandiani and Chitedze. Farmers have been invited to a field day where they are given the freedom to inspect what materials are being grown and to evaluate which ones are of interest. Farmers are encouraged to collect a few seeds of the materials that they are interested in to aid identification of the variety.

Following the field visits a meeting of the farmers is held. Likes and dislikes are discussed and from these discussions a "general" feel for which varieties were appreciated, and which criteria are most forefront in the farmers minds, is generated.

There are a number of appreciated weaknesses to this particular methodology:

a. the farmers who attend can only come from a small area within the vicinity of the research station, they may through contact with the research staff and other research initiatives be dominated by "innovators" and more "dynamic" farmers.

b. the group meetings after the visit are dominated by a small number of male, better resourced farmers who have some role or status within the local community. The feedback and perceptions gathered therefore represent this groups' influence more than a consensus for the whole group. Female farmers have much less opportunity to express their opinions or to disagree with the more vocal male orators.

c. the visit to the station is at one point in time, therefore the evaluation criteria that the farmers can use is essentially limited to this one visit. Beans in Malawi are important for more than their grain harvest, e.g. leaves and green beans, and so if a static one shot evaluation is all that the farmers can make it is difficult for this type of evaluation to allow the farmer to make choices using the whole spectrum of criteria that they would for a variety they grow on their farms.

To address some of these weaknesses and to generate some more sensitive information and to canvass the views of Malawi's main bean cultivators, women, a second visit is arranged with a smaller group of farmers who are selected by the Ministry of Agriculture (MOA) Field Assistants (FA). The Field Assistants are briefed to select a range of bean growers, but to identify female-headed households and the less well resourced households within their section.

Individual conversations between the farmers and breeding staff take place, and more specific recommendations from farmers are generated about the materials in the nurseries. The interaction is at an interpersonal level rather than the group interface, and is between research staff and farmers directly.

The outcomes of these initial farmer visits are that a range of seed characteristics and particular materials are broadly identified from the research stations nurseries. From these materials selections are made for the varieties that go on to be tested at the farmer level, in the On-farm Trials.

On-farm Trials

The On-farm trials are the next stage in the cycle whereby the farmer participates in the evaluation of new varieties in comparison to her/his own varieties. On-farm trials allow a continuous evaluation of the whole plant cycle. Evaluations are made according to the farmers own criteria within the specific agro-ecological, socio-cultural and economic niches where the farms are located.

The MNBP have instigated 3 sets of On-farm Trials this year during Malawi's dry winter season. These trials are located in the Central Region of Malawi at Bembeke, a medium altitude site of around 1650 meters above sea level, Kalira another medium altitude site at approx. 1400 meters above sea level and lastly at Zidyana a low altitude site of around 500meters above sea level. The three trial sites has a total of 45 participating farmers, of which 25 are women and 15 are from female headed households.

Another eight On-farm trials are planned this coming wet/summer season. Each trial will have 15 participants, so a total of 120 farm families will test MNBP seed material.

The winter season trials are on-going with partial results from Zidyana which are discussed later. All sites rely on residual moisture and fields are situated in valley floors, known as "dimba", or as at Zidyana on a low lying riverine flood plain close to Lake Malawi.

In order to access a range of farmers from the very diverse economic and socio-cultural strata within Malawi's rural communities, a farmer selection process is used to identify participating farmers.

Guidelines are discussed with MOA FAs who actually select participating farmers. These guidelines emphasise the need for a range of farmers from different wealth categories, with different levels of access to land and water resources. Also as it is recognised that in Malawi women are the principle cultivators of beans within the family unit, therefore a criteria is that five of the fifteen farmers must be female headed households. This also enables access to the most resource poor strata within the communities.

Rigid externally imposed farmer selection criteria are inappropriate given the very different characteristics of the areas that the trials are located in. The training and understanding of the Field Assistant, together with his/her in-depth knowledge of the local area and the farmers is the key to representative farmer selection.

The trial has two components, a "Farmer Managed On-farm Trial" and a "Researcher Managed On-farm Trial". Five randomly selected farmers undertake the researcher managed trial, and the remainder the farmer managed.

Farmer Managed On-farm Trials

The essence of this trial is that farmer participation is maximised and researcher interference is minimised. Farmers are given one packet of 200 seeds for each of the varieties that they evaluate. They are requested to plant this seed as they would normally, but are asked to mark carefully where each packet has been planted. An empty packet is provided for 200 seeds of their own local variety which is grown as the comparison.

They are asked to cultivate this seed as they would their own variety. No other help or advice is given. The farmers decide on plant date, plant spacing, seeds/station, etc. Usually farmers practises do not include the use of inorganic inputs such as fertilisers/pesticides, etc.

The farmer is the researcher and experimenter, whatever practises she/he wishes to use are acceptable. The MNBP and MOA field staff act as observers and collectors of information and opinions.

Researcher Managed On-farm Trials

The five farmers who do this type of trial have more input from researchers and MOA FAs. The trial is two replicates, where plot size, row spacing, seed interval, seed/station, and seed depth have been specified by the MNBP researchers. But, management of the crop, use of labour input and other inputs or management practises have been left upto the individual farmer.

This trial is essentially a transfer of a station trial to the farmers field incorporating the farmers post-planting management techniques. The MOA FAs have been trained how to layout the trial and label the trial, and in some cases have helped the farmers to plant the trials.

Monitoring & Evaluating On-farm Trials

The day to day monitoring of the trials has been undertaken by the MOA field assistants. They have been encouraged to record any farmer comments, practises and interventions in a prepared field data collection book.

The MNBP plan a schedule of a minimum of three multidisciplinary visits to each farm site. These monitoring visits are scheduled to coincide with the flowering stage to score pest and disease challenges on the trials. These visits also involve talking to farmers and canvassing their perceptions of the varieties at this point in the crop growth cycle. A further visit is planned to assess the progress of the crop with respect to harvesting. Again discussions with farmers in the field play an important role in breaking down the institutional and cultural barriers that exist between researchers and farmers.

In practise each site and farmers have been visited by MNBP staff about half a dozen times to ensure that evaluations are timely and cover all the participating farmers. Disease and pest scores have been made, and farmers and field assistants comments have been noted.

The final evaluation is the main evaluation involving all farmers and the colleagues from the MOA. This is the Post-Harvest Evaluation and Cooking Trial. So far only one of these evaluations has taken place and the methodology requires fine tuning.

First, yields of the trials are collected and weighed and then the farmers assemble with their trial harvest at convenient location not too far from everyones fields.

Two activities are undertaken. Evaluations of each farmer's trial, using an open-ended interview format, and the cooking and tasting trial.

The women from the group with the help of the MOA Farm Home Advisor (FHA) begin the fires in order to cook each of the bean varieties on a separate fire in the traditional clay pot, known as a "mphika". Each participant donates about 200 or so seeds of each variety for cooking. The cooking times, and amount of water used is recorded for each variety.

Meanwhile the open-ended interviews begin with each individual participating farmer and records are made of the positive and negative aspects that each farmer noticed about the trial. The interview aims to record perceptions for the whole crop cycle, and ascertain which of the varieties each farmer likes and for what reasons, and which varieties the farmers do not like and for which criteria the farmers are using as their evaluation tools.

When the beans are all cooked and the most common local staple (nsima) is prepared to accompany the varieties of beans and the farmers all taste each of the varieties that they have grown.

These are then evaluated by the farmers as a group, according to criteria that they generate. Usually men and women will eat separately and so the taste evaluation is duplicated, a discussion with the men and then with the women.

For each of the criteria farmers are asked to vote for their best variety by this criteria. These preferences are then recorded, and finally a vote for the overall preferred variety including both agronomic and post harvest criteria is taken.

The process is lengthy, but the farmers enjoy meeting together and discussing how their own trials performed, and then eating and comparing their crop. As in the initial station visit by farmers, the tasting and discussion of aspects of palatability of the bean varieties are open to hijacking by dominant, or more enthusiastic members of the group. Alternative evaluating methodologies could be used, but constraints of time and distance and farmer fatigue have to be considered. However fine tuning and adapting the methodology will continue as the MNBP undertakes more farmer participatory exercises and trials.

Results from the First Set of On-farm Trials

Out of the three Dimba (winter) On-farm trials, results have so far been collected from Zidyana, a low altitude site close to Lake Malawi, some 180kms north east of Lilongwe, the capital of Malawi. The three trials each had six varieties of seed contributed from the MNBP. These six varieties had been selected for use in the On-farm trial programme based on a combination of results from mulit-locational trials within Malawi, at Bvumbwe (Southern Region), Bembeke (Central Region), Chitedze (Central Region) and Meru (Northern Region), representing some of the diverse agro-ecological conditions within the country, and the feedback generated from farmers visits to open days at Bembeke and Chitedze research stations.

Results from the Zidyana On-farm trials are based on the post-harvest evaluation where a total of 16 farmers and their wives participated. However, not all farmers had harvested their plots yet and so the yield data is incomplete.

