Table 1. Performance of the 8 'NRI' lines at Uyole compared to Uyole varieties

Variety or line	Grain yield Kg/ha	100 seed wt	Days to 95% maturity	Diseases score 1-9	
				ALS	ANTH
7071/3	2159	30	84	4.5	4.0
7078/1	1870	36	83	5.5	4.0
7068/2	2165	31	83	4.5	4.5
7078/2	2276	32	82	6.2	5.0
7072B/2	2023	31	84	6.5	5.0
4[7070/2]	2073	29	82	6.0	5.5
7[7070/2]	2122	30	82	4.0	4.5
7075/2	1714	32	82	4.2	4.0
Uyole 96	1938	44	78	2.0	1.0
Uyole 98	2406	33	81	3.0	2.0
Cal 143	2221	41	83	2.0	2.0
Bilfa 1	2270	38	81	2.0	2.5
Mean	2105	34	82	4.2	3.7
LSD[0.5]		± 7			
P	NS	***	NS		

Table 2. Performance of selected 'NRI' lines and improved varieties in on-farm trials at Lyadebwe village [2003].

Variety/line	Yield Kg/ha	Preference score 1 – 5
7071/2	730	2.5
7078/1	700	3.0
7018/2	850	2.8
7068/2	830	3.0
CAL 143	865	2.0
Uyole 98	1030	1.3
Wanja	1200	2.5

Table 3. Performance of improved varieties in on-farm trials at Katani village [2003].

Variety	Yield Kg/ha	Preference score 1 – 5
NRI [7068/2]	1316	2.0
DRK 124	1455	1.5
Uyole 94	1345	1.5
Uyole 96	1327	2.2
Uyole 98	1182	2.2
Local	676	1.0

Table 4. Reaction of improved bean varieties to three important diseases in the Southern Highlands [Myunga Village, 2003]

Variety	Diseases		
	ALS	ASC	RUST
Uyole 98	1.0	2.0	1.0
Uyole 96	3.0	1.5	1.0
Uyole 84	3.0	3.0	6.0
Cal 143	2.0	3.0	1.0
Wanja	3.0	2.0	1.0
Bilfa 16	1.0	1.0	1.0
NRI 7068/2	2.0	1.1	1.0

ALS = angular leaf spot, ASC = ascochyta

Appendix 2.CPP Project R8415: Multiplication and distribution of improved bean varieties in the Southern Highlands of Tanzania.Working Paper A1145/1

Farmers' bean information systems in the Southern Highlands

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Contents

Summary

The report is based on discussions with farmers in eight villages in three districts. There is a strong demand for information about new varieties of beans and associated husbandry practices. Different sources and channels of communication complement one another. Key individuals can play catalytic roles within the information system. The bean programme's strategy of introducing new varieties through on-farm trials, open days, NGOs and extension officers matches well the farmers' preference to assess new varieties by visual inspection of the seed and their performance in the field. Organised groups play a pivotal role in the information system, but may also restrict the flow of information in some situations. ARI Uyole is valued as a source both of useful information, and of seed of high quality.

1 Purpose and methodology

The purpose of the visit was to contribute to Output 2 of the project by assessing the extent to which information about improved varieties has diffused within the population of farmers who grow beans in the Southern Highlands, and present the findings to a project workshop in Mbeya[1] on 26th September 2005.

The five days of fieldwork were designed to assess knowledge and use of varieties and sources of information among three distinct strata:

a). farmers who have direct contact with ARI Uyole and its varieties through interaction with the bean programme (through on-farm trials, field testing, etc.)

b). farmers in the same villages as a) but who have no direct contact with ARI Uyole and its varieties (e.g. farmers who are not members of a group with which the bean programme interacts)

c). farmers in nearby villages which have no current direct (or indirect through NGOs or other projects) contact with the ARI Uyole bean programme.

This would enable us to see how far the information available to farmers in category a) has spread to their neighbours in the same village and beyond to other villages. However, category c farmers were elusive, as the villages selected turned out to have, or have had in the past, contact with the bean programme either through past involvement in on-farm trials or through purchase of seed with the facilitation of a contact farmer.

The fieldwork was conducted by Chris Garforth (The University of Reading), Mary Simbeye (Farmer Education and Publicity Unit [FEPU], Dar es Salaam) and Mr Martin Mwakasendile (ARI Uyole).

Data were gathered through discussions with groups of farmers, and interviews with individual farmers, in eight villages (Table 1). We developed a checklist of questions as a basic guide for these discussions (Annex A) which, after using on the first day, we revised (Annex B). Farmers were not selected randomly. A total of 93 farmers

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[1] Bean Variety Promotion Workshop, held at the Youth Centre, Mbeya, 26/9/2005

took part in discussions or interviews, 41, 35 and 17 in categories a, b and c respectively. Fifty one were women and 42 men (Table 2).

Table 1 Respondents by village, category and gender

Village	District	Group	Category	No. women	No. men
Simike		Leaders of 2 groups	a	1	1
Mahango		Members of 2 groups	a	6	0
Ilembo	Mbozi	Members of Upendo group	a	3	
		Non-member (next village)	c		2[3]
Isango	Mbozi	Members of Neema group	a	7	1
Hatelele[1]	Mbozi	Members of church group	a	8	8
		Non-members	b	12	13
Shiwinga	Mbozi	No group	c	3	6
Lyadebwe	Njombe	Bean growing group	a	4	2
		Non-members	b	3	7
Mayali[2]	Njombe	No group	c	4	3

Notes: [1]Hatelele was selected as a village which had not received Uyole varieties. However, although the village had not been part of any on-farm trial or free distribution of seed, the church group had purchased seed from Uyole through the facilitation of the contact farmer for the area.

[2]Mayali, which is the neighbouring village to Lyadebwe, was involved in on-farm trials in 2001 and 2002, but has had no seed from Uyole since then. The respondents are not members of group involved with beans, but some are members of animal traction groups linked to the extension service.

[3] One of these two men was from the neighbouring village of Hasamba.

Table 2 Summary of farmer respondents by category and gender

Category	gender		total
	female	male	
a)	29	12	41
b)	15	20	35
c)	7	10	17
Total	51	42	93

2 Briefing at ARI Uyole

Dr Catherine Madata, Head of beans programme, and Mr E Kiranga, the Zonal Research Extension Liaison Officer (ZRELO), briefed us on recent developments in the bean programme including promotional activities. The bean market is a dynamic one. New varieties are assimilated readily into the market. Farmers recognise which varieties are suitable for local, national and export markets. There is a growing market for green leaves as vegetables, so the quality and amount of leaves have become criteria for farmers' assessment. Even immature "green" beans are now becoming popular; people are looking for ways of getting them fresh to Dar es Salaam. Farmers are actively looking for new markets and new varieties.

Promotional activities have included the distribution of posters and leaflets produced under the previous CPP project (R7569) and a radio broadcast about the new varieties, produced by FEPU and aired in September or October 2004. During the broadcast, farmers were interviewed about new Uyole varieties, particularly Uyole 03 and Uyole 98. The programme also focused on marketing, telling farmers that there is a good export market for yellow types and in Dar for red types. Currently all radio broadcasts relating to research and extension go out on Radio Tanzania. However, there are now several local radio stations in the country but they are expensive to use.

ARI has produced a set of A4 information sheets about Uyole varieties; they are based on the earlier posters but are smaller and in black and white (which makes them easy to photocopy and to handle) with a single colour photograph, and have been laminated for increased durability.

Village Information Centres are a relatively new concept and are being introduced under the DANIDA-supported District Agricultural Development Support (DADS) project, within the local government institutions.

3 Findings

As the situation in the villages was quite different, the findings are first presented separately for each village before a discussion of the overall pattern of information access and flow.

Simike

With no prior arrangement, we were fortunate to meet the leaders of two farmers' groups, one male and one female. They (i.e. the group and/or group members) had received five varieties from Uyole last year (i.e. for planting in 2004-2005); "sugar", Uyole 94, 98, 03 and 04. Some they received free, others they paid for. They also bought local varieties in the market, including kablanketi, msafili, red and white msukanywele, and kigoma. They have not heard of Urafiki or NRI lines. *[The village is only 1.5 km. from Mahango, where farmers have received Urafiki.]* They plant April/May and (with irrigation) August. Their sources of information on beans and bean husbandry are Dr Madata and other officers from Uyole. There is no extension officer in the area. They also get information on Radio Tanzania – they sometimes hear about new varieties. There is no Village Information Centre here, and they have not heard about Village Information Centres. They have not seen the laminated A4 information sheets before, but they do have some leaflets from Uyole.

Their main problems in bean production are pests and shortage of water. Bean fly and aphids affect all varieties, both local and new. They get some control by using *utupa (tephrosia spp.)*. They got information about this from ARI Uyole: farmers had used the plant before, but Uyole gave them advice on how to use it and the rate of application. The area is very productive for beans, but water is far away.

Mahango

We met five members from three groups (total membership of the groups is 37). The Women Irrigation Agriculture group was set up in 1993 under a FAO programme and is the only such group still active in the area. The other two are “clinic women groups”.

All had received seed from Uyole last year (2004): U96, U03, U96, U98. plus 0.5kg of Urafiki received by one group which they planted as a group (because the amount was so small) and the product of which they have eaten. They also bought local seed, e.g. Maspangere. They like U94, U96, U98 best because of their high yield and marketability. We asked what proportion of their output is sold: they preferred to answer by variety – e.g. U94 is used for home consumption, U96 is sold.

Before receiving Urafiki, they had not heard about it by name; they only heard that Uyole had produced some good varieties. The first time they heard the name was when Dr Madata brought the seed. Urafiki has a sweet taste, high yield, resists drought.

Their main source of information on beans and bean husbandry is Dr Madata. They also get some information through the radio. There is no extension worker in the village and no Village Information Centre. They have not seen the A4 laminated information sheets before, but they do have leaflets.

The group suggested that in future seed given by Uyole should come direct to farmers groups who would ensure it is used properly. When it is given to the village leaders to distribute, they keep much of it for themselves and eat it, so the farmers get only small quantities.

The man whose house we were meeting in (a retired medical doctor from Mbeya) said that demand for new seed is high; farmers are cycling all the way to Uyole to find it. He had also had some Urafiki (it was not clear whether this was through his wife as a group member, or through a separate arrangement with ARI Uyole). They have eaten it all – they particularly like to eat it with tea and mixed with groundnuts.