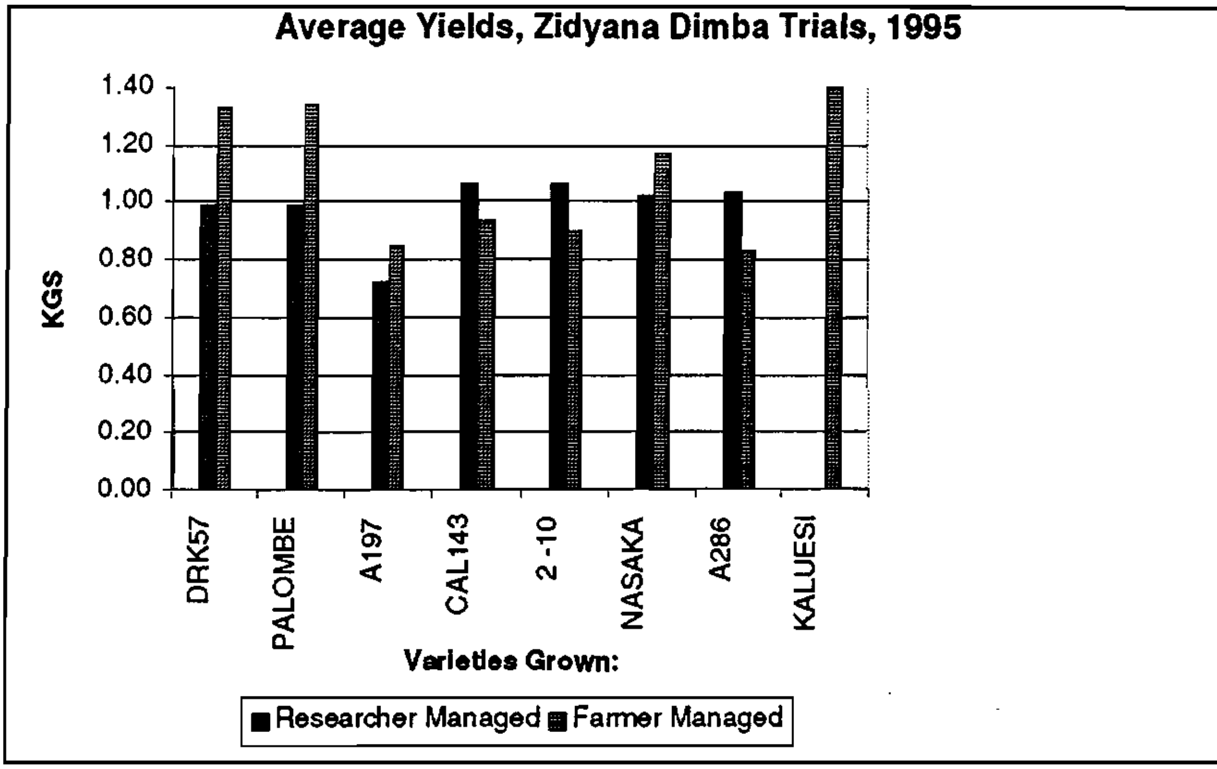
Given the small number of participants, and the incomplete data, these indications of preferences or

Table 1: Varieties of Beans Testes On Farm, Zidyana EPA Dimba Season 1995.

Variety Name	Seed Colour	Seed Size	Growth Habit
2 - 10	White	Medium	Dwarf
Nasaka	Khaki	Medium/Large	Dwarf
A 197	Khaki	Large	Dwarf
Cal 143	Calima (red/white)	Medium	Dwarf
A 286	Carioca (cream/brown)	Small	Dwarf
DRK 57	Red, Dark	Medium	Semi-Climber
Local (Palombe)	Red, Dark	Medium	Dwarf
Local (Kaluesi)	Purple	Medium	Semi-Climber

Table 2: Average Yield Weights Per Farmer, Zidyana EPA

Researcher Managed OFT	KGs	Farmer Managed OFT	KGs
Variety Name		Variety Name	
2 - 10	1.06	2 - 10	0.9
Nasaka	1.03	Nasaka	1.17
A 197	0.73	A 197	0.85
Cal 143	1.06	Cal 143	0.93
A 286	1.04	A 286	0.83
DRK 57	0.99	DRK 57	1.33
Local (Palombe)	0.99	Local (Palombe)	1.34
Local (Kaluesi)	-	Local (Kaluesi)	1.40



dislikes are of interest, and do exhibit some very definite opinions as expressed by the farmers at Zidyana. But care should be taken in extrapolating these choices, because of the small sample size, and the very heterogeneous nature of Malawi's agro-ecology and cultures.

What can be concluded is that farmers do have opinions, are able to articulate these eloquently, and have sophisticated crop evaluation methodologies which researchers can benefit from by interacting with farmers. These data suggest that in this trial yields from Farmer Managed plots for 4 of the 7 varieties performed better than on the Researcher Managed plots. The two local varieties used by the farmers were Palombe, and one farmer used Kaulesi. Both yielded well in this trial.

Of the introduced varieties, Cal 143 and 2 - 10 gave the highest yields, with A197 performing poorly in both the Farmer Managed and Researcher Managed trials.

Visits by the MNBP team to score diseases and pests highlighted some attacks of aphids on the later planted plots. In one farmer's field all varieties were attacked but the most severe infestations were on DRK57, A286 and the local variety, Palombe.

The main pest discussed by the farmers through the trial was mice. Farmers indicated that mice preferred climbers and semi-climber varieties because the foliage gives them cover from predators and allows them to eat the green beans of the plant. (It is not common for farmers to stake up climbing beans in this area.)

Disease scoring indicated that Bean Common Mosaic Virus (BCMV) was prevalent on Nasaka, Palombe and 2 - 10. In some fields Cal 143 was also attacked. Angular Leaf Spot (ALS) was observed on Palombe, 2 - 10 and Nasaka. Common Bacterial Blight (CBB) was seen but not seriously. Rust however was common in all varieties and heaviest on A197, Palombe and 2 - 10. Generally, diseases and pests were not key factors stressing the varieties used in this set of trials.

The farmers through their individual interviews at the Post-Harvest evaluation suggested that they preferred certain characteristics of each variety, see table 3. But they also indicated that they were disappointed with the performance or did not like certain characteristics of each variety as shown in table 4.

Zidyana Post-Harvest Evaluations Of Variety Performance, Farmer by Farmer:
From the farmer evaluations of positive aspects of the varieties, it can be seen that early maturity appears to be a very important criteria in their evaluations. Nasaka, Palombe and 2 - 10 were mainly mentioned for this characteristic.

In estimations of yield, Nasaka was mentioned by most farmers as having produced most grain, with 2 - 10 and A286s' yields being noted as positive characteristics. The growth habit of Palombe, Nasaka and 2 - 10 and the vegetative vigour of Nasaka and Palombe were other characteristics that farmers mentioned as positive criteria.

One variety was not appreciated by most farmers and had a number of negative characteristics including seed size, seed colour, poor yield, bad growth habit, late maturity and poor drought tolerance. A286 is different to what the farmers are used too, and did not appear to have any characteristics that they thought would make it worthwhile growing.

Some of the other varieties recorded negative comments for early maturity and for poor drought tolerance, Cal 143, DRK57, A197. Interestingly for the varieties that the farmers knew, Palombe, Nasaka and Kaluesi, no comments of a negative nature were made.

The main negative criteria that the farmers appear to be evaluating the varieties on are early maturity, drought tolerance, growth habit, vegetative vigour and yield. Before they accumulate additional criteria from the Post-Harvest evaluations.

The results from the cooking and eating test are summarised in appendix 1.

The men and the women ate separately and voted for their favourite varieties in single sex groups. The farmers could only vote once for each criteria, and the list of criteria was established from the information gathered at the individual interviews.

The women were asked about cooking and 2 - 10 was the quickest cooker, with the other varieties showing little difference in times. With regard to palatability criteria, 2 - 10 was heavily voted for by the men for its soft skin. Two comments were "soft, like chicken meat, smells like Chambo," (a common tilapia type fish from Lake Malawi) and "this one is good for people with teeth problems". The women's group were not so enthusiastic assessing 2-10 and Kaulesi a local variety as having equally soft skin.

Another criterion often used to assess the palatability of cooked beans is translated as "good smell", but may be a criterion related to taste? The variety that was favoured by both men and women was DRK57, followed by 2-10, and the men's group also liked A197 for this criterion.

Table 3: Percentage of Farmers Recording Positive Criteria For Each Variety:

Criteria:	Cal 143	DRK 57	2 - 10	A286	A197	Nasaka	Local (Palombe)	Local (Kaluesi)
Early Flowering	0	0	0	0	0	6	0	0
Seed	25	6	25	0	13	38	25	6
Seed Colour	6	19	31	0	6	44	25	13
Reaction to Soil	31	19	31	13	0	38	13	6
Reaction to Field Pests	0	6	0	0	0	0	0	0
Reaction to	0	13	13	0	0	25	13	0
Reaction to	0	0	0	13	0	0	0	0
Growth Habit	6	19	25	0	13	25	31	6
Weeds	0	0	0	0	0	0	0	0
Leaf Colour	0	6	19	0	0	44	19	6
Early Maturity	13	19	56	0	0	63	50	6
Vegetative Vigour	13	31	13	0	6	44	25	6
Leaf	13	25	25	6	13	19	19	0
Reaction to Storage	0	0	0	0	0	0	0	0
Marketability	6	25	6	13	13	19	13	6
Yield	31	31	44	44	0	56	25	6

Note: Farmers can vote for more than one variety.

Table 4: Percentage of Farmers Recording Negative Criteria For Each Variety:

Criteria:	Cal 143	DRK 57	2 - 10	A286	A197	Nasaka	Local (Palombe)	Local (Kaluesi)
Early Flowering	0	0	0	0	0	0	0	0
Seed	6	6	0	56	0	0	0	0
Seed Colour	6	6	0	50	13	0	0	0
Reaction to Soil	0	0	6	31	25	0	6	0
Reaction to Field Pests	0	0	6	6	19	0	0	0
Reaction to	19	25	0	13	19	0	6	0
Reaction to	0	0	0	0	0	0	0	0
Growth Habit	6	13	6	25	0	0	0	0
Weeds	0	0	0	0	0	0	0	0
Leaf Colour	6	0	0	31	6	0	0	0
Early Maturity	13	19	0	38	13	0	0	0
Vegetative Vigour	13	19	0	19	6	0	0	0
Leaf	13	0	6	13	6	0	0	0
Reaction to Storage	0	0	6	0	0	0	0	0
Marketability	13	6	0	13	0	0	0	0
Yield	13	0	0	13	19	0	0	0

A negative cooking and palatability criterion is that of the cooked beans being "floury". Both the men and the women agreed that A197 was "floury", and the men also mentioned Cal 143 and the local variety Kauelesi.

An overall "taste" assessment showed that the men overwhelmingly liked 2-10 while the women favoured 2-10 and the local Kauelesi equally.

The votes for the other agronomic criteria favoured Nasaka for most criteria, with only Palombe and 2 -

10 getting a range of votes. A286 although unfavourable talked about in the interview and during the taste test, was recognised as a heavy yielder together with DRK57 and Nasaka.

With respect to the marketability of the varieties, the men and the women differed in their opinions. The men seemed less risk averse, and were very sure that

Table 5: Most Favourite Variety using all criteriato evaluate the Varieties.

Men's Result:		Women's Result	
Variety Name	Rank	Variety Name	Rank
Nasaka	First	Nasaka	First
2 - 10	Second	2 - 10	Third
Kaulesi		Kaulesi	Second

2 - 10 would be easy to sell, whereas the women's group was more conservative and cautious voting for Nasaka, which is a well known and established seed grain in the markets.

Finally the groups voted for their overall favourite varieties from the seven varieties they had grown. Nasaka was the most popular for the whole range of criteria, for both men and women. Given that the results here portray one group of fifteen farmer's conclusions are hard to draw. What can be said with certainty is that without exception A286 was unpopular, even though some farmers indicated that it was a high yielding variety. The seed colour and the seed size, referred mockingly to as "cowpeas", plus a distinct and unusual taste, were clear factors against this one variety. One farmer described eating A286 as "like eating vegetables, sweet potato leaves, it is not suitable for growing".

The other new varieties appeared to have had some characteristics which were not liked. A197 was "floury" in taste. Late maturity and drought resistance and plant vigour were other criteria where the new varieties were poorly liked. 2 - 10, was by far the most well liked new variety, its colour, seed size, fast cooking, and its potential for sale were agreeable to the farmers, even though the yields gained appear to be nothing extraordinary.

CONCLUSION

The OFT at Zidyana has illustrated to the MNBP that farmers are sophisticated in their variety evaluations, and that the criteria that is traditionally used such as yield, pest and disease resistance, are often not the key criteria that farmers judge new seed material by.

The initial results indicate that in this area among this group of farmers who are interested not just in bean production for domestic consumption but also for marketing, the following criteria are what they are looking for in additional seed varieties.

A large seed type, the colour should be khaki, white, or a dark red, it must be early maturing to benefit from the residual moisture and to avoid high temperatures, it should be a dwarf thereby giving mice as little protection as possible, and it should be a fast cooker, with a soft skin and a good "smell".

By incorporating this type of farmers information into the following seasons breeding agenda, the MNBP breeders can focus in on these characteristics, add to these their knowledge and expertise that focuses of disease and pest resistance and select a number of more appropriate new varieties to test on farm.

Once new varieties have been positively identified by farmers, the second stage of seed multiplication and dissemination will be entered into. From this initial trial result 2-10 would appear to be a candidate for multiplication and dissemination among these farmers in this agro-ecoligical zone.

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Q: J Musanya
The variety A197 is being released in Zambia how was it evaluated by your farmers?

A: J Scott
In Zidyana EPA - farmers were positive to A197 - only that it has a "Floury Taste" which was a negative criteria.

V Aggarwal
Comment:

His work is preliminary and should be careful in making conclusions. Varieties selected may not be ideal for winter growing and may not be acceptable for seasons based on one season and one group of farmers.

APPENDIX 1

RESULTS OF THE ZIDYANA COOKING TRIAL & FARMER EVALUATIONS:

*Table 1: Mens Rankings of the Key Criteria Generated: (10 farmers)

*Table 2: Womens Rankings of Key Criteria:(6 farmers)

* Unable to interpret tables

Appendix 1: cont.

Table 3: Whole Group Rankings of Key

Variety Name:	Earliest Germination	Earliest Flowering	Production of Most Pods	Most Resistant to Drought	Best Seed Size	Best Seed Colour	Heaviest Yield	Fastest Cooking	Softest Skin	Floury Texture	Best Smell	Best Taste	Easiest to Sell
2 - 10	0	4	0	0	10	9	1	6	12	0	4	12	10
Nasaka	15	12	9	3	4	6	3	0	0	0	0	0	4
Local (Kaluesi)	0	0	0	0	0	1	1	0	3	1	1	0	1
A197	0	0	0	0	0	0	0	0	0	12	3	3	0
Cal 143	0	0	0	0	0	0	0	0	0	1	0	0	0
A 286	0	0	5	9	0	0	5	0	0	0	0	0	0
DRK57	0	0	0	1	0	0	5	0	0	0	9	1	0
Local(Palombe)	1	0	2	2	2	1	1	0	1	0	0	0	1

EXPERIENCES OF A DECADE OF BEAN RESEARCH FOR THE SMALL-SCALE FARMERS IN KWAZULU/NATAL.

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ABSTRACT

Dry beans are part of the cropping programme of most small-scale producers in KwaZulu-Natal. Yields of the traditional landacres such as the Umzumbe bean are low as a result of the susceptibility of these races to most of the common bean diseases.

In 1981 a dry bean research programme was initiated at the University of Natal aimed at improving dry bean yields in KwaZulu-Natal. The programme was carried out over ten years and involved close co-operation between the researchers and the farming community. Several new cultivars have been successfully introduced in recent years. The results of the programme and the experiences with the methods followed are discussed.

INTRODUCTION

Agriculture in South Africa is historically divided in a commercial and a subsistence farming sector. The average areas available per household for cropping in the latter sector is often less than one hectare.

Government research in support of the small-scale farmer was virtually non-existent in the old political dispensation and it was left to the NGO's and Universities. The research discussed in this paper was carried out at the University of Natal and was funded by the De Beers Chairmans' Fund. It was the first plant breeding programme in this country aimed at the small-scale farmer.

In the commercial sector approximately 60000ha are planted to dry beans annually in South Africa. The contribution of the small-scale farmer to the agricultural economy has in the past been largely ignored in official economic data and little was therefore known about the extend of production of beans in this farming sector. Lyne (1989) summarizes the results of six surveys in different areas in KwaZulu. In total 7% of the arable land was planted to dry beans annually as a monocrop, while an additional 6% was planted to a mixture of beans and maize. Based on an estimate of 390000 arable ha of the approximately 410000 households we can extrapolate that in the region of 27300 ha is planted annually with dry bean as a monocrop plus another 23400 ha with beans as an intercrop. If we add the areas in the former Transkei to the above we can assume that the total area planted under dry beans in the small-scale farming sector is most likely bigger than that of the commercial sector.

LANDRACES IN KWAZULU/NATAL

The landrace germplasm base in KwaZulu/Natal is fairly limited. The dominant bean landrace is by far the Umzumbe or speckled sugar bean. Determinate type I sugar beans are most common but type III are occasionally found. The bean is named after the Umzumbe region where beans are still a very important crop and this is possibly the first area where these beans were grown. The Umzumbe beans traditionally make up more than 95% of all the beans grown. Other beans found are Natal Round Yellow bean and small brown beans. Kidney beans are occasionally found.

The Umzumbe beans are from the Andean gene pool and under low-input farming generally yield not more than 350 kg per ha. These beans are susceptible to most of the major bean diseases such as rust, BCMV and root rots. Farmers generally keep their own seed and seedborne diseases such as BCMV and common blight are therefore common.

RESEARCH AREA

The dry bean programme focused on the Vulindlela area near Pietermaritzburg in the KwaZulu/Natal midlands. The community is peri-urban to rural and beans are a major subsistence crop in this area. The climate is moist upland with an annual rainfall of 850mm. Mist is common and the climate favours the spread of diseases such as rust.

The area is predominantly a conservative rural community with tribal structures. In the course of the programme we have seen the community move from a relatively quiet way of life to a situation of increasing social and political turmoil.

Despite the tension and atmosphere of suspicion we have managed to gain the confidence of different sectors of the community through our involvement with the farmers. It was the first project of this kind in the area and the concept of research was foreign. However, the merits of cultivar improvement were clearly evident which assisted in generating an interest amongst the farmers in the progress.

CULTIVAR IMPROVEMENT PROGRAMME

Our research followed a two-step approach. In the first years the emphasis was on the screening of new germplasm in order to identify cultivars which could be introduced or used in later breeding programmes.

In later years the emphasis moved to the breeding programme aimed at improving the local landrace Umzumbe.

Testing new germplasm

Different CIAT nurseries were screened over several seasons under low-input conditions in the Vulindlela area. No fungicides were used and the fertilizer regime followed the rates used by farmers in the area. It was clear from the beginning that the new cultivars outperformed the local land races in disease-resistance and yield potential. Table 1 summarizes the yield of selected cultivar over three seasons. Several of the small-seeded cultivars of the meso-american genepool, particularly the carioca cultivars, were identified in the early stages as being well suited to local conditions.

Resistance to diseases such as rust, BCMV and root rots contributed largely to the better performance of the introduced cultivars.

Two cultivars were released in the mid-eighties from the CIAT lines namely Mkuzi (A286) and Vulindlela (A344). A286 was preferred above the original Carioca because of its more upright growth habit. Mkuzi in particular has become popular with the farmers because of its yield stability and resistance to diseases.

Breeding programme. Despite the agronomic merits of the small-seeded types it was found that the sugar bean seed type was preferred by many consumers and that a local breeding programme was needed.

The emphasis of the programme was on the incorporation of disease resistance in the Umzumbe beans. Priority was given to rust as this diseases resulted in the most severe losses in yield.

The following improvements to the Umzumbe land race have been made over the years:

Rust resistance. Multiple gene resistance to rust was crossed into the bush type Umzumbe bean generating cultivars with low levels of rust infestation at the end of the season. The first rust resistant sugar bean was ENSELENI which became widely accepted throughout the provence.

Fusarium root rot resistance. Fusarium root rot is a common problem in the KzaZulu/Natal midlands. Single gene resistance was identified in 1988 and incorporated in cultivar UMGENI.

BCMV resistance. I-gene resistance to BCMV was added to later releases such as UMLAZI and LIMPOPO. Although the necrotic strains are around we have seen no problems with this resistance on the farms.

Angular leaf spot resistance. Cultivar GADRA was recently released which has resistance to the local angular leaf spot race.

Seed quality. The appearance of the seed has been improved in the later releases. Seed is bigger and rounder than the Umzumbe bean and the speckle is brighter.

Table 1: **Yield of introduced and local dry bean cultivars over three season from 1984 to 1987 at Vulindlela. Yield in kg per ha**

84/85		85/86		86/87	
A 344	2354	RAB 106	2419	BAT 1514	1602
Carioca 80	2318	Carioca	1953	A 286	1523
A 286	2307	A 344	1642	Carioca	1289
Carioca	1785	A 286	1639	A 344	1136
Umzumbe	182	Umzumbe	497	Natal Yellow	401
Bonus	94			Umzumbe	325

COMMUNITY PARTICIPATION IN RESEARCH

Over the years several systems were put in place to facilitate the communication between researcher and the farmer. The programme eventually took the format as shown in diagram 1.

Phase 1 Cultivar trials/ Volunteer programme
Farmers from different farmers associations in the area were invited to participate in the trials. They planted, maintained and harvested the trial and received training and the produce in return. The involvement of these farmers was valuable to the researcher programme as these farmers gave feedback on the entries in the trial.

Phase 2 On-farm trials
A selected group of farmers cooperated with the programme from the beginning. Annually these farmers were given a maximum of two new cultivars and they were asked to plant these under their own farming practices. The opinion of the farmers was monitored in the course of the season by the research staff.