Ilembo

Background We were accompanied by the Acting DALDO, Mrs Kazi, and the contact farmer, Joseph Mampashi, through whom Uyole and the District Agriculture Office maintain contact with farmer groups in sixteen villages. Joseph assists groups buy seed from Uyole. Although earlier varieties – e.g. Uyole 96 and Uyole 98 – are plentiful in the market, traders mix them with less favoured varieties. Farmers know they cannot be sure of the quality or purity of seed bought in the market, hence their preference to buy seed from Uyole.

The new laminated information sheets on varieties were on display at the DALDO office, the office of ADP Mbosi Trust, and the Ilembo village office.

The women’s group (“Upendo” = “love”) started in 2003 after a seminar on bean (and other crop) production and varieties in town by Mrs Kazi. Of the fifteen original members, nine remain. Initially they were given c. ¼ kg. each of different varieties, which they planted as a group on land they rented. Once they have enough seed, they will probably plant as individuals on their own land.

We conducted five interviews with individuals: three women who are members of the bean growing group, and two male non-members one of whom was from a neighbouring village.

Group members The group members got Uyole 03 in 2004, and Urafiki and Uyole 98 in 2003. The initial motivation was their interest in trying out new varieties, and they now want to increase the amount of production. They know it will be profitable. They want these varieties because they are high yielding and palatable and (though not Urafiki) marketable. All the seed has come from Uyole via the village extension worker. Previously when they needed seed they would buy from the market, but they do not any more because they have access to new varieties.

Regarding Urafiki specifically, they first saw it when the extension officer brought it to them following the seminar in 2003. From the first harvest, they planted 3 kg the following season. Uyole has bought back some of the seed, and so has the extension officer for distribution to other farmers. One member said she had sold some to other farmers. All said that other farmers in the village were interested in the variety, and came to the group plot to see how it was doing. The members think it is palatable, and the leaves are better than other varieties as a vegetable. They also say it is drought resistant: the land they rented was not available on time so they planted late and thought the crop would fail; however it produced well. But, like other varieties, it has disease and pest (especially bean fly) problems. They want to increase the area they plant to Urafiki.

Individual answers on their preferred varieties to plant ranged from Uyole 03, Uyole 98 and Urafiki. One pointed out that while Urafiki is good for home consumption, it does not yet have a market (for purchase for eating) because people don't know it.

The group is expecting more seed from Uyole this year because they don't have enough seed of their own: they have written via the extension officer with their request. Although they have been given seed without payment in the past, they are ready to buy it.

Their main sources of information on beans and bean production are the seminar in 2003, the local extension officer, and the radio. There is no Village Information Centre in the village. They have not seen the laminated information sheets before, though one member said they were expecting to receive print material from the DALDO office.

Non-members The two non-members cannot be regarded as typical, by the very fact that they came along to the meeting when they heard we were coming from Uyole. They both regard the women's group as a source of information, and potentially of bean varieties. Neither of them acquired any seed for planting last year, using only their own saved seed. They have heard of Urafiki through members of the group and the Ilembo resident has seen it on the group's plot. Both want to acquire Urafiki seed to try out for themselves and see how it performs; they hope to be able to buy from the Ilembo group. They have heard that it is palatable, but not marketable. The (local) varieties they currently prefer to plant are kigoma and namaini, because they are palatable, marketable and do well in their villages. Their main information sources are friends and neighbours, the Ilembo group, and the radio. One also mentioned the extension officer. There is no Village Information Centre in either village. Their main information needs are on control of insect pests and diseases.

Isango

We had discussion with eight members of the "Neema" group, in the presence of the Village Executive Officer (VEO).

They got seed of Uyole 98 last year through the village extension worker, and a small amount of Urafiki in 2003 following a seminar in town run by Mrs Kazi. The seminar aroused their interest in trying out the new varieties. They heard they were palatable and gave high yield.

The Urafiki they planted as a group on the land of one of the group members. From the initial 0.5 kg., they planted 15kg. the following season which produced approx. 100 kg. They have given or sold seed to 15 other people; many farmers have asked them about the variety and asked for seed. They say it yields more than other varieties and does well in this village. It is palatable, but not marketable because it is new in the area and people don't know it. They also said it is "heavy" (meaning dense?) and have been told it is nutritious. They want more seed to expand their production and want the whole village to be able to plant it and other new varieties. As well as Urafiki, they expect to get from Uyole seed of Uyole 03 and Uyole 96 (nsafiri). They are ready to buy it. They will get it through Joseph.

They get information on beans mostly from the DALDO, neighbours/friends, radio and from posters and leaflets from Uyole. There is no Village Information Centre in the village. They have seen the laminated information sheets at the ward office: these should be photocopied so that villagers can have them. They information they need relating to beans is about use of fertilisers, control of bean fly, new technology, and how to get new varieties.

The VEO commented that there is a lot of interest in Uyole varieties in the village but there is not enough seed. Planting season is November, so it is important that seed comes in time, otherwise other crops will have been planted where beans might grow. Farmers here like to plant early so they can plant a second crop.

Hatelele

On our way to the pre-arranged meeting, we met some farmers near the Village Office who said the have seen Urafiki but don't know how to get the seeds. The farmers we were due to meet are members of a church group who have acquired seed (but not Urafiki) from Uyole via Joseph (the contact farmer). They were down at the brick kilns making bricks with others. We first had a discussion with 16 members of the group, and then with 25 non-members.

Group members The group bought Uyole seed through Joseph last year: Uyole 96 and 98. They are growing it as a group during the rainy season, and on their individual plots under irrigation in the dry season. They had learned, from Joseph, of the new varieties' high yielding characteristics, easy cookability and the sweetness of the green leaves. They wanted to get the seed so they could try it out and see how it performed. They have heard of Urafiki, from Joseph, but haven't seen it or grown it. But from what they have heard, they want to plant it.

Their preferred varieties to plant are Uyole 98, Urafiki, Kablanketi, Uyole 96. The characteristics they like in these varieties are:

- Uyole 98: the seeds are big and so a few seeds fill a tin
- Kablanketi: is marketable

- Uyole 96: is high yielding
- Urafiki: we want to try it out.

They expect to get new seed this year, again through the contact farmer: Urafiki, Uyole 96 and 98, and Kablenketi. The new varieties yield higher than local ones.

Their sources of information on growing beans are the contact farmer and Radio Tanzania. There is no Village Information Centre in the village and they have not seen the laminated information sheets. As for their information needs, they want to be trained on timely pesticide applications, planting, and information about marketing. They want leaflets on bean production.

Non-members are growing their local varieties “from their ancestors”, from saved seed. They did not buy or otherwise acquire any new seed last year. They have heard of Urafiki, from the radio. They haven’t seen it, and want a chance to see it and to plant it. They don’t want to say what it is like until they have tried it.

Their preferred varieties are Msafiri local, Kablanketi, Kigoma, Maini. The characteristics they like are:

- Msafiri: palatable, quickly cooked and fetches high price in the market
- Kablanketi: easily cooked
- Kigoma: marketable
- Maini: large seeds, marketable.

They expect to get seed this year. They want any improved varieties because they don’t have any at the moment; for example improved Kablanketi, Uyole 96 and 98, and Urafiki. They don’t know how they will get the seed.

There sources of information on growing beans are neighbours, group members and the radio. There is no village information centre and they have not seen the laminated information sheets. They need information on improved varieties, disease and pest control, and market information.

Shiwinga

We met in the village office, in the presence of the Village Executive Officer and (initially) the local extension officer (bwana shamba): the latter left shortly after we began for another engagement. We began with an individual interview with a male farmer who had acquired Uyole seed through the contact farmer; then a group discussion with nine farmers who had no experience of the improved seeds.

Individual farmer He used to grow beans but unprofitably and without any insect pest control. He heard from a farmer in another village that there were new varieties at Uyole and saw them growing in that farmers’ field (c. 2km distant). He wanted to get the new varieties because they are marketable (Uyole 96), and high yielding and sweet (Uyole 98). He asked for some of the new seed through the contact farmer and bought 10 kg (Uyole 96 and 98) which produced 80 kg. He has planted again and harvested three sacks of one variety and five tins of the other. He has sold c. four tins of Uyole 96 (for food, not as seed). Some farmers are now asking to buy seed from him so they can try the varieties.

He has heard of Urafiki but not seen or grown it. Hhe wants to try it after getting some seeds. He heard about it from the radio. He prefers to grow improved varieties, such as Uyole 96 and 98: they are early maturing, cook in a short time, high yielding and palatable.

He expects to get some new seeds this year, because he has not got enough seeds and he wants improved varieties. He particularly wants Urafiki and would like some climbing varieties. He will buy the seed through the contact farmer.

His main sources of information on growing beans are friends and neighbours, and radio. There is no Village Information Centre and he has not seen the laminated information sheets. He needs information on planting, spacing, and pest and disease control.

Other farmers grow their own varieties because improved varieties are not available. Some say they don't know the farmer above has new varieties; others say they know but did not know if he was selling them. They did not get any new seed last year. They have not heard of Urafiki/NRI. They prefer to grow Maini (good for eating), Kablanketi (marketable) and Kigoma (marketable).

They expect to get some new seed this year because they don't have improved varieties at the moment. They will be happy with any improved variety and expect to get it through the contact farmer. Their sources of information are radio (for three of the farmers), extension worker and seminars. There is no Village Information Centre and they have not seen the laminated information sheets. Their main information needs are insect pest control, storage, planting and new varieties.

Lyadebwe

We met in the Village Office, under the chairmanship of the Village Executive Officer and with the Divisional Extension Officer (Mr Makaif) in attendance. It had been arranged that we meet members of the bean growing group which has been associated with ARI Uyole since on-farm trials in 2001.When we said we would like also to talk with farmers who are not members of the group, ten non-members were quickly found and joined us. The meeting began with the secretary of the group reading out a handwritten report of the group's activities. We then had a discussion with the group members, followed by a discussion with the non-members.