Phase 3 Wider release
The small-seeded CIAT cultivars were released to a large number of farmers through NGO's and farmers associations and the feedback was monitored in order to identify preferences within the community for certain types.

Phase 4 Release
In order to assure that good quality seed becomes available to farmers, cultivars are protected by plant breeders' rights and placed on national cultivar list. Seed companies are given a sole right to produce seed. The researcher are involved in the production of the breeders' seed.

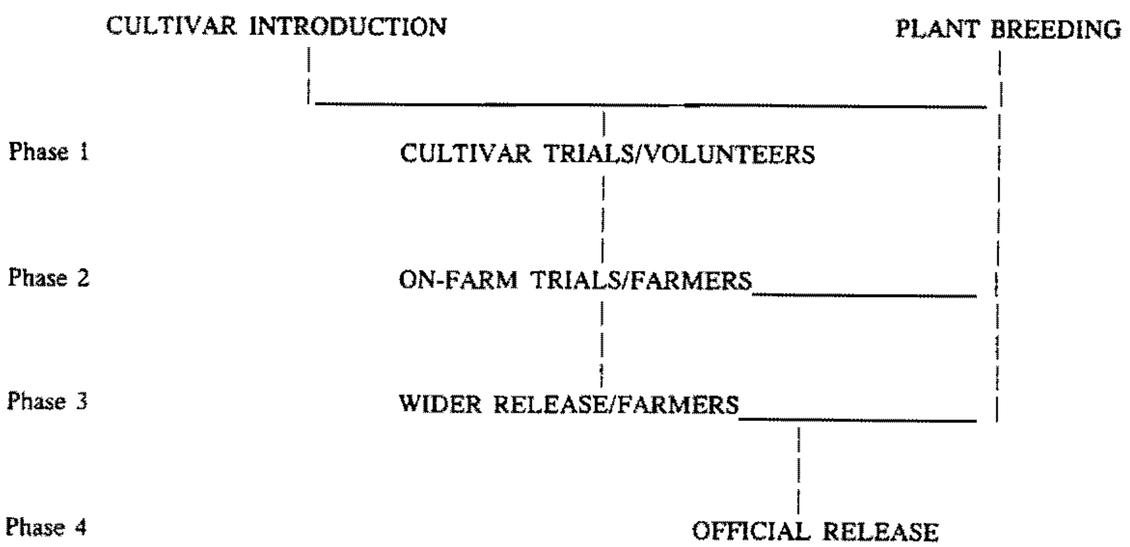

Diagram 1.

Feedback

Interaction with the farmers supplied the research programme with valuable information on preferences with regard to agronomic as well as quality characteristics. The farmers that grew the beans for own consumption were less specific about the quality of the bean. Small-seeded types such as the Mkuzi bean were readily accepted as the farmer appreciated the better agronomic qualities. Farmers that sold beans, however, still preferred the Umzumbe seed type. Regional preferences were also found. F.e. in the former Transkei farmers accepted new beans more easily than farmers in KwaZulu/Natal.

The short cooking times of the small- seeded carioca type was considered a positive characteristic.

Other characteristics on which the farmers supplied feedback on, were taste, resistance to goat damage, growth habit and length of season of the cultivars

CONCLUSION

Small-scale dry bean production in South Africa traditionally had a very narrow germplasm base, namely of a low-yielding and disease resistant landrace. The prospects of improved yields through the release of new cultivars were therefore good. Farmers initially readily accepted the small-seed introduction, but once the improved Umzumbe beans became available tended to favour these above the small-seeded types.

A number of factors have played a role in the success of the cultivar development. The participation of the community in the programme and the availability of a trial site in the bean producing areas for ten years contributed to the continuity of the project.

The funding for our programme ended in 1992 and the project is presently completely self-supporting through the income of the cultivars.

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FARMER PARTICIPATION IN BEAN RESEARCH IN AFRICA: EXPERIENCES FROM THE FIELD[1]

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ABSTRACT

This paper defines basic tenents of the participatory research approach in the context of agricultural technology development. It reviews CIAT's experiences in Eastern Africa with involving farmers in bean research at three levels: research planning and implementation, varietal selection and seed multiplication. The role farmers can play in evaluating the impact of new bean technologies is briefly assessed.

INTRODUCTION

While some degree of farmer participation in technology development, testing and dissemination is now considered essential in agricultural research and development circles, in reality, in most LDCs systematic and meaningful farmer input into the research process is weak. In many cases, farmer involvement in research is limited to on-farm technology testing for validation where participation by farmers takes the form of rejection or adoption of the new technology. The purpose of this paper is to review selected experiences of bean scientists in Eastern Africa with participatory research and point out some requirements for the successful use of the approach. The paper starts by defining key features of participatory research then goes on to describe experiences in three areas: farmer participation in the selection of genetic material, planning and implementing research with farmers and bean seed production by farmers.

DEFINING THE PARTICIPATORY RESEARCH APPROACH

Participatory research in an agricultural context refers to a systematic approach to incorporating farmers' views, knowledge and research agenda in the technology development process based on set principles and using specific methods. It is an approach rather than a model and is not synonymous with on-farm research (OFR), farming systems research (FSR) or simply talking to farmers. The participatory research approach, which first gained popularity in the early 1980s, has its roots in anthropology. In agricultural research, this approach grew out of the acknowledgement that the transfer-of-technology (TOT) model for technology development resulted in low rates of technological adoption by resource poor farmers, who, for the most part, live in diverse and complex environments.

The prototypical TOT model is a vertical scientist-led process of technology generation and transfer which has as its main objective the generation of technology by scientists and the adoption of that technology by farmers. The steps involved are collection of information from farmers by scientists (diagnosis), identification and analysis of problems by scientists, technology development based on on-station experimentation and on-farm trials for validation under farmers' conditions. The technology transfer process begins with on-farm trials, field days or demonstrations. Since farmers' input in technology development mainly comes at the end of the process, participation by farmers takes the form of rejection, modification or adoption of the new technology.

The participatory research approach (farmer participatory research or FPR) turns the TOT model on its head and starts with the explicit recognition that research must be client-driven. FPR is based on 3 major assumptions:

[1] Paper presented at the SADC Regional Bean Research Workshop, Potchefstroom, South Africa, 2-4 October, 1995

1. adaptive research should be problem oriented to be cost-effective;

2. farmers have differing needs in line with their specific agronomic and socio-economic situations, and can best articulate their own demands;

3. farmers are a valuable source of technical knowledge due to years of experience and informal experimentation.

Instead of starting with the knowledge, problems, analysis and priorities of scientists, the process begins by first considering the knowledge, problems, priorities and analysis of farmers. FPR may be directed by multiple objectives, namely:

1. to generate technology that will meet the diverse needs of farmers, particularly the disadvantaged (e.g. women, poorer farmers);

2. to increase the rate of technology adoption and ensure greater sustainability of new innovations;

3. to develop closer, long-term working relations and networks of collaboration between farmers and researchers; and

4. to promote farmer empowerment- farmers' ability to exert pressure on institutions such as the state or research organizations and hold them accountable.

Given the emphasis on equity and the diverse needs of farmers, FPR work usually involves communities or groups of farmers, another dimension which distinguishes this approach from the TOT model.

Although the basic steps typically followed are similar to those used in the TOT model, farmers participate together with researchers in planning and conducting research by explaining, mapping, giving opinions, analyzing, designing, implementing and evaluating. In some situations, they may even take the lead in these activities. Although the researcher contributes to the planning and implementation of the research, in order to ensure farmer participation, he/she has added responsibilities not emphasized in the TOT model: to convene, initiate, facilitate, watch, listen, learn, support and explain. Farmer-to-farmer diffusion is encouraged alongside diffusion through the extension system.

It is important that the participatory research approach be seen as a complementary "paradigm" to the conventional TOT approach rather than a substitute for it. The uses and applicability of FPR are broad and run the spectrum from farmer-involved approaches, which require minimal farmer participation, to the more farmer-centred approaches (e.g. Robert Chambers' "farmer-first-and-last" approach). The degree of farmer participation in technology generation will depend on a number of factors including the extent and level of farmer experience with, and knowledge about, the research issue and the orientation and specific objectives of researchers.

FPR TECHNIQUES

To obtain an emic perspective (i.e. one which uses units of meaning drawn from the local culture) and to gain a holistic understanding of agricultural problems requires specific research methodologies. Participatory research methodologies (PRMs) form an eclectic collection of techniques designed to enable research clients i.e. farmers, to present, share and analyze their knowledge and view of life and their own conditions and expectations regarding interventions in an interactive manner. The general characteristics of these methods can be described as: participatory, lightly structured, flexible, adaptable, exploratory, iterative, interactive, inventive and empowering. The researcher assists farmers to command and use these tools of analysis.

Techniques in the participatory "toolkit" include, among others, ranking (e.g. matrix ranking, wealth ranking), comparison (pair-wise comparison, triad testing), mapping, diagramming and participatory monitoring and evaluation. The flexibility of PRMs means that they can be used at various stages of research and for a wide range of purposes: diagnosis, planning research with farmers, selection of trial farmers, designing trials, baseline data collection, evaluating technologies and monitoring and assessing technological impact. Other participatory methodologies include farmer workshops, group meetings and transect walks.

The remainder of the paper draws on the experiences of CIAT (the International Centre for Tropical Agriculture) and NARS bean scientists in Eastern Africa over the past 8 years in involving resource-poor farmers in the research process. While the emphasis is on the methodologies used, where available, results are presented to highlight the advantages of the participatory approach.

FARMER SELECTION OF GENETIC MATERIAL (from Sperling *et al.* 1993)

Several issues prompted a pilot study in the late 1980s by bean scientists in Rwanda to involve farmers in the selection of early bean genetic material. These include: 1. the focus of the formal breeding program on yield and disease resistance and the development of a few widely adapted cultivars; 2. farmers' interest in several varietal characteristics (at least 15) and their need for a range of cultivars for planting under very heterogenous conditions; and 3. farmers' late and limited participation in the selection of genetic materials.

By bringing carefully selected farmer bean "experts" on-station to evaluate breeding lines, the project sought to take advantage of the comparative advantage of breeders and farmers: breeders' access to world genetic resources, ability to screen for responses to stresses and farmers' indigenous knowledge and practical experience with their own soils and planting conditions, and of course, socio-economic conditions. While the study was designed as an experiment to compare the performance of materials selected by farmers to those selected by breeders using the conventional breeding scheme, the following summary concentrates on the role of farmers in the experiment.

A five step system was used for participatory selection of genetic materials:

1. farmer experts (mainly women) were identified with input from the community;

2. groups of farmer experts (a total of 90 over 4 seasons) were brought to three research stations (at low and high altitudes) to evaluate 15-80 bush bean lines in advanced yield trials at two stages: flowering/pod formation and physiological maturity;

3. farmers were asked to predict which lines would grow best on their farms and selected 2-3 lines to test at home;

4. farmers received seed samples and planted the lines on their farms;

5. farmers' ability to predict which lines would perform well on-farm was evaluated and a follow-up study was conducted to assess adoption 3-6 seasons after testing began.

A number of interesting and important findings emerged from this study, which was unfortunately interrupted by the departure of the main investigator and the civil war in Rwanda. Firstly, farmers selected bean lines for a range of characteristics, including, in order of frequency, yield, performance in heavy rain (linked to disease resistance), performance under bananas, early maturity, performance on poor soils, grain colour and drought tolerance. Thus, unlike breeders the study showed that farmers select for diversity and, moreover, select differently in accordance with their socio-economic characteristics such as wealth status, market orientation and gender. Secondly, farmers proved capable of predicting which lines will perform well on their own plots. The 21 lines they selected outperformed local mixtures 64-89% of the time, with average production increases of up to 38%. Although direct comparison with breeder selected material in the same region and years was not possible, countrywide results from on-farm trials conducted in the same years showed that breeders' selections outperformed farmers' mixtures only 41-51% of the time, with the largest average yield increase of 8% in any one season. Finally, follow-up surveys showed that farmer selected lines had a 71% survival rate after being grown for 6 seasons compared with 61% for a popular breeder selected variety.

Advantages/disadvantages: Involving farmers in on-station selection of genetic material is not intended to replace the conventional breeding approach or to make breeders obsolete. Based on the Rwandan experience, advantages of this approach include higher and accelerated rates of adoption of new varieties selected by farmers, and hence greater impact of new varieties. Among various options for farmer involvement early in the breeding process (e.g. having breeders select material on-farm), the approach used in Rwanda appears to be more feasible and cost-effective. However, it is unclear whether this approach can be replicated elsewhere. Specifically, the need to involve farmer "experts" (who may not exist in other societies) and the number of lines farmers can evaluate without getting confused, remain as unresolved issues.

FARMER INVOLVEMENT IN PLANNING AND IMPLEMENTING RESEARCH (From Fischler *et al.*, 1995)

Frequently the participatory research approach has been used by agricultural researchers as a means of facilitating the implementation and adoption of external interventions. Farmer participation in research in this cases becomes a mere means to an end, a legitimization of conventional top-down approaches (Haverkort, 1991; Scoones and Thompson, 1994). The use of a participatory approach to involve farmers in planning and implementing research seeks to ensure farmer participation in establishing long-term research agenda at the community level. The objective of participation at this level is improving the efficiency and effectiveness of problem solving research, as well as farmer empowerment- developing farmers' capacity to exert pressure on research organizations and hold them accountable. In this approach, researchers are considered to be equal participants in the planning process.

The methodology described below is based on the experience of CIAT and NARS scientists at five locations in Uganda and Tanzania. The research team varied between locations but generally consisted of two agronomists and a soil scientist. In some cases, scientists from other disciplines were invited to assist. A local facilitator assists in organizing meetings and monitoring experiments.

Research planning: During 2-3 day meetings with groups of farmers (25-45), the planning process covers the following steps: identification and prioritization of problems, determination of causes, identification and evaluation of possible solutions, design of experiments and planning and implementation of experiments. Table 1 outlines the specific tasks involved at each stage and the degree of farmer and researcher input.

In designing experiments three approaches, differing in the amount and type of researcher input were used to design experiments:

1. Researchers described scientific methods and principles of experimentation and farmers then worked in small groups to design experiments;

2. researchers assisted farmers during small group sessions to design experiments without elaborating on scientific methods of experimentation;

3. researchers only had input after farmers themselves tried to design experiments.

The first approach resulted in farmers' use of a "blueprint" design for all experiments, while the third approach produced vague designs that could not be used. The second approach was best because it allowed researchers the opportunity to suggest application of relevant principles as needed, although it was important for researchers to restrain their input.

Current experimentation involves improving soil fertility with green manures and agroforestry, testing of improved varieties (beans, groundnuts, cassava), crop pest and disease management and control of storage pests (beans, sorghum). At seasonal planning meetings trials are modified, new ones added and others dropped. Table 2 shows the evolution of crotalaria trials in Ikulwe, Uganda over several seasons. Notably, researcher input into trial design is relatively high since farmers in that area have little experience with green manures. Exploration of appropriatecommunity-basedinstitutionalframeworks for farmer-led research is underway.

Advantages/disadvantages: Since the systems oriented participatory research approach described above was not designed and implemented as an experiment for comparison with a conventional on-farm technology validation approach, conclusions about its advantages are based on researchers' impressions after only 3 years of work. The most important advantage of this approach, as implemented in the case described, is the quick response it allows to farmers' preferences and suggestions and the subsequent rapid modification of trial design. Researcher costs in the initial stages of this work were higher compared to the conventional on-farm approach where monitoring of trials are left to extension staff due to the need for frequent planning and organizational meetings (monthly visits are recommended). Whether this higher cost in terms of time and resources will be made up by greater returns to research, as measured by higher and accelerated rates of technological adoption, has yet to be seen.

FARMER INVOLVEMENT IN SEED PRODUCTION (author's own work)

In countries where certified bean seed is produced, small-scale farmers typically have limited access to it due to untimely and ineffective delivery systems. At the same time, the demand for certified bean seed by resource-poor farmers is depressed by its high price, large packaging quantities (e.g. 5 kg and above) and the limited number of widely adapted improved varieties produced by large-scale centralized seed producers. A major bottleneck affecting the success

Table 1: STEPS AND METHODS USED, AND ROLE/TASK OF FARMERS AND RESEARCHERS DURING THE RESEARCH PLANNING PROCESS (from Fischler *et al.*, 1993)

Steps in research planning	Methods used at farmers meetings	Role/task of farmers	Role/task of researchers
Identify problems	"Brainstorming" in full farmers' group	List all the problems related to crop production	Record problems
Rank problems	Pair-wise ranking in small groups.	Rank problems according to importance	Explain ranking method; Try to eliminate bias in ranking.
Identify causes	Participatory diagramming in small groups (flow charts on manila paper)	Diagram causes of problems if known; Ask for further information if causes not known; Present diagrams to full group and discuss them	Provide additional knowledge if causes of problems not known
Identify potential solutions	Listing of all potential solutions in small farmers' groups	Suggest potential solutions; Discuss solutions in full group and refine them	Stimulate group discussion; Assist in articulation of farmers' ideas; Suggest alternative solutions
Evaluate potential solutions	Discussion in full group. Selection of research topics by open voting.	Assess benefits and feasibility (ease of carrying out experiments) of solutions; Chose topics for research	Indicate likely benefits and difficulties of experiments
Trial design	Farmer designed trial layouts on manila paper.	Design trials; Discuss trial layouts in full group; Chose trials to implement	Explain principles of experimentation; Refine design and verify site selection

Table 2: Evolution of experimentation with Crotalaria as a green manure crop, Ikulwe, Uganda 1992-1994

1992/93	Crotalaria as an intercrop 2 crops, 5 treatments, 2 reps/farm RP/RD
1993a	Crotalaria as an intercrop sown same time as food crop 1 crop, 3 treatments, 2 reps/farm RP/FD
1994a	Crotalaria sown 2-4 weeks after planting of food crop 1 crop, 3 treatments RP/FD Crotalaria as a strip crop 2 crops, 5 treatments, single observation plots/farm RP/FD
1994a/b	Crotalaria as a fallow vs weed fallow 2 treatments, single observation plots RP/FD
19941/b	Independent farmer experimentation Single observation plots of vrotalaria with other crops FP/FD

RP/D= researcher proposed or designed; FP/D= farmer proposed or designed

TABLE 3: CHARACTERISTICS OF BEAN SEED ENTERPRISES IN UGANDA

	Ikulwe Bean Farmers' Association	Makhai Women's Group	Budama Kyelema Tubana Women's Group	Gwagalo Women's Group
Location	Iganga District	Mbale District	Mbale District	Mukono District
Type of group	Mixed group	Women's group	Women's group	Women's group
Year established	1993	1990	1994	1992
Year/season seed production started	1993b	1995a	1995a	1995b
Membership	15 house-holds	14 women	12 women	9 women
Other group acting	None	Sale of food crops	Sale of food crops, piggery	Sale of food crops, indivi-dual income genera-ting activi-ties
Collaborators	None	Extension	Extension	NGO, extension

of bean research in Eastern and Southern Africa is therefore the lack of appropriate systems and channels for producing and disseminating new bean cultivars.

While the availability of non-certified bean seed does not appear to be a problem in most countries in the region, farmers in some countries complain about the poor or variable quality of seed obtained from commercial sources and the unreliability of depending on other farmers for seed, factors which probably contribute to low bean productivity (David, 1994). It is also notable that in some countries, relatively few local bean varieties (two or three) are sold in shops and rural markets which are important sources of bean seed for small-scale farmers (David, 1994). The erosion of genetic diversity in beans may be directly affected by seed supply and quality since seed unavailability and/or poor seed viability frequently results in varietal loss.

In response to a request from a group of farmers to multiply bean seed commercially, a pilot project to involve farmers in small-scale commercial production of bean seed, using a participatory approach, was initiated in Uganda in 1994. Artisanal seed production is designed to address two issues: the development of alternative systems for supplying seed of improved varieties to farmers and 2. involving farmers in maintaining/increasing genetic diversity in beans. Farmer involvement in the production and distribution of bean seed is likely to have several advantages over formal seed production: lower cost of production relative to large-scale production, the likelihood of timely seed delivery, the selection by farmers themselves of varieties for multiplication in accordance with local preferences and the maintenance or improvement of genetic diversity through the dissemination of improved as well as local varieties. The less structured nature of farmer seed production may also mean that traditional means of exchanging seed (e.g. in-kind exchange, labour exchange) could be employed, with the result that the poorest farmers may benefit from introduced varieties. investigated.

The objectives of research on artisanal bean production are to explore principles and methods for establishing small-scale bean seed enterprises and assess the quality of seed produced by farmers. Four groups, the details of which are provided in Table 3, are currently involved in artisanal bean seed production in Uganda with technical support from CIAT. This support takes the form of training in seed production, simple small-scale post-harvest equipment (a thresher and sorter) and seed of improved varieties. To date, two improved varieties, MCM 5001, a Carioca seed type, and CAL 96, a Calima seed type, are being multiplied by all groups.