Group report The group began in 2001 with 10 members one of whom has since died. Each member was given 6 varieties to try out on their farm, including Urafiki (or NRI as it was then known). They identified those that were drought resistant. Other farmers have come to buy these varieties from them; an agent also came from Makambaka to buy so he could sell to others. The number of other farmers who had been given or sold seed by members ranged from 0 (for two members) to 14. Some of these were sales to others in the village or Makambaka, others were gifts to relatives. (A copy of the written report is with ARI Uyole.)

Discussion with group members They did not receive any new seed in 2004, but were given NRI/Urafiki twice, in 2001 and 2002 (along with other varieties). They like Urafiki and will continue planting it. It is drought resistant (an important quality in this relatively dry area) and disease resistant; it is also high yielding. Two members have given or sold Urafiki to a total of five others outside the group.

The varieties they prefer to grow are kabanima, Wanja, Uyole 94 and Urafiki:

- Wanja: for eating, it is marketable and fetches a high price
- Kabanima: is marketable and drought resistant

- Urafiki: is high yielding, drought resistant and marketable locally.

They do not expect to get any new seed this year, because they have enough seed.

Their sources of information on growing beans are Uyole, posters from Uyole and the extension worker. There is no Village Information Centre, only the village office. They have seen the laminated information sheets (they are on display on the external wall of the village office) since they were put up some three weeks ago; they say they contain information about new varieties of beans and how to grow them. Their main information needs are on improved varieties, specifically those that are drought resistant and high yielding; disease control and market information – e.g. when and where they can get a good price, what varieties are fetching high prices.

Non group members did not get any new seed last year. They have not heard of Urafiki or NRI and so have not seen it or grown it. The varieties they prefer to grow are (with the characteristics they like):

- Wanja: high yielding, palatable, quickly cooked
- Semtitu / mwafrica – a local variety: high yielding, drought resistant
- Long kablanketi: marketable, palatable
- Uyole 96: early maturing, marketable.

They are now planning to get new seed this year, particularly now that they have seen the information sheets, because they don't have improved varieties at the moment. They want Wanja, Urafiki, Uyole 94. They expect to get the seed through the extension worker.

Their sources of information on bean varieties are members of the bean group; but they do not get information on bean husbandry because they do not ask them. They don't get information from the radio – they are too busy to listen when the agricultural broadcast is on and they do not think it is relevant to them. There is no Village Information Centre. They have seen the laminated information sheets, on the wall outside the village office. Some of them thought the sheets were only for the group members and had not read the content. But they had noticed the photographs of the bean seeds. Their main information needs are on the yield of each improved variety, varieties which are drought resistant, disease resistant, and in high demand in the market.

In general discussion afterwards, the lack of awareness of the new variety (Urafiki) among non-group members was attributed to the fact that the amount of seeds around is still low so group members have not felt the need to advertise the fact that they have seed for sale.

Mayali

Mayali village is next to Lyadebwe. We had no arrangement to visit on this day, and were able to gather seven farmers in the home of one of them. Although none of them were members of a group associated with beans or with Uyole, four of them were members of animal traction groups linked with the Divisional Extension Office at Wanginjombe. They said they do not have any new beans; they simply recycle their existing varieties. They have not heard of Urafiki/NRI.

Each had a different set of preferred varieties:

- Mhabuka: high yielding; marketable; but requires high rainfall

- Kablanketi: marketable; palatable; requires low rainfall (and can do badly if rainfall is too high); but low yielding
- Nyamuhanga: big size - a few seeds fill the tin; palatable; but difficult to harvest due to its climbing characteristics (they grow beans with maize; this variety climbs up the maize)
- Masusu: marketable; early maturing; easy cooking
- Maini: marketable; palatable; but low yield
- Uyole 96 (grown by one of the farmers got from another farmer in exchange): high yielding; early maturing; but not marketable

(Apparently, Uyole 96 came here five years ago as part of a programme of on-farm trials. It has large seeds, matures early and has high yield; but not marketable in this area because the red soup does not go well with the staple, ugali.)

They expect to get new seed this year, because currently they have no improved varieties. They will take any improved variety. They will get it from Uyole through the extension worker. Once they have planted them, they will be able to assess whether they want to continue using them. They may also buy seed of local varieties from their neighbours.

Their main source of information on beans is Uyole, and from the bwana shamba. There is no Village Information Centre here and they have not seen the laminated information sheets. Their main information needs are seasonal weather forecasts so they know which varieties to plant; new varieties; and market information (prices for different varieties at different locations).

4 Discussion

Several points emerge from the village level findings. There is a strong demand for information about new varieties and associated husbandry practices. Different sources and channels of communication complement one another. Key individuals can play catalytic roles within the information system. The bean programme’s strategy of introducing new varieties through on-farm trials, open days, NGOs and extension officers matches well the farmers’ preference to assess new varieties by visual inspection of the seed and their performance in the field. Organised groups play a pivotal role in the information system, but may also restrict the flow of information in some situations. These points are discussed in the following paragraphs.

The demand for information was evident in all our discussions with farmers. The main categories of information they seek are related to new varieties, markets and control of pests and diseases. They are particularly keen to hear of varieties that will give high yield, tolerate drought and fetch a good price in the market. Disease resistance was not prominent in farmers’ lists of important or attractive characteristics: the impression given is that all beans are equally susceptible and control measures must be taken. This interest in hearing about new varieties is not only found in the groups which have a history of involvement or contact with the beans programme at ARI Uyole: it is widespread among farmers and seems particularly important for those growing beans specifically to sell.

The information sheets provoke a lot of interest and discussion. Their display at Lyadebwe seemed particularly effective: they are on their own – i.e. not surrounded by other posters or notices – and cannot be missed by anyone approaching the door of the village office. Literacy rates in rural Tanzania are relatively high and there is real demand for printed information. The lamination makes them robust when passed from hand to hand. Farmers do like the photographs of the seeds: visual appearance is an initial criterion farmers use to assess whether an unfamiliar variety is of potential interest. For this reason, the photographs should perhaps be larger, without too much potentially confusing superimposition of images. The very act of passing these sheets around a group for their scrutiny can stimulate requests for specific varieties.

But as with much print material, it is easier to find copies of the information sheets in District and Divisional offices than in the village; and they are more likely to be found in the village office than in farmers' homes. Only when print material is available in large quantities, or when farmers have an opportunity to buy it, will it become readily available at village and household level. Evidence that farmers are willing to pay for print material related to beans comes from ARI Uyole's experience of selling leaflets about bean production at the NaneNane show in Mbeya.

Information flow within villages seems fragmented. When information arrives in a village it does not necessarily or automatically flow to everyone in the village. Even when a variety has been in a village for four years, many farmers may not know of it (at least, by name). This is because information flow and communication take place within social networks: people who are not connected either directly or indirectly with someone who is using a new variety may well not hear about it. For the same reason, information can flow between villages through kinship and social ties. However, if we rely solely on these "natural" social flows of information, the process of dissemination will be slow. Part of the task of extension is to speed up the process by helping information move in new ways and to places that will not easily be reached through normal processes of social interaction.

The role of groups here is important. They are a cost-effective means of interaction between scientists, or extension, and farmers. But more than that, they offer an environment of mutual support and learning. Some groups choose to grow new varieties as a group activity, on a single plot of land which then becomes a learning site for the group members and a means of creating awareness and interest among other farmers in the village. Several non-group members mentioned the groups in their village (or indeed in neighbouring villages) as one of their sources of information on beans and bean production. However, groups can also become "closed" networks with little of their acquired knowledge passing beyond the group to others. This is more likely to happen when the group is based in a particular local institution (e.g. a church) and so is not open to non-members of that institution. But it can also be a reflection of local politics and social tensions which have nothing to do with the beans themselves.

If groups are important, so are individuals. The work of the contact farmer in Mbosi District, for example, is a key factor in the spread of improved varieties beyond the on-farm trial villages. He is not a contact farmer in the T&V sense; he is someone whose enthusiasm for improving local farming systems and people's livelihoods, and his ability as a communicator, brought him to the attention of the District extension team and of Uyole scientists. Though he is now compensated for the time he spends away from his farm contributing to the promotion and dissemination of improved beans, the underlying ethos is one of volunteerism. Farmers in the Mbosi villages frequently mentioned him as an important source of information as well as a means of access to seed from ARI Uyole.

Several farmers, unprompted, mentioned radio as a source of information on beans. Others when prompted added it to their lists. Some mentioned specifically that they had heard of Urafiki on the radio. It is well established in mass communication theory that one of the functions of radio and other mass media is to "set the agenda" for local discussion. In the present context, it seems that radio is helping to create a basic level of interest in Uyole varieties in communities which have not been directly involved in the bean programme, and that is stimulating them to find out more. In some communities, however, radio was not seen as an important source either because few households have radios or because they do not regard agricultural information on the radio as relevant to them.

Farmers' decisions whether to adopt a new variety of bean are based on their own assessment of the variety in the local environment. Therefore the most important information and knowledge about the variety comes from observing its performance on one's own land. While information on the radio, in the information sheets, from friends and neighbours, extension officers, NGOs and scientists can arouse interest in the variety, it is crucial that sufficient seed is available so that as many farmers as possible can try it. This does not mean handing out free trial packs: all the farmers we spoke with said that they are ready to pay for new varieties and indeed those who have had seed already, apart from those receiving it for use in on-farm trials, have paid. Stimulating interest in the variety has to go hand in hand with increasing the availability of seed.

This raises the distinction between *information* – i.e. what someone else tells me – and *knowledge* – i.e. what I know to be true. An extension officer might tell a farmer that a particular variety is drought tolerant or disease resistant. Only when the farmer has tried it out will she/he "know" whether it has either of those characteristics in the particular circumstances of her/his own farm.

Where Urafiki has been around for longer, a market has developed (Lyadebwe). So statements in other villages that it is not marketable need not be taken as a serious constraint to further and widespread uptake of the variety. Earlier Uyole varieties have by now found a place in the market: Uyole 96 and 98, for example, can be bought in the market (though farmers are reluctant to use this for seed because they suspect – or can see for themselves – that the beans have been mixed with other less preferred varieties).

One strong message that comes through the discussions with farmers is the high regard they have for the beans programme and for ARI Uyole. It is valued as a source of useful information, as well as of seed of high quality. This credibility as an institution which seeks to serve the interests of farmers by providing planting material and objective information of high quality is an important attribute of a research institute and one that should not be jeopardised by short term constraints of funding and staffing.