After four seasons of operation, the Ikulwe Bean Farmers' Association (IBFA), provides the best example of the prospects and problems involved in artisanal bean seed production in Africa. Problems encountered can be classified into three broad areas: production, group and business related. At the level of production, the group has encountered difficulties in securing land for collective production. Due to the high cost of rent and the reluctance of some members to contribute labour on collective plots, the group switched from collective production to individual production in 1995a. Post-harvest activities are still done collectively. Lack of trust between members, members' concern to obtain immediate financial benefits, overpricing of the seed and poor record keeping remain as problems to be overcome. It is notably that many of these same problems were experienced by artisanal seed producers in Latin America.

Results from lab testing of seed samples produced during 1994b indicate the absence of major bean pathogens. *Fusarium oxysporum* f sp. *phaseoli* was the only frequently occurring pathogen and insignificant presence of *Colletotrichum lindemuthianum* was recorded. The high level of incidence of saprophytic fungi on seed samples indicates improper post-harvest handling. Germination percent in four samples (unsorted/sorted, treated/untreated) ranged between 59 and 92% (the target is 80%). While the groups do not aim to produce certified seed, the classification of their seed produced has yet to be addressed in consultation with Ugandan seed authorities.

After 4 seasons of operation, IBFA sales exceed 1.5 tons (Table 4) but precise information on sales is unavailable due to poor record keeping by the group. Nearly half of this seed (600 kg) was sold to an NGO operating in the district, while the remainder was bought by farmers in nearby villages. The majority of farmers purchased 500 grams of seed. The price of seed ranged between Ush. 600-1200 (US$0.63-1.26), about 2-4 times the price of grain of local varieties at the time of planting.

Advantages/disadvantages: Artisanal seed production is not intended to replace or compete with formal seed production. Indeed, limitations are set by the amount of seed small groups can produce given land and labour constraints, the number of varieties they can multiply at a time and problems with their linkage to research or the formal seed sector to obtain regular access to breeders seed of new varieties. On the other hand, their comparative advantage lies in multiplying improved varieties that may not be economically attractive to large-scale centralized seed schemes (e.g. small seeded varieties in the Ugandan case) and preferred landraces that are in scarce supply.

REQUIREMENTS FOR THE SUCCESSFUL USE OF A PARTICIPATORY APPROACH TO RESEARCH AND TECHNOLOGY DEVELOPMENT

The above case materials show the flexibility of the participatory approach to research. It is, however, important to reiterate that this approach is not intended to replace other research paradigms. As the above case materials show, greater farmer involvement is required in systems-oriented research and on research issues of a multi-faceted nature.

The successful use of a participatory research approach by NARS however requires change at various levels, namely, institutional and attitudinal. Some of these issues are briefly addressed below.

ATTITUDES AND BEHAVIOUR

One seldom mentioned, though crucial, requirement for the successful use of participatory research is a change in scientists' attitudes toward farmers and vice versa. The conviction held by many professionals in Africa and elsewhere that modern specialized knowledge has universal validity over local knowledge and the attitudes, demeanour and behaviour that accompany this view, makes application of the participatory mode difficult. Not being convinced that farmers can analyze and articulate their problems, some scientists may be sceptical about the idea of greater farmer participation

TABLE 4: Quantity of bean seed planted and multiplied by the IBFA, over 4 seasons, 1993b-1995b

VARIETIES	AMOUNT PLANTED (KG)	QUANTITY OF SORTED SEED PRODUCED (KG)
MCM 5001	179	1130
CAL 96	89.5	249
K20	100	235
SUG 50	15.5	50
TOTALS OVER 4 SEASONS	384*	1664*

* Incomplete information from 1995a

in conducting collaborative research. At the same time, years of a "top down" research and extension orientation in African countries have resulted in farmers' loss of confidence (at least in public expression) in local knowledge. Farmers are often puzzled when FPR practioners insist on asking them questions, instead of showing them the "correct" practice. It may take some time for farmers to appreciate the advantages of this approach and gain a high level of trust and confidence even when interacting with the best trained and most experienced PR practioners. But since PR is usually researcher initiated, the onus lies on researchers to first change their own attitudes toward farmers.

CLIENT-ORIENTED APPLIED RESEARCH

Participatory research can only be successfully used to develop new agricultural technology when accompanied by changes in the functioning of the applied research system. Without going into the required institutional changes, a few suggestions for reorienting applied research within NARS can be offered. It is crucial that a more interactive and proactive mode of operation develop between on-station and on-farm work. This means, on the one hand, that applied research must effectively incorporate farmers' feedback into the research process and involve farmers in the research process at an early stage. At the same time, scientists must also anticipate the diverse needs of farmers by developing many technological options (Ashby and Sperling, 1992). This requires researchers to have a fairly good idea about the broad range of farmers' needs and constraints. Ashby and Sperling (1992) propose that on-station research should be geared toward generating "unfinished" technologies in the form of: 1. component technologies and 2. a "menu" of technological options, thus allowing for farmer modification and adaptation. These early "prototype" technologies constitute the best working tools in participatory research.

INTER-DISCIPLINARY SYSTEMS APPROACH

Farmers' holistic approach to farming clashes with the commodity and discipline orientation of scientists and NARS. In the complex, diverse and risk-prone agricultural environments found in sub-Saharan Africa, farmers' multiple and varied needs are best addressed from a systems perspective where emphasis is on the whole farm enterprise and relations between its component parts. This requires the formation of multi-disciplinary teams comprised of both agricultural and social scientists using an inter-disciplinary perspective. However, problems of team interaction among scientists involved in inter-disciplinary teams often develop due to differences in perspectives arising from disciplinary concerns. The PR literature offers several suggestions for promoting fruitful interaction between scientists involved in PR (Chambers, Pacey and Thrupp, 1989; Rhodes and Booth, 1982). These include "hands-on" team involvement in the entire participatory research process (i.e. exercises, meetings) by a fairly small group of scientists, working knowledge by team members of each other's disciplines and use of report writing as an opportunity for interaction.

In addition to the disciplinary composition of the team, attention also needs to be paid to its gender composition. In the context of many African societies where the bulk of the responsibility for farming typically lies with women, all male research teams may face difficulties due to cultural norms which inhibit a free flow of information between men and women. Ideally, an equal number of men and women should be on the team and effort made to ensure that discussions/activities with women farmers are moderated by female researchers.

CONCLUSION

The potential for using participatory approaches in bean research is unlimited. Challenges facing scientists are greatest in the area of changing negative attitudes and behaviour toward farmers, reorienting the applied research system towards its clients and adopting an inter-disciplinary systems approach.

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WORKING GROUP 1: PLANT PROTECTION

The group acknowledged that priorities set in the past by working groups on entomology and pathology were stimulating. but now the role and needs of South Africa needed to be identified and addressed.

The group divided the plant protection problems in 5 main areas:

1. Entomology
2. Pathology
3. Weed Control
4. Nematology
5. Biotechnology

ENTOMOLOGY

* Priority and key problems identified in the past included:

    i) Bean Stem Maggot
    ii) Bruchids
    iii) Foliage Beetles (*Otheca* sp.)
    iv) Aphids
    v) Spiny Brown Bugs
    vi) Thrips

* Of these sub-projects on BSM, Brushids and Otheca are on-going. The group noted that these are still major problems and research should continue on these.

* As regards insect problems in South Africa, *Helicoverpa armigera* (American bollworm) was identified as a researchable topic. However, the problem was not widespread, but of localised importance and could at times be devastating.

* Of more importance were the **Vectors of viruses**. It is thought that the leafhopper (not confirmed) is responsible for the "grandfather" virus disease. Emphasis should be placed on this problem. The disease is of localised importance in South Africa but can be devastating.

    - Surveys and monitoring of this virus disease has commenced in South Africa.
    - It is regarded as a potential danger.
    - The prevalence, spread, etc. in the region is not known, but due to the potential danger of the disease, networks are requested to provide information if observed.

* ARC/PPRI would put together a pamphlet or make information available on symptoms and recognition of the disease. The network are requested to report any incidences in respective countries to gain a clearer picture of presence and/or spread in the region.

* South Africa to coordinate "grandfather" virus sub-project.

* Identification of the vector (leafhopper?) and research.

PATHOLOGY

* Working groups on:

    i) fungal
    ii) bacterial and viral pathogens

have in the past prioritized projects and reviewed progress. Sub-projects in Eastern Africa programme are on-going, the research needs identified here with complement each other and strengthen/develop linkages with South African counterparts.

* Priorities identified for SADC:

i) Angular leaf spot

Although a high priority in SADC, not regarded as high priority in South Africa at the present moment. BUT is likely to increase in importance in Natal.

* Sub-project submitted in the past by Ngulu (Tanzania) has not been implemented due to lack of funding. It was proposed this project be rejuvenated and linkage developed with South African countries.

* Pathogen Diverity. Isolate characterisation regarded as important. Lead countries to characterize the pathogen should be:
  i) Tanzania
  ii) Malawi
  iii) South Africa.

* Reports of working groups (Entomology and Pathology) to be submitted to dr Pakendorf for information and to support any requests so that appropriate representations and donors may be sought if seemed necessary.

* Feed back from International Conference at CIAT on the disease requested by South Africa.

ii) Anthracnose

Group acknowledged work in Ethiopia and noted projects on this disease in Great Lakes Region temporarily suspended. Work in Tanzania by "Fredrika" noted and networking/linkage with South African counterparts suggested.

* Diversity/Isolate characteristics of pathogen was regarded as important and necessary. PPEI have quarantine facilities so isolates could be sent to South Africa for characterizing.

* Collaboration between Tanzania and South Africa recommended viz between S Koch and Fredrika Mwalygeo.

Other diseases of interest in the region:

iii) BCMV

BCMV work initiated previously to continue with mandate for resistance development to Zimbabwe by Olivia Mukoko. BCMV strain characterization and monitoring to continue.

iv) CBB and Halo Blight

CBB on-going project in Uganda (Dr Mabagala and also South Africa (Deidrè). Collaboration to be initiated between these two researchers.
Halo Blight. The knowledge of this disease is good, a clearer picture of races and distribution is now clear.

* Emphasis therefore should be placed on resistant breeding of halo blight.

* A sub-project on resistance breeding for halo blight is recommended. South Africa has sufficient information on races of halo blight. South Africa to initiate a sub-project and developing a sub-project proposal for this in collaboration with dr Madata (Uysle - Tanzania).

v) Rust

Group noted previous projects in Ethiopia and Madagascar. Currently a proposal from Ethiopia on IPM of rust and race characterization. NB not project on rust in SADC in the past and regarded as important problem that need addressing.

In South Africa rust regarded as very important and given highest priority.
Collaboration with South Africa and Tanzania (Dr Mushi) recommended.
Need for proposal and development of linkage with Ethiopia (Dr Assefa?).

vi) Root Rots

Considered important eg. in Natal and other SADC countries.

Need to identify willing collaborators possibly at University of Natal or Cedara Research Station (Contact Brian Birch through Susan Koch).

NB Prof. Pretorius of University of Orange Free State interested in root rot research if funding available.

vii) Brown spot

An increasing problem in South Africa and work has started here (ARC).

viii) Nematology

Root knot nematode and Pratylenchus problems on the increase in SADC, including South Africa. In response surveys started in South Africa i) some work on-going in Kenya and PLD project at Sokoine Univ. in Tanzania, ii) need to develop proposal and submission of sub-project.
Contact persons in South Africa: Sonia Steenkamp and Cheryl Venter.

iv) Weeds

Imperative to initiated sub-project on Integrated Weed Management Programme in SADC.
Research should be based on IPM principles with emphasis on cultural practices. Newly appointed Agronomist need to gain in-sight and experience on this aspects so SADC weed scientists requested to assist and develop collaboration with South Africa (viz with Dawid Fouché).
Mr Mmbaga (Tanzania) undertakes to develop proposal for sub-project.

v) Biotechnology

* Group acknowledges the progress and work on Biotechnology at ARC/South Africa. Interest and programmes (in other crops other than *Phaseolus*) being established in Tanzania, Kenya, etc.

* Recommendation for developing contacts for information exchange and particularly on methodologies - protocols, etc.

NB Centre of excellence in pathology viz fungal virus - bacteria in South Africa. Specific interaction noted above need to develop with ARC and centres in Africa these on-going project.

WORKING GROUP 2: PLANT BREEDERS

Priority bean research areas to be addressed by the SADC network activities.

A. AREAS WITH ON-GOING RESEARCH PROJECTS

1. Bean Stem Maggot
2. Common Bacterial Blight
3. Bruchid
4. Low soil fertility
5. Bean Common Mosaic Virus

On-going research activities to develop resistant/tolerant varieties to the above constraints are already in place in the region.

B. AREAS TO FOCUS ON

1. Diseases

    a) Angular Leaf Spot
    b) Rust
    c) Halo Blight

    These three diseases are important and more work is required to be done in them. One sub-project proposal can do for all the diseases. South Africa can take the lead and collaborate with other national programmes.

2. Drought

    There is need to revive the drought screening work in the region. A sub-project proposal would provide the service.

3. Consumer evaluation

    Each national programme should identify the preferred seed type of beans. Breeders' effort should focus on the few preferred seed types, so that rapid impact can be realised. Seed type information should include shape, size and colour.

4. Seed

    Breeders should be responsible for breeders seed. They should keep at least 5 kg in store for every variety that has been released.

5. Variety release

    National programmes should relax the variety releasing coordination. Some countries have very strict conditions which require that a variety should be excellent in all aspects. Varieties should still be released on grounds that they are better in certain aspects than the existing ones.

6. Government commitment

Governments should support the network activities by providing funds for scientists to participate in regional network activities.

WORKING GROUP 3: CROP PRODUCTION AND TECHNOLOGY DEVELOPMENT AND DISSEMINATION

1. LOW SOIL FERTILITY

a) DRIS system - plant analysis to make fertilizer recommendations based on prediction model (available from Kriby). Cheaper than soil analysis but needs laboratory national coordinators to be contacted. Funding?
TZ/SA/ZA/MD/MW

b) Low N and low P
Bilfa Funding from Steering Committee MW/ZA next year 1996.

c) Improve organic manure. Improve fertility in local farming systems using crotalaria, macuna. Form sub-project for participatory research in these technologies.
ZA/MOR

2. PROBLEM Y

Covered by sub-project in TZ. MW to be informed.

3. "NEW BEAN PRODUCTS"

Bean cookery book, new recipes such as samosas, rous to utilise high yielding varieties. Encourage MW sub-project with Steering Committee.

Also study of trader (marketer) and consumer preferences in the region. Devise a standard questionnaire through MW Steering Committee funds? Home economist.

4. EROSION CONTROL

ARC in South Africa. NGO's? Guatemala grass.

5. BEAN SUGAR CANE INTERCROPPING SYSTEM

Mauritius/SA/TZ/Swazi. Sub-project proposals to establish links (Ben Liebenberg).

6. FUELWOOD CONSERVATION

Reduce environmental impact cooking beans (7 kg for 1 kg). Overnight soaking and improved stoves of pressure cookers.
NGO's

7. SEED RELATED CONSTRAINTS

Production and distribution of seeds. Seed regulatory constraints should be examined. Encourage farmers to produce for profit. Multiplicator of breeders seed important, small schemes with rolling fund to ensure sustainability - Steering Committee.

Distribute through entrepreneurs working for profit. Seed should be sold to farmers as free seed has a negative impact. National coordinators.
MW/TZ

Multiple cutlets. Study local seed systems in each country to improve seed delivery systems.
MW/TZ

8. ADOPTION AND IMPACT STUDIES

Development of methodologies for social and environmental impact CRSP doing studies.

MW/TZ

9. NATIONAL CULTIVAR TRIALS

Within or across ecological zones?

10. FARMER PARTICIPATORY RESEARCH

Develop methodology, practical training with such themes as IPM and soil fertility management.

11. DROUGHT

Sub-project

SCHEDULE MEETINGS:

Bilfa 1996/1997
Drought Steering Committee

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APPENDIX: Addition to Session 3

SEED QUALITY: ISSUES IN SMALL SCALE FARMER BEAN PRODUCTION.

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ABSTRACT

Bean production in Africa is estimated to cover about 3.7 million hectares per year, with annual seed requirements of approximately 350000 metric tons. The predominant sources of seed is farmers' own seed and purchases from markets and/or shops. Certified seed is rarely used in major bean growing countries of Eastern and Central Africa, due to its unavailability or lack of its production because of low demand. Demand is however high for new genetic materials. Hence, much of the bean seed used for planting is produced by small scale farmers under unspecialized seed production systems.

Given the importance of amounts of bean seed "produced" and used by small scale farmers, studies have been conducted in a number of countries to assess its quality with the objective of determining if there is need for its improvement and also to develop appropriate policies for bean seed.

High quality certified seed is expensive to produce and its cost varies between 2 to 6 times the market price for bean grains. Results from a number of countries in Africa and Latin America show little or no evidence that, centrally produced certified seed is significantly more disease-free than farmers' seed. Similarly, seed produced by formal systems compare well with, and does not result in significant yield improvement over farmers' seed. However, in certain areas, poor post-harvest management can result in insect attack and infestation by saprophytic fungi which may results in quality reduction. Farmers get rid of apparently diseased or poor seed by selection, but "losses" due to such selection is variable and depends on the source of the seed. Use of high seed rates is practiced where farmers doubt the quality of seed. Renewal of seed is rarely due to quality reasons. Seed acquisitions are meant to get new genetic materials or to compensate for insufficient seed stocks. Implications for research and policy interventions are suggested.

INTRODUCTION

Bean production in Africa is predominantly done by small scale farmers, particularly women, for subsistence but also for sale. Production in Africa is estimated at 3.7 million hectares (CIATb 1995) per year with annual seed requirements of approximately 350000 metric tons. Much of the seed comes from farmers' own seed stocks saved from previous harvests or bought from local markets and shops, with very little if any use of certified seed (Sperling et.al.,1995; CIAT, 1995). Since much of it, is produced under varied environmental conditions and production systems, and not even primarily as seed (basing on formal seed standards), there have been concerns as to its quality and whether the latter could be responsible for low bean yields. This paper highlights some of the lessons learnt on seed quality issues in small scale bean production in eastern and central Africa.

Sources of Bean Seed.

The major sources of bean seed are farmers' own stocks saved from previous harvests, and seed bought from local markets and shops (CIAT, 1992; Lepiz, 1994; Sperling et.al., 1995). These two sources provide for about 95 % of seed planted in the Great Lakes Region (GLR) of central Africa (CIAT. 1992). Some seed is also obtained from neighbours and relatives. Use of certified seed is very insignificant, and is available as new genetic materials. In terms of preferences, own seed is most preferred and considered "good", because its varietal characteristics and adaption are known. Also considered good is seed obtained from neighbours and relatives. Seed from markets, despite constituting a significant proportion of seed used by farmers, is least preferred.

The limited use of certified seed is due to a number of factors. Phaseolus bean is an autogamous crop. Once farmers obtain seed of particular varieties, they multiply it without the risk of genetic degeneration, thus creating limited demand for a continuous supply of seed, except in case of new or varietal replenishment. Certified seed is considered expensive (varies between 2 - 6 times the market price of bean grains) and is not widely available largely due to few formal distribution channels (Sperling et.al., 1995).

Although sold in local and distal markets, beans are grown primarily for home consumption, and farmers tend to keep the cost of production low by using own or cheap sources of seed. In the GLR, some parts of Malawi and Ethiopia, beans are grown as mixtures. It is impractical to produce seed of mixtures under the formal system. This is because mixtures are dynamic and are constituted by farmers for different purposes, such as poor soils, staggered harvesting, or tolerance to rains (usually implying diseases). Farmers modify mixture components to suit their needs (Voss and Graf, 1991; Voss, 1992). What all this means is that, much of the bean seed used in small scale bean production is produced within this system of production by farmers.

Seed Production

In a formal seed production perspective, little or no specialization is practiced in seed production by small scale farmers. Seed is obtained from a regular crop harvest which is meant for food or sale. However, in south-west Rwanda, farmers referred to as "seed experts" specialize in producing seed. Seed experts are recognized in their communities as individuals who produce and sell high-quality seed and can produce as much as 450 kg of seed per season (CIAT, 1992). Farmer groups are initiating seed enterprises in Uganda (David, 1994; CIAT, 1995). Bean production is done under varied cropping practices and systems; pure stand, intercrop or as varietal mixtures. More beans may be grown in certain seasons (usually short rains season to avoid damage from diseases or for rotation purpose) than others (Sperling et.al., 1995). Regardless of the source, farmers usually select or sort seed for planting, removing physically damaged, blemished or defective seed (Buruchara, 1990; CIAT, 1995; Janssen et.al., 1992; Voss, 1992). Severity of selection depends on seed availability; being less severe if seed supplies are low.