5 Conclusion

Farmers acquire information about beans and bean production from several different sources, which complement one another. Farmers' knowledge about varieties, however, comes from trying them out on their own farms. There is a general awareness, probably stimulated partly by radio but also by communication within and between villages, that there are new varieties around that are worth trying out. There is also a widespread feeling that they need access to more information – particularly about markets and the control of pests and diseases. ARI Uyole occupies an important position within the bean information system in the Southern Highlands. For most farmers, however, this is not through direct contact with Uyole but through membership of village level groups and via individuals and organisations who act as intermediaries. In this way, the bean programme can maximise its impact on farmers. At intra- and inter-village level, information flow is somewhat fragmented: a challenge for extension, NGOs and the mass media is how to overcome this fragmentation and facilitate a more efficient flow of information within and between villages.

Annex A

Access to and need for information on beans: checklist of questions to discuss with farmers.

1. Did you get any bean seed in the last one year?

    Which variety or varieties?

    How did you get it?

        (e.g. gift from another farmer of NGO; purchased from market; through farmers' group; from ARI Uyole …..)

    Why did you get the seed?

        (e.g. to try out a new variety; because I didn't have enough seed from last harvest; …)

    Why did you get this particular variety?

2. Have you heard of Urafiki? or NRI lines?

    have you seen it? if so, where?

    have you grown it?

    what do you think about it?

    is it different from other varieties you grow? if so, how is it different?

    where did you get information about Urafiki?

3. Which beans do you prefer to grow?

    what characteristics of those beans do you like?

4. Will you be getting any new seed before the coming season? If so:

    why?

    what varieties?

    how will you get the seed?

5. Where do you get information from about growing beans? e.g. about controlling pests and diseases?

    (e.g. – radio; friends/neighbours; family; posters; …)

6. Is there a Village Information Centre here? if so, what services does it provide?

7. (show the information sheet): have you seen these? where did you see them? what information do they have? how useful is the information ? …

Annex B CPP Research Project R8415 - Farmer questionnaire on access to and need for seed and information

Details of farmer(s): 1. Gender: male female

2. Member of group getting Uyole seed yes no

Access to seed

3. Did you get any bean seed in the last one year? yes no

If "yes": a) Which variety or varieties?____________________________

b) How did you get it? ____________________________

(e.g. gift; from market; through farmers' group; from ARI Uyole …..)

c) Why did you get the seed?____________________________

(e.g. to try out a new variety; didn't have seed from last harvest ..)

d) Why did you get this particular variety? __________________

4. Have you heard of Urafiki? or NRI lines? yes no

a) have you seen it? if so, where? __________________

b) have you grown it? yes no

c) have you given or sold Urafiki to others? yes no

[if yes, how many? __________]

d) what do you think about it? ____________________________

e) is it different from other varieties you grow? yes no

f) if so, how is it different? ____________________________

g) where did you get information about Urafiki? __________________

5. Which beans do you prefer to grow? ____________________________

a) what characteristics of those beans do you like? __________________

6. Do you expect to get any new seed for the coming season? yes no

a) why? ____________________________

b) what varieties? ____________________________

c) how will you get the seed? ____________________________

Access to information

7. Where do you get information from about growing beans?(e.g. – radio; friends/neighbours; family; posters; …)____________________________

8. Is there a Village Information Centre here? if so, what services does it provide?

____

9. (show the information sheets): have you seen these? where did you see them? what information do they give? how useful is the information ? …

____

10. What information do you mostly need about beans and bean production?

____

Appendix III: CIAT Report

Assessment of seed supply and dissemination chains of improved bean varieties in the southern Highlands of Tanzania.

Table of contents

List of acronyms

ADP	Agricultural Development Project
AEZ	Agro-Ecological Zone
ARI	Agricultural Research Institute
ASPS	Agricultural Sector Program Support
BP	Bean Program
BIP	Bean Improvement Program
CIAT	International Centre for Tropical Agriculture
CPP	Crop Protection Programme
DFID	Department for International Development
DRC	D.R. Congo
DRK	Dark Red Kidney
ELCT	Evangelical Lutheran Church of Tanzania
FO	Farm Operations
HIMA	Hifadhi ya Mazingira –Environmental Conservation
LAC	Laela Agricultural Center
LTF	Liuli Trust Fund
LFIS	Laela Farm Input Shop
NGOs	Non-Governmental Organizations
QDS	Quality Declared Seed
SABRN	Southern African Bean Research Network
SHT	Southern Highlands of Tanzania
SPSS	Statistical Package for Social Scientist
SUA	Sokoine University of Agriculture
TAZARA	Tanzania-Zambia Railway
UK	United Kingdom
WFD	World Food Day
NRI	Natural Resources Institute

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Executive Summary

Common bean is grown for household food security and income generation and it has become an important cash earner. Yields are still low due to many biotic, abiotic and socio-economic factors. Preference is also very high among farmers, consumers and markets. ARI Uyole Bean Breeding Program (ARI Uyole BBP) has developed many varieties to address the problems and to meet the various preferences. ARI Uyole BBP produces breeder and foundation seeds of its released varieties. The programme also disseminates varieties through on farm work seed sales and promotional materials in Iringa, Mbeya and Rukwa regions. The programme closely collaborates with government extension, NGO's FBO and CBO to address farmers' needs in improving bean yield through availing seeds of new varieties to farmers.

This study analysed outputs of the set objectives that are to identify bean seed supply chains and to characterize the actors involved including the role of government extension. The study also assessed sources of farmer seeds of new varieties to identify gaps in seed supply chains and to suggest areas of interventions.

The study was conducted in Mbeya, Mbozi and Mbarali districts in Mbeya region, Sumbawanga and Nkasi districts in Rukwa region and Njombe district in Iringa region. I was conducted by staff from Agricultural Research Institute (ARI) Uyole, CIAT/SABRN and Sokoine University of Agriculture (SUA). Purposive sampling procedure was used to select sites (regions, districts and villages) and farmers who grow beans and work with ARI- Uyole BBP directly and or with other partners. Farmers were randomly selected. The study used individual structured questionnaire to interview partner organizations, farmers, traders, and government extension staff.

The study established seed supply chains of improved bean varieties with its key actors which included ARI -Uyole, service providers, farmers and trader. Seed grades used in the chain are breeders, foundation, certified and farmer served seed. ARI -Uyole BBP produces breeders and foundation seeds for use in on farm work and for sell while ARI Uyole farm operation (FO) produces certified seed for sell.

The study found that the current seed supply and dissemination chains do not meet the requirement of the Zone. ARI Uyole can not produce sufficient foundation and certified seeds due to insufficient resources because seed requirements for this vast zone is enormous.

Other actors have not been able to supply sufficient amount of seeds mainly because seed production and dissemination is not their primary mandate. The areas of their primary support are wide so they have less time and expertise to support farmer seed production. Agricultural Sector Program Support (ASPS) has few Quality Declared Seed (QDS) producers whose contribution is very low.

Government extension staff is not directly working with bean seed partners which leave limited or no expertise in seed production. Also in some areas seed of new varieties were not readily accepted due unadapted varieties or are not accepted by farmer and traders. Evangelical Lutheran Church of Tanzania (ELCT) – Mloo which aims to improve livelihood of its members have been collecting foundation seed from ARI- Uyole BBP on loan bases and providing to farmers on loan. Although the church seems efficient, cannot serve a large community. Possible solutions to alleviate seed shortage are to decentralize the production of foundation and certified seed to regions and districts and establish seed production as a business by farmers for effective seed business staff and farmer training is recommended.

Research is advised to release varieties that are adopted and accepted by farmers and traders and these users be involved in all stages of evaluation. The released varieties should also be promoted widely.

1.0 INTRODUCTION

1.1 Background Information

Common bean (*Phaseolus vulgaris* L.) is an important grain legume to farmers and traders in the Southern Highlands of Tanzania for household food security and income generation. Both grains and leaves are consumed at household level or sold, and grains are also saved as planting material. Beans are grown in all districts in the Southern Highlands Zone except Tunduru. The crop is grown in 8 of the 11 agro-ecological zones (AEZ) of the zone and in 40 land forms, which are characterized, by land form, altitude, temperature, rainfall and growing periods.

As of the mid 1990's it was estimated that about 450,000 tons of beans were produced per annum in the Southern Highlands of Tanzania (SHT), of which 20–60% were marketed, both within the zone and to neighboring countries (Malawi, Zambia and DR Congo), but some were sold as far as Kenya (Nkonya et al, 1997; Wortman et al. 1998 and Madata and Mussei, 1998).

1.2 Production problems

Despite the importance of bean crop to the livelihood of most Tanzanians, bean yields are still low due to many biotic, abiotic and socio-economic problems. The crop is susceptible to 6 major diseases and 4 insect field pests depending on environmental condition. As the rainfall period is ever shrinking, the bean yields are affected by moisture stress and insect pest damage. Preferences for bean types vary among consumers, farmers and traders, which resulted into search for diverse but suitable varieties. Unavailability of seeds of improved varieties resulting from limited production and lack of dissemination also contributes to poor farmers' access to improved bean varieties, leading to continued low bean production and failure to meet high demands for beans.

1.3 Bean research work and seed dissemination in the SHT

The bean Breeding Programme (BP) at ARI–Uyole in collaboration with other stakeholders has been able to release more than 10 varieties to meet the demand of farmers, consumers and traders. Among these varieties is Urafiki, which was released in 2003 in collaboration with the UK bean team. The variety was initially disseminated through on-farm evaluations with farmers in some selected villages in all three regions. During this study, farmers and bean grain traders highly appreciated for its high yields, pre and post harvest, desirable traits such as taste, resistance to angular leaf spot, medium maturity, seed colour, size (medium) and tolerance to drought.

These released varieties are however not readily available to farmers, which can be attributed to limited access to seed. Production of breeder, foundation and certified seeds is still limited because seed companies are not interested in seed business of self-pollinated crops. However, ARI–Uyole in collaboration with NGO's, Church Organizations, Government Extension and Farmers have played a major role in filling the gap, to make some seed of improved varieties available. This study aimed at assessing different seed supply chains through which improved bean varieties including Urafiki were made available from ARI-Uyole to farmers through different stakeholders.

1.4 Objectives

This study analysed issues related to variety/seed supply systems with the aim to achieve output from the following objectives.

a. To identify bean seed supply chains and actors involved.
b. To characterize each actor involved in the seed supply chains
c. To analyse the role of government extension and traders in the seed supply chains
d. To trace multiple sources from which farmers access new varieties and estimate the number of farmers who have accessed the seed of new varieties.
e. To identify any gaps in the seed supply chains related to new variety seed interventions and to suggest areas for improvements.

2.0 Methodology

This section describes methods, tools and procedures that were used in the study, which includes description of the study areas, survey and sampling procedures, data collection and analysis. The ARI-Uyole socio-economic unit in collaboration with the ARI-Uyole BP, CIAT-SABRN, Sokoine University of Agriculture (SUA) and agricultural extension staff conducted the survey in the selected villages and intervied partners. The interviews were carried out in December 2005 – January 2006.

2.1 The study areas

The study was conducted in 6 districts: Mbozi, Mbeya, Njombe, Sumbawanga, Mbarali and Nkasi, representing 3 regions: Iringa, Mbeya and Rukwa **(Figure 1-Maps to be included later)**.

In all districts, beans are important and are grown in association with other crops in various farming systems. For example in Mbozi, they use the maize-coffee-bean farming systems, while the other districts (Mbeya, Njombe, Sumbawanga, Mbarali and Nkasi) use the maize–bean farming systems. In most areas beans were grown in two seasons per year. Table 1 presents important characteristics of the agro ecological zones where the study was carried out. In these areas, the altitude ranged from 800 – 2,200 (m.a.s.l) with annual rainfall ranging from 700-2000 mm.

All these areas have good access to transport infrastructure, which enables them to move their agricultural produce to major market centres. For instance, Mbarali, Mbeya and Mbozi are close to Zambia–Dar es Salaam highway, Tanzania-Zambia Railway (TAZARA) and Mbeya city; Njombe is close to Zambia-Dar es Salaam highway, Makambako-Ruvuma road and TAZARA railway while Sumbawanga and Nkansi are close to Sumbawanga-Tunduma road.

Table 1**:** Important characteristics of study areas

Important Characteristics	**Districts**					
	Mbeya	**Mbozi**	**Njombe**	**Sumbawanga**	**Nkansi**	**Mbarali**
Latitude South	8^0 - 9^0	8^0 - $9^{0\prime}$	8^0 - $9^{0\prime}$	**8^0 – 00'**	**7^0 - 00'**	7^0- 9^0
Longitude East	32^0-33^0	32^0 -33^0	34^0 -35^0			33^0 -35^0
Total area (km^2)	**2,646**	9,679	10668			16,000
Population	254897	515,270	420348	373,080	208,497	234,908
Altitude (m.a.s.l)	1000 – 2500	800 – 1800	1200 - 2200	1200 - 1700	1200 - 1700	1000- 1500
Mean annual rainfall (mm)	900 – 2000	800 – 1200	900-1200	700 -800	800 - 950	900
Growing period(unimodal)	November – July	November – May	November – June	November - April	November - April	November - April
Dominant soils	Mollic/Hap	Brownish	Red clay	Shallow, dark	Shallow	Rocky

	lic Andosols	ash, deep red clays	soils, Humic ferralsol, Cambisol	brown sandy loams	dark brown sandy loams	shallow and stony (chromic Cambisol. Eutric cambisol)
Temperature regime (^{o}C)	Isothermic (12 – 23)	Isothermic	Isothermic (12 – 26)	Isothermic	Isothermic	Isohyperthe mic (17 – 28)
Agro- ecological zones	1-Highlands 4f-Songwe Trough	1-Highlands Mbozi plateau 4-High altitude plateau 7-Chunya plains	1c Njombe plateau 3b Northern Ubena plateau Makambako Njombe road	Namanyere – laela plain – (4g)	Namanyere – laela plain – (4g)	3e Usangu flat border Makete Njombe districts
Main crops	Maize, Potatoes, Beans, Coffee	Coffee, Maize, Beans, Rice	Beans,Maize and Sunflower, Tea, Wattle, wheat, Pyrethrum ,P otatoes	Beans, Maize, Sunflower, ground nuts, Finger millet sugarcane	Beans, Maize, Sunflower, ground nuts, Finger millet sugarcane	Rice, beans, Sorghum, Maize Finger millet and bamboo
Livestock	Cattle, Goats, Sheep	Cattle, Goats, Sheep	Cattle, Pigs, Goats, sheep	Cattle, Pigs, Goats	Cattle, Pigs, Goats	Cattle, Pigs, Goats

Source: Mussei et al, (1999) and Census (2002).

2.2 Sampling procedure

Purposive sampling procedures were used to select regions, districts, villages and farmers which grow beans and worked with the ARI-Uyole BP directly or through partners (Table 2). To avoid bias, **farmers were randomly selected. The same procedures were used to select contact farmers working with ARI-Uyole BP and non contact farmers.** If the same random selection procedures were used those sentences need to be merged. Suggestion: To avoid bias farmers working with partner organizations, the ARI-Uyole BP contact[1] and non-contact farmers were randomly selected (Table 3).

Table 2: The villages involved in the bean seed supply chain study - partners organizations. Or partner villages involved in the study on bean seed supply chains

[1] Farmers previously contacted by the ARI-Uyole BP. Non-contact farmers are farmers who were not previously contacted by the BP or any other partner organization involved in the seed supply chain

Region	Partner organization	Partner villages
Mbeya	CARITAS -Mbeya	Ikukwa and Ifumbo
	ARI-Uyole	Iyawaya
	ADP-Mbozi	Ibembwa
	Lutheran church	Ivwanga, Ilembo and Mlowo
	ARI-Uyole farm	SHZ[2]
Iringa	ASPS	Mambegu and Luduga
	CARITAS -Njombe	Igwachanya
	ARI-Uyole	Lyadebwe
	HIMA	Kidegembye, Image and Matembwe
Rukwa	ARI–Uyole	Kipande and Kantawa
	Laela Agricultural Center (LAC)	Mshane and Kizumbi

Table 3: Contact and non contact villages involved in the bean seed supply chain

Region	Contact	Non - contact
Mbeya	Azimio	Kongolo Mswisi
Iringa	Banavanu	Igenge
Rukwa	Nkomolo II and Milundikwa	Ndelema

The sample size for the study was 219 (101 were farmers under partner organizations, 47 were contact farmers, 53 were non-contact farmers, 10 partner organizations, 3 extension officers and 5 traders) Tables 4 and 5.

Table 4: Total number of farmers under partners interviewed

Region	Partner organization	Number of farmers
Mbeya	CARITAS -Mbeya ARI Uyole BP ADP Mbozi Lutheran church	6 10 9 12
Iringa	ASPS CARITAS -Njombe ARI-Uyole BP HIMA	2 10 8 11
Rukwa	ARI-Uyole BP Laela	19 14
Total		**101**

Table 5: Number of contact and non contact farmers interviewed

[2] Provide service to all stakeholders in the Southern Highlands Zone

Region	BP contact farmers	Non -contact farmers
Mbeya	20	20
Iringa	14	20
Rukwa	13	13
Total	**47**	**53**

2.3 Data collection and analysis

2.3.1 Data collection tools

The study used individual interviews to collect information from key actors: ARI-Uyole BP, partner organizations, farmers working with partner organizations, ARI-Uyole BP -contact and non-contact farmers, traders and extension staff. Different sets of questionnaires were developed and used to obtain information from the actors. The questionnaires were pre-tested for validation. Personal observations were also used to triangulate the information collected from partner organizations and farmers in terms of bean varieties accessed and areas planted. We used individual interviews and personal observations to capture the details and individual actors' perceptions of the roles that each actor had played in the bean supply and dissemination chains.

2.3.2 Data analysis methods

The collected data were coded and then analyzed using Statistical Package for Social Scientist (SPSS). Descriptive statistics particularly means, cross tabulations and frequencies were mostly used to summarize the analysed data to obtaine the average quantities of seed supplied to farmers; quantities harvested, sold, retained or shared as seed by farmers. Sources of improved bean varieties and information on these varieties by farmers were also analysed **Inferential statistics were used to measure the statistical significance of sources of information on improved bean varieties by type of farmers (contact and non contact farmers). Our report did not discuss this, so we delete the inferential statistics.**

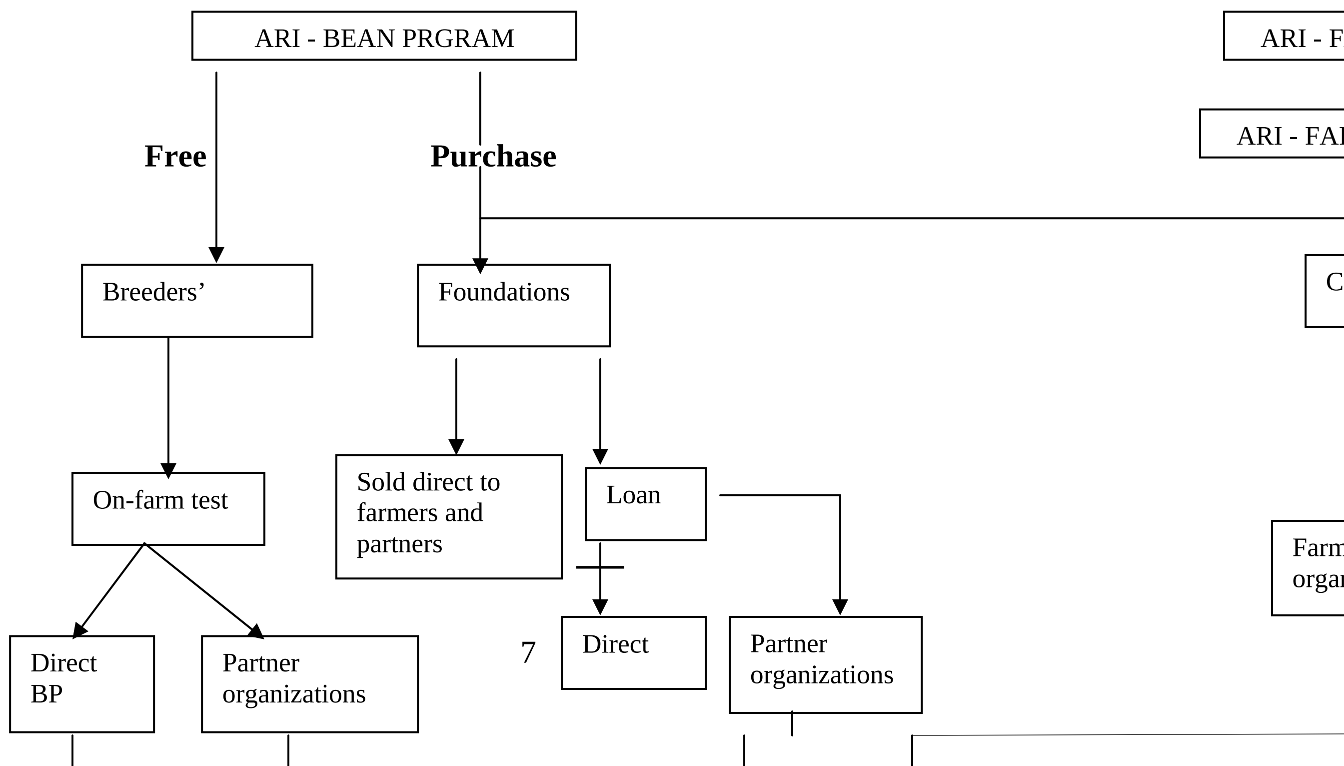
The information collected from partner organizations was summarized into institutional frameworks and used to compare and analyze different actors in terms of their objectives, geographical coverage, seed related skills, past and current scale of seed interventions (types, amounts and grades) and lessons learned. The information on type of bean varieties and amount of seed sold or distributed free for on-farm experimentation from ARI-Uyole BP to different actors was summarized using the EXCEL computer program.

3.0 RESULTS

3.1 Bean variety-seed supply chains and actors involved

A participatory assessment of the bean seed supply chain in the target sites showed that there were several partners, which were involved in the process of disseminating seeds of improved bean varieties from ARI-Uyole BP to farmers. The supply chain analysis also showed that there were three distinct categories of the seed chains (Figure 2). The first category uses free breeders' seed as part of on-farm testing in the variety development process. The second one uses foundation seed of approved varieties which individuals or partner organizations buy or loan directly from BP. The last one uses certified seed which is procured from the ARI-Uyole Farm Operation (FO). All these chains start with ARI-Uyole BP, which provides nucleus seeds (breeders and foundation). Then it is followed by a range of intermediary partners such as government organizations (ARI-Uyole FO, HIMA and ASPS), NGOs (CARITAS-Mbeya, CARITAS–Njombe, ADP-Mbozi, LAC, and Liuli Trust Fund (LTF)), Lutheran Church-Mlowo, farmer groups and traders. Although farmers are end-users of the seeds, it is important to note that they also do play a role in seed dissemination.

Many actors in these seed supply chains played multiple roles. Most partners had been involved in organizing communities for on-farm testing of improved varieties and in the seed dissemination. In addition, ARI-Uyole as an institute had two distinct components whose roles were also different. One component was the BP which supplied breeders' seed of new bean cultivars for on-farm testing and foundation seed for further multiplication or dissemination, either directly to farmers or through partner organizations. The other was the FO which obtained foundation seed from the BP and produce certified seed of improved varieties for commercial sale to interested stakeholders. Many intermediary partners accessed seed of the improved varieties in either one or both grades: breeders' seed for participatory on-farm variety evaluation and foundation seed or certified seed for further seed multiplication and or dissemination, depending on the purpose of the partners' interventions.



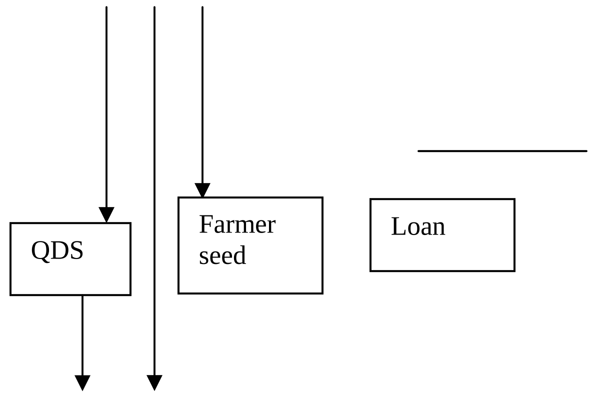


Figure 3: Bean seed supply chains

Partner organisation other than ARI-Uyole who produce seeds are Agricultural Sector Programme Support (ASPS) for Quality Declared Seed (QDS) and LAC (farmer's seed). Many other intermediary partner organisations obtained foundation or certified seed from ARI-Uyole, which they distributed to farmers, to basically produce food. However, farmers saved part of their produce as farmers' seed for sale, to re-plant a subsequent crop or to share with neighbours and relatives. This pattern was applicable to almost all varieties that were captured in this study: Uyole 84, Uyole 90, Uyole 94, Uyole 96, Uyole 98, Uyole 03, Uyole 04, Wanja, Urafiki and BILFA - Uyole.

Various actors in the seed supply chains involved farmers in different ways. The ARI-Uyole BBP involved farmers in participatory on-farm variety evaluation. Apart from farmers' provision of useful information about the varieties to the breeding program, they were allowed to select and keep seed of the varieties of their choice. That helped to spread the seed and information about the new varieties in the communities. The intermediary partners involved farmers differently depending on the objectives of their programmes. Many partners (HIMA, Evangelical Lutheran Church of Tanzania (ELCT) - Mlowo, ADP-Mbozi, CARITAS-Njombe and CARITAS-Mbeya) were mostly focused on dissemination of improved bean seed to boost agricultural productivity for food security and income generation. Farmers or farmer groups were involved as recipients of new bean seed varieties, for them to produce more beans for food, sale and keep some for further planting and sharing with other farmers. LAC and ASPS had seed production on their agenda. However their approaches were different in that ASPS was interested in empowering the communities to produce their own bean seeds. They obtained foundation seed from ARI-Uyole, which was distributed to farmers to produce quality declared seed (QDS). This QDS seed was allowed to circulate within the communities. LAC obtained foundation seed from BBP, produce farmers' seed and sell it to farmers in the communities. As such their intervention operated like a seed production and marketing enterprise.

3.2 Characterization of each actors involved in the seed supply chains

This section characterizes actors involved in the bean seed supply and dissemination chain in terms of their institutional objectives, geographical coverage, experience in seed work and current scale of seed multiplication (crops, varieties and amounts), seed related skills and knowledge enhancement and lessons learned.

The actors in the seed supply chains can be grouped into three distinct categories: research, service providers and end users. These played different roles in the seed chain, but all intended to increase farmers' accessibility to bean seed for food security and income generation. The role of research was to develop and disseminate improved bean varieties through participatory on-farm evaluation. The role of the service providers was to disseminate seed and information of improved bean varieties to different stakeholders, and those end users were to produce beans for food, sale or share with other farmers.

The three categories of actors had different geographical coverage. Research covered all the three regions, CARITAS and ASPS operated at regional level, other service providers operated at one of the three regions (LAC in Rukwa, HIMA in Iringa, ADP-Mbozi in Mbeya). Among the actors involved in the seed supply chain, only ARI- Uyole BBP, ASPS and LAC had training and seed related experiences. Research had seed development, production, dissemination and marketing skills, while ASPS had seed production skills. LAC, ADP-Mbozi and CARITAS Mbeya had some knowledge/experiences in seed production. In addition, LAC has also seed marketing experiences. These actors mostly used their own extension staff to reach farmers they worked with. HIMA and CARITAS Njombe did not have any seed related skills and experiences, but used /collaborated with the government extension staff to disseminate seed, information and train farmers on production skills for improved bean varieties. Nevertheless, all the actors in the seed supply chains also handle other crops. The scale (amount, variety and crops) of seed interventions by the three actors is provided in the following section.

The section below provides a detailed description of each actor involved in the seed supply

3.2.1 ARI-Uyole BBP

The role of ARI-Uyole BBP is to develop appropriate bean varieties through participatory approaches with stakeholders in the SHT. In addition, the ARI- Uyole BBP has to ensure that farmers have access to seeds of new varieties. In this regard they are engaged in catalyzing the process to multiply, disseminate and promote bean-based technologies with stakeholders. As such the ARI- Uyole BBP multiplied breeders' seed for the test cultivars and foundation seed for approved bean varieties. The breeder's seed is supplied free to partners and farmer groups that participate in on-farm evaluation, while foundation seed is sold at commercial value.

To-date, the seed interventions skills and knowledge enhancement of the BBP in collaboration with other ARI-Uyole departments have contributed to the development, multiplication and distribution of potential bean varieties for different agro-ecological zones in the SHT, which include: Uyole 84, Uyole 90, Uyole 94, Uyole 96, Uyole 98, Uyole 03, Uyole 04, Wanja, Urafiki and BILFA-Uyole **(Appendix…..).** Three major mechanisms are used for seed distributed directly to farmers or through partner organizations by BP, which include free, cash or seed loan**.**

Free seed distribution

a) From mid 1980s through early 1990s the BP distributed free seed in small quantities to farmers in different villages as starter-up seed for multiplication. However, this distribution mechanism was perceived to be expensive and not sustainable. **The other** problem was that the small quantities were perceived by farmers to be too little and free. Such that farmers did not attach value to it. Most farmers often consumed it all in the process of testing the variety for cooking and taste qualities.
b) Through participatory variety evaluation with farmers small quantities of different bean varieties were supplied for experimentation to verify their adaptability, yield performance and acceptable quality characteristics. Apart from direct distribution to the BP contact farmers the programme also distributed free seed to partner organizations that facilitated farmer participatory variety evaluation.
c) Through agricultural shows – Nane-Nane and the World Food Day (WFD), different released and promising varieties were displayed. The released varieties were promoted in these national shows, where some free samples (400 g) were distributed to farmers that showed interests as a way of creating awareness of new varieties.
d) The BP also distributed free seed to farmers who attended different seminars on improved bean production technologies.

Seed distribution on cash sales

The BP sold bean seed directly to different stakeholders in the SHT. Farmers form a large percent of the number of clients that buy seed directly from the BP. The BP sometimes facilitates the transportation of bean seed to farmers particularly in areas where the programme has research interventions. This is usually combined with their research activities. Other farmers collect their seed directly from ARI – Uyole, which turned out to be expensive particularly for the farmers from far distant places, and those had bought small quantities of seed. The BP also sold bean seed to partner organizations that in turn multiply or distribute the seed to farmers they work with. These organizations include agricultural district extension offices, ADP-Mbozi, HIMA project, ASPS, LAC, Liuli Trust Fund (LTF), CARITAS and Evangelical Lutheran Church of Tanzania (ELCT) – Mlowo. In addition, during national agricultural technology promotion functions (Nane-Nane and the WFD) the BP sold seed to farmers that show interests in specific varieties.

Seed distribution on loan

This kind of seed distribution mechanism was tried on a limited scale with a very few partners. In 2003 the BP tried to distribute 500 kg of seed on loan to farmers through one intermediary institution in Mbozi and 700 kg to another institution, the LTF in Mbamba Bay. However, recovery of loans had been very poor due to lack of commitment of partners to repay the loan. This led the BP to stop providing seed on loans to these intermediary partners. However, they now have confidence in a church based organization - ELCT-Mlowo, which gets seed from BP on loan and their repayment rate has been good. After obtaining seed loan from BP the ELCT-Mlowo sold or loaned the seed to individual farmers in the communities preferably to their church members.

a) ARI-Uyole farm operations

The FO is the institute’s arm, which has the mandate to multiply certified seed of improved varieties for various crops developed by ARI-Uyole. Major crops include beans, soybeans, maize and wheat. Initially, FO multiplied Kabanima, U94 and U96. Over the years, they have included (U98, U03 and Wanja). This year they will start producing Urafiki. The FO obtains foundation bean seed from the BP, which is used to produce certified seed. They also produce grain as part of their rotation system on the farm. The FO sells certified seed and grain through the farm store to different stakeholders from all over in the Southern Highlands. The FO also collaborates with the BP to promote and sell bean seed to various stakeholders during national agricultural shows (Nane Nane). The Table 6 indicates the quantities of bean seed that were multiplied, packed and sold by the farm to different clients during the 2004/05 planting season.

Table 6: Amount of seed crops multiplied by the ARI Uyole farm during the 2004/05 planting season

Crop	Variety	Amount (kg)
Bean	Uyole 94	17,500
	Uyole 96	46,000
	Uyole 98	7,000
	Uyole 03	4,800
	Wanja	4,100
Soybean	Uyole Soya1	2,100
	Bossier	7,200
Maize	Uyole Hybrid 6303	28,830

c) Hifadhi ya Mazingira (HIMA) – environmental conservation project

The project started its activities in distributing seed to bolster food production from 2000 through 2002 in two divisions of Njombe district. The objective was to offer farmers a wide range of improved crop varieties, which included maize and beans. In beans the strategy was to involve farmers in experimentation with new varieties under their own farm conditions. As such, farmers were given little amount of seed of each variety. The types of varieties distributed to farmers were U96, U98, U90, U84 and Kabanima. HIMA obtained foundation seed for these varieties from the BP and distributed it to farmers who then produced food but saved part as planting material for the subsequent crop. This process started with 20 kg in the first year and increased to 800 kg of foundation bean seed in the final year. Individual households received about 0.5 kg and overtime the project had reached more than 7000 farmers. By the end of the project some households had raised enough seed, which enabled them to plant up to 1.5 ha of land using seed of improved bean varieties.

HIMA project did not have seed related skills or experience, but used government extension staff that had general knowledge on crop agronomy. Since the project ended in 2002, there are no longer specific seed interventions activities in the areas, although farmers still maintain bean varieties for their own food production and marketing.

b) The Evangelical Lutheran Church of Tanzania (ELCT)

The ELCT aimed at improving farmers' agricultural knowledge for increased food security and income generation. The church engaged in seed interventions in 2003, to facilitate farmer participatory variety evaluation processes, and to disseminate bean seed of improved varieties to farmers. The church obtained free breeder seed from the BP for participatory variety evaluation. The foundation seed was obtained on loan, which was either sold or loaned to farmers to produce beans for food. However, farmers were allowed to save saved part of their harvest as planting material for the next crop. The quantity of seed purchased by each farmer was determined by the ones purchasing power. Some farmers could buy up to 200 kg of seed, particularly of Uyole 96. The other varieties included U98, U04, Wanja and Bilfa. Table 7 indicates the quantities of seed for each variety they supplied over the past three years.

Table 7: Quantity of bean varieties supplied by Lutheran church (2003-2005)

Variety	**Amount (kg)**		
	2003	**2004**	**2005**
U96	1,200	800	2,500
U98	300	200	100
U04	-	-	100
Wanja	100	100	200
Bilfa-Uyole	-	100	-

The church still continues with seed interventions focusing on U96 (2,500), U98 (100), U04 (100) and Wanja (200). The results indicate that the church has reduced the amount of U98 supplied to farmers because farmers perceived that U98 is less marketable, but very palatable. The church does not have any seed related skills or experience, nor does it provide any knowledge enhancement to farmers who produce beans for food or save part for seed. Nevertheless, it helps its church member and other in the community to access seeds of improved bean varieties. Already this intervention has reached more that 100 beneficiaries in the area.

c) Laela Agricultural Centre

LAC is another church based organization whose objective was to contribute to the improvement of agricultural production and income through farmers' increased access to markets. Their operations were limited to Laela Parish which covering approximately 25 villages, where they were able to reach more than 500 households. The activities covered a number of crops which included hybrid maize, soybean, finger millet, sunflower, horticultural crops and beans. In beans, they facilitated farmer participatory variety evaluation and supported seed increase of the selected varieties. LAC obtained free breeders' seed from BP for farmer participatory variety evaluation activities, and the harvest from selected varieties was increased and shared among participating farmers, who in turn used it to produce beans for food or sale or saved part as planting material. In addition to organizing farmers to participate in variety evaluation, LAC also provided training services to communities in agricultural production.

LAC had another seed intervention activity where they operated a seed production program as an agro-enterprise. They had a farm, where part of the land was devoted to seed production of different seed crops. For example they planted bean varieties (2 ha), maize (20 ha) and soybeans (0.5 ha) annually. For beans the bought foundation seed from BP and produced non-inspected (farmer) seed. The major bean varieties included U94, U96 and U98. The seed multiplied from their on–station farm was sold directly to farmers through Laela farm inputs shop. LAC did not have any seed related or seed knowledge enhancement skills *per se*, but had crop production (agronomy) and plant pathology skills that helped the centre in the production and management of various seed crops.

Table 8: Amount of bean varieties supplied by LAC (2002-2005)

Variety	**Amount (kg)**			
	2002	**2003**	**2004**	**2005**
U94	600	360	-	-
U96	960	1800	1680	360
U98	1200	1800	2160	600

The seed multiplication and marketing interventions are on-going, and currently they are working with two bean varieties U96 and U98, maintaining the same amount of land (2 ha) that they plant to beans. This is after dropping other bean varieties like Kabanima, U84 much earlier, because there was limited demand for these varieties from farmers, while U94 was last produced in 2003. The explanation for limited demand for Kabanima and U84 could be that farmers already had seeds of these varieties. It is shown in the adoption study which was conducted ARI-Uyole in 2002, that U84 had 50% adoption rate in Sumbawanga district, Mussei *et al*., (2002).

d) Agricultural Development Project (ADP) – Mbozi

The objective of ADP Mbozi was to promote sustainable agriculture by supporting farmers to access improved agricultural technologies. ADP Mbozi started seed distribution activities in 2002, operating within Mbozi district, reaching more that 450 households. They had some trained staff (graduates) with some seed related skills who attended seed technologies courses at University level. These graduates also had experiential knowledge in seed interventions. The project purchased foundation seed from BP, which was disseminated to farmers through direct sales or loans. For the first and second years of the project interventions, focused only on bean varieties: U96 (3,500 kg), U98 (1,400 kg) and Wanja (4,100 kg) **(**Table 9). Individual farmers purchased or received seed loans from 5-10 kg, which the used to produce beans for food and saved part as planting material. Currently ADP Mbozi has expanded seed interventions to include maize (3000 kg), sunflower (1200 kg), Sesame (200 kg) and paprika, but is not distributing bean seed to farmers during the 2005-06 crop season. They just stopped distributing bean seed to farmers in 2004-05, because the project perceived that farmers had accessed enough seed from there previous interventions. They believed that the seed which is in the community will keep on circulating (farmer-to-farmer) through the farmer seed system.

Table 9: Quantity of seed supplied to farmers over the past four years

Variety	Amount (kg)			
	2002	**2003**	**2004**	**2005**
Uyole96	900	100	2,500	-
Uyole98	500	500	400	-
Wanja	600	1,000	2,500	-
Maize	-	-	3,000	-
Sunflower	-	-	-	1,200
Simsim	-	-	-	200

e) CARITAS

CARITAS is a Non Governmental Organization that aimed to facilitate community development through improved crop and livestock production. The ARI-Uyole BBP involved CARITAS only in Mbeya and Iringa, which were both involved in the bean seed supply chain.

Initially the BP provided breeders' seed to farmers working with CARITAS Njombe for on-farm bean evaluation. After farmers selected the bean varieties, they moved on to seed distribution. The seed distribution started in 1999, with beans, which they obtained from the BP as foundation seed (100 kg). By 2000, they included such other crops as sunflower (300 kg), soybeans (100 kg) maize (400 kg) but maintained beans (100 kg). For beans they focused on U94, U96, BILFA-Uyole and Kabanima, and distributed the seed through the village governments. The village governments were formed from representative farmers' groups that worked with CARITAS Njombe. Individual farmers in the groups purchased or received seed on loan through the village government to produce beans for food, but farmers saved part of the produce as planting material. It is worthy noting that seed loans were only provided under circumstances where a farmer could not purchase seed on cash basis. On average, individual farmers accessed about 3kgs of seed through the intervention. Currently the program continues with seed distribution activities in 12 villages in the area where they operate. However, the NGO stopped distribution of bean seed after 2000, because they changed their mode of operation. In the beginning the NGO provided seed distribution service to farmers for bean varieties selected during the on-farm evaluation. Farmers perceived that these selected varieties were not suitable to their condition. CARITAS now encourages farmers to come up with the type of seed that farmers need.

The Mbeya program started later (2000-02) and focused on maize and a new sorghum variety (Pato). The NGO started distributing bean seed in 2004-05, concentrating on three varieties, U96, U98, and Wanja, which were distributed in both crop seasons (short and long rains). In the first season CARITAS Mbeya started with 24 kg of foundation seed for each bean variety, which they obtained from the BP, and increased the supply to 50 kg for each bean variety in the second season. Individual farmers and farmers in groups received 1-2 kg of seed of each variety on loan, which was to be repaid in-kind by passing on the same quantity to another farmer after harvest. The seed distribution mechanism was basically for increased farmers' access to seed of improved varieties. Most farmers used the harvest as food but saved part as planting material. The programme operates in seven villages in Chunya district and has reached more than 130 households. Their scale of seed interventions have expanded to include sunflower, maize, Sesame and paprika, while maintaining the same bean varieties: U96, U98 and Wanja.

The NGO had no seed related skills when the project initially started in Njombe district, but had its extension expertise to facilitate, organize farmers and enhance farmers' knowledge in food production. CARITAS Njombe also advocated seed sharing among farmers. Hence, the new seed interventions in Mbeya has not only borrowed from seed intervention skills from Njombe, but also employed a seed technologist who is in charge of seed interventions.

e) Agricultural Sector Program Support (ASPS)

This was a donor funded bilateral program with Tanzania government that had adequate resources (capital, transport, seed knowledge/skills) and explicitly involved the national institutes (research, extension and seed regulation) in its activities. The objective of this program was to train farmers on how to produce improve seed of various crops for them to have increased access to new varieties. This was a national program that covered all regions of Tanzania focusing on specific or potential crops for each region.

For this study, in Njombe district the program operated in Makambako division covering two villages Luduga and Mambegu. The activities started with participatory on – farm evaluation where farmers experimented with eight bean seed varieties. Out of the eight varieties farmers selected U96 for further increase. ASPS then obtained foundation seed for U96 from the BP and distributed 36 kg of seed free to one farmer in each village (Mambegu and Luduga). These farmers used foundation seed to produce Quality Declared Seed (QDS) under government extension supervision. The farmers and extension staff received training in seed related skills. In addition extension staff were also trained on how to organize farmers for community seed multiplication scheme.
Every year the two farmers combined produce 860 kg U96 QDS, which they sold to other farmers after retaining 36 kg each for further multiplication. This program is still on-going and the two farmers still plant 36 kg of U96 each for further seed multiplication twice annually. These two farmers service a community with 320 households in the two adjacent villages.

Role of government extension in the seed supply chains

Generally, every village is expected to have an extension worker. But in time of shortage of extension staff one person can cover more than one village. The government extension through village extension staff plays significant role in the technology dissemination. Their expected roles in the agricultural technology dissemination include:

- Participatory problem identification with farmers
- Organizing farmers to produce different improved crops
- Linking farmers with researchers and other stakeholders such as marketing institutions
- Advising and training farmers on crop management, harvesting, storage, diseases and pest control for increased food security
- Dissemination of information on new seed varieties through different extension methods and materials
- Promotion of seed varieties through demonstrations and farmers field schools
- Providing feedback to researchers and farmers on different seed varieties

This study identified the following practical roles of government extension in the seed supply chains:

- Participatory on-farm variety/technology testing and evaluation with farmers
- Promotion of improved bean varieties through demonstration and field days, the world food day and national agricultural shows (Nane-Nane)
- Advise farmers on multiplication and dissemination of bean varieties within partner villages and to farmers outside the partner villages
- Advise bean farmers on where to obtain seed
- Advise farmers on proper management /agronomic practice for bean production
- Providing feedback to researchers on preferred traits, adaptability and market potential of bean varieties.

This study found that some extension staff managed to play all the above practical roles in the seed supply chain, for instance in Rukwa region. Farmers in Rukwa were better organized and sensitized, in such a way that they were able to demand/produce seeds of improved bean varieties. However, in some areas the extension staff failed to play their effective roles in the seed supply chain due to limited resources or lack of involvement in the seed supply chain. For instance HIMA in Iringa, which was a bilateral project between DANIDA and the Government of Tanzania, even after obtaining sufficient quantities of foundation seed of bean varieties from the BP, they failed to distribute them fairly to farmers. Farmers received very small amounts of seed to plant, and most of them lost the seed of the new varieties due vagaries of weather (drought or too much rain). As such many farmers did not benefit from the program.

ROLE OF TRADERS IN THE SEED SUPPLY CHAIN

It is important to note that traders were mostly involved in farmer seed, which is the same as grain. Several traders were engaged in beans and other crops depending on the season. Most of these traders had storage facilities where they kept their stocks. This enabled them to buy in bulk when the commodity was plenty at the farm gate price. After storage they sold the commodities at higher a price when the supply was lean. This usually coincided with the planting time. In special cases, some traders like in Uyole market were very specific on the commodities they stocked. These were specifically bean traders, and stocked different types of varieties including U94, U96, U98 and Wanja. They also had local varieties and some mixed beans.

However, the study identified three traders who were involved in the other seed grades in the seed supply chain. These were FO, Laela Farm Input Shop (LFIS) in Sumbawanga and farmers traders in Luduga and Mambegu villages in Njombe district. The FO sold certified seed, farmer seed traders sold QDS and LFIS sold farmer seed. The LIFS farmers' seed is put in a different class because it produced an institution which follows all the seed production regulation, only that the seed is not inspected. This is because seed inspection is an extra cost, but also farmers do not demand inspected seed. The traders also have roles which include promotion, advising farmers on crop production. LFIS also provides advice on storage, pest and disease management.

This study has realized that the role of traders in the bean seed supply chain is very limited, particularly in other seed grades than farmer seed. This is due to the fact that bean crop is self-pollinated and most farmers use own saved seed or buy from fellow farmers and open markets as food/planting material (Tables 10 and 11). However, there is potential to enhance the role of traders in areas where seed of improved bean varieties are unavailable, for instance in the non-contact villages. The role of traders may also be enhanced if traders were explicitly involved in variety development, promotion and dissemination, so that they provide a guaranteed market to farmers. This entails that traders should be equal partners in the seed supply chain.

Multiple sources of improved bean seed varieties

This study found that farmers had multiple sources for improved bean seed as presented in Table 10. **G**enerally most farmers indicated that they obtained seed of improved bean varieties from partner organizations particularly ARI Uyole. The multiple sources of seed varieties were highest in U96 (10 sources) and U98 (7 sources). Only few farmers reported to get seeds from extension staff, market, fellow farmers and District extension office. Regarding sources of seed among farmers under partner organizations it was found that 28.6% of farmers obtained U94 from ARI-Uyole and CARITAS – Njombe, U96 from ARI-Uyole (48.3%), U98 from ARI-Uyole (35.5%), U03 from Laela agricultural center (43.5%), U04 from Laela agricultural center (67.7%), Wanja from ARI Uyole (58.8%), Bilfa from Laela agricultural center (68.8%), U90 from Hima (100%), U84 from Hima (57.1%)**,** Kabanima from ARI-Uyole (52.9%), CAL 143 from ARI Uyole (100%) and Rosecoco CARITAS – Njombe (100%).

For contact farmers major sources of improved bean seed varieties were from ARI-Uyole (51.7%), followed by extension officers (34.5%). Where as for non-contact farmers the major sources were fellow farmers (57.1%) followed by ARI-Uyole (42.9%). Relatively few contact farmers indicated other sources of seed which were HIMA, fellow farmers, Ichenga research and Nkundi (ARI - Uyole sub station) with 3.4% each (Table 11**).**

Table 10: Sources of improved bean seed varieties among farmers under partner organizations

Source	U94 N = 21	U96 N=58	U98 N=40	U03 N=23	U04 N=3	Wanja N=34	Urafiki N=20	Bilfa N=16	U90 N=5	U84 N=7	Kabanima N=17	CALI43 N=4	Rosekoko N=1
ARI Uyole	28.6	48.3	35.5	39.1	33.3	58.8	65	25	-	42.9	52.9	100	-
Caritas -Njombe	28.6	1.7	-	-	-		-	12.5	-	-	-	-	100
ADP Mbozi	19	8.6	7.5	-	-	20.6	-	-	-	-	-	-	-
Hima	19	15.5	-	-	-		-	-	100	57.1	23.5	-	-
Lutheran Church	-	6.9	7.5	13	-		10	-	-	-	-	-	-
Laela	-	1.7	25	43.5	67.7	29.4	35	68.8	-	-	23.5	-	-
Caritas-Mbeya	-	10.3	15	-	-	17.6	-	-	-	-	-	-	-
ASPS	-	3.4	-	-	-		-	-	-	-	-	-	-
VEO	4.8	1.7	2.5	-	-		-	-	-	-	-	-	-
Market	-	1.7	-	-	-	2.9	-	-	-	-	-	-	-
Fellow farmers	-	-	2.5	-	-		-	-	-	-	-	-	-
District extension office	-	-	-	4.3	-		5	-	-	-	-	-	

Table 11: Sources of improved seed among contact and non-contact farmers

Source	Farmer type			
	contact		Non- contact	
	N	%	N	%
Uyole	15	51.7	3	42.9
HIMA	1	3.4	0	0
Fellow farmers	1	3.4	4	57.1
extension worker	10	34.5	0	0
Uyole and Ichenga training center	1	3.4	0	0
Nkundi sub-station	1	3.4	0	0

GAPS AND SUGGESTED AREAS OF IMPROVEMENT IN THE CHAIN RELATED

The breeding program is doing a good job in involving different partners in the variety development process, but they would do much better if they included traders' at the very beginning all the way through the seed supply chain.

Participatory selection, routine market information from distant major towns and the information has to be linked to the partners. Sensitize farmers to influence policy markers on bean export in regional markets or bilateral countries to improve the market which in turn can stimulate seed production.

The BP should consider marketing component in the breeding programme so that the released varieties are accepted by traders. Bp should also come up with varieties of high nutritional quality, and processed marketable products. This will enhance more consumption of beans, marketing and production. The BP should develop promotional materials