Quality of Farmers' Seed.

Given the role and importance (quantities used) of farmers' seed in bean production, and the fact that it is not produced as recommended by the formal sector, the quality of this seed is a subject of concern and interest to both researchers, the formal seed sector and policy makers. Considering the methods of production used, the quality of farmers seed is usually assumed to be poor comparing with for example, certified seed produced under the formal system. As a result a number of questions can be asked: Is it feasible to expect formal seed sources to economically produce and satisfy bean seed demands (varieties, affordable price, quantity and accessibility) ?. Is the quality of farmers seed actually poor and a limiting factor in bean production and is it an issue for improvement ?. Can seed production at farmer level be specialized ?

A number of studies have been conducted in Latin America and Africa examining the quality of farmers' seed (Janssen, 1992, Sanchez and Pinchinat, 1974). Results obtained in Latin America (Colombia and Guatemala) showed that, in general there was no difference in yield, between farmers' seed and "clean" seed produced using recommended practices. Yield of "clean" seed was superior to the farmers' seed only in three out of 13 cases implying that seed used by farmers compares well with "clean" seed. A summary of these results (adapted from Janssen et.al., 1992) are presented on Table 1. Studies by Trutmann and Kayitare (1991) in Rwanda showed a yield advantage of 21% with pathogen free seed over seed produced in the traditional way but this differences disappeared over time (three seasons).

Physical purity is not a major concern as farmers can easily manage this aspect. Studies on germination in Rwanda showed overall rates of farmers' seed to be high (CIAT, 1991) and where farmers are doubtful about germination rates, they increase the seeding rates. Early harvesting (before complete maturity is reached) and production in acid and low phosphorus soils had, similarly, no influence on germination and yield (CIAT, 1991).

Seed health is an important concern in the production (sites and practices) and quality of seed. This is because bean pathogens (including the most important ones) are seed-borne and can be transmitted through seed. Seed-borne pathogens potentially, results in poor germination, diseased and less vigorous plants thus affecting both the quality and productivity of the bean crop. Under favourable environmental conditions, seed-borne infection by some pathogens can cause epidemics.

Relatively fewer studies have been conducted to compare the health quality of farmers seed and "clean" or certified seed, but results from work already done are consistent across countries. Research in Kenya (Buruchara, 1990) and Rwanda (CIAT, 1992) show that the level of infection of farmers seed is surprisingly low (Table 2) than otherwise expected. A comparison made of seed of the climbing bean variety Umubano, from both formal and farmers' seed in Rwanda, showed no difference in emergence, vigour, and yield of samples tested. Seed infection levels were too low to make meaningful comparisons. Similar studies in Kenya also showed no significant difference between certified and farmers' seed on the level of contamination with *Pseudomonas syringae* pv *phaseolicola* in variety GLP-2 (Mwang'ombe et.al., 1994). These results suggest that the health of farmers' seed is not as bad as usually assumed to be and that farmers use measures to control its quality (Buruchara, 1994).

Farmers value good quality seed. However, their perspective of "good" seed emphasizes first, varietal aspects, and second, other more visible characteristics such as rotten seed, broken, mature and bruchid-damaged grains (Sperling et.al., 1995). Whatever the criteria based on, farmers actively carry out practices which seem to positively affect the quality of their seed. This includes, choosing adapted varieties, growing more beans in a season when beans are less likely to suffer from rains (favours foliar diseases; example in Rwanda more beans are grown during the short rain season) (CIAT, 1992), and removal of primary leaves when weeding (Trutmann et.al., 1993). But the most common and significant practice is seed sorting. In Rwanda and Burundi, farmers

Table 1 A summary of studies comparing farmer-saved and "clean seed".

Year	Researcher	Site	Variety	Yields		95% Statistical difference	No. of observation s
				Farmer	Clean		
1974	Galves	CIAT	Guali & ICA-TUI	85% increase		yes	n.a.
1975	n.a.	Guatemala	Not reported	515	1545	yes	some farmers
1976	Pinistrup-A	Valle de Cauca	ICA-Pijao	906	1060	No	30.
1976	Galvez	CIAT	ICA-TUI	1691	2720	yes	n.a.
1976	Voysest	Palmira Popayan Monteria	ICA-TUI	Minimal effect		no	n.a.
1978	Sanders & Herrera	Huila	Calima	1509	1630	no	15
1978	Restrepo	Huila	Calima	1000	1138	no	13
1978	Stable	Restrepo	Calima	1341	1254	no	12
1978	Sanders & Ruiz de L.	Carmen de Viboral	Cargamanto	2019	1826	no	15
1979	-do-	-do-	Cargamanto	2136	2168	no	15
1979	Sanders & Herrera	Huila	Calima	1402	1333	no	30
1983	Woolley & Beltran	Carmen de Viboral, Marinilla	Cargamanto	no diff.		no	n.a
1983	-do-	El Tambo	Limoneno	557	514	no	4 places 2 reps

n.a. = not available

Clean seed refers to seed produced under special circumstances, which was physically clean and apparently free of disease. In all cases, farmer and clean seed were of the same variety.
Source: Janssen et. al. 1992.

Table 2: Bean pathogens and levels detected in farmers' seed from four districts in Kenya.

Bean Pathogen	Level in Farmers seed[1].
Colletotrichum lindemuthianum	1 out of 26 samples at 0.25%
Rhizoctonia solani	1 out of 26 samples at 0.25%
Phoma spp	12 out of 26 at maximum 3.2%

[1] = 400 seed per sample examined.

Source: Buruchara, 1990.

consider seed from neighbours to be good, not only because environmental and edaphic conditions are similar to theirs (adaptation), but also because they know those who can deliver well sorted beans. When purchasing seed in markets, farmers look for types which they believe might do well in their soils and which are free of evident physical defects (Sperling et.al., 1995). Seed selection is a very common practice among small scale farmers (Buruchara, 1990; CIAT, 1992; CIAT, 1995; Voss, 1992; Janssen et.al., 1992; Sperling et.al., 1995). The criteria used to select or sort seed include, shrivelled, weevil-damaged, rotten or soft, germinating, broken/cracked, discloured, moulded, undersize, lightweight, or old (Sperling et.al., 1995; CIAT, 1995). A number of bean diseases, particularly, those which affect pods, such as anthracnose, common bacterial blight, ascochyta etc do results in shrivelled, rotten, discoloured, moulded and undersize seed. Hence, the use of these criteria in seed sorting, results in the removal of infected seed thus improving the health quality of the seed. Recent studies conducted by the authors in Uganda confirm this observation. Samples collected from markets and shops from Mbale, Mukono, and Iganga districts in Uganda were divided into two parts. One part was subjected to sorting (selection) by women as they normally do for seed used for planting and the proportion selected out was determined. The sorted and unsorted were then subjected to seed health testing.
Four fungal bean pathogens observed were *Fusarium oxysporum* f. sp. *phaseoli* (FOP), *Fusarium solani*, *Colletotrichum lindemuthianum* and *Macrophomina phaseolina*. Comparison of sorted and unsorted seed showed that, sorting reduced the number of samples infected with fungal pathogens (Table 3). Sorting also significantly reduced the level of fungal infection in seed samples (Table 4). A similar pattern was observed for saprophytic infection. This study clearly shows that selection does improve the quality of farmers seed and is evidence of what may be happening when farmers sort seed. This practice is common with small scale farmers on seed saved and bought from markets for planting.

The amounts of seed selected-out was variable with different samples. On average 36% of seed was selected out in samples obtained from markets and shops and varied between 8 to 64% (Table 5). Sorting to remove apparently undesirable seed results in seed "loss". But seed selected out can be used for food and as such is not entirely lost (CIAT, 1995). If this loss is high, it becomes significant in a seed production enterprise and can affect the price of seed or viability of the enterprise. Importance of seed loss due to sorting is not fully known but appears to vary with the source of seed.

Implications for Research and Policy Development.
It is taken for granted that, farmers' seed which forms the bulky of seed used in bean production in Africa is not of good quality. However, there is a body of growing evidence suggesting this not to be necessarily correct. This has implication for research geared at generating information which can be used as the basis for rational policy decisions or

Table 3. **Bean pathogens / organisms and levels detected in seed from markets/shops at Mbale, Mukono, Iganga districts in Uganda.**

Pathogen / Organism	Number of samples with pathogen		Frequency of seed borne pathogens (%)	
	Sorted	Un-sorted	Mean	Range
Fusarium oxysporum f.sp. *phaseoli*.	12/31	18/30	1.85	0 - 10
Fusarium solani.	2/31	12/30	0.62	0 - 12
Colletotrichum lindemuthianum.	1/31	2/30	0.005	0 - 1
Macrophomina phaseolina.	0/31	3/30	0.018	0 - .035
Saprophytes.	*[1]	***		

[1] = Relative occurrence of saprophytes; * = low, ** = medium, and *** = high.

Table 4. **The number and frequency of seed borne pathogen on selected (sorted) and un-selected bean seed obtained from markets and shops.**

Types of seed	Relative no. of seed borne pathogens	Frequency of seed borne pathogens
Selected	0.996	3.43
Unselected	1.507	9.30
LSD (P = 0.05)	0.155	2.59
CV (%)	22.1	72.9

N = 26

200 seed tested per sample.

Table 5. Mean percentage and range of seed selected out from two different types of seed sources.

Seed source	Seed selected out (%)	
	Mean	Range
IBFA [1] (4 samples)	4	0 - 8
Market / shops (26 samples)	36	8 - 64

[1] IBFA = Ikuwe bean farmers Association.

modification on seed issues. Much can be learnt from experiences gained elsewhere, but certain aspects may have to be studied considering variation in production systems, germplasm diversity, seed systems and regulations across countries. Availability, farmers' perception and price of seed are some of the factors that influence sources which farmers use to obtain seed. Production of seed by farmers themselves using methods and areas similar to those normally used, could offer a compromise in availability, price and quality. Examples are the seed experts in Rwanda and emerging small seed enterprises in Uganda whose primary interest is seed production. Apart from producing seed which is qualitatively acceptable, they

can also serve as avenues complementing existing seed channels linking production and distribution and also which offers good opportunity to keep the cost of seed lower and
affordable.

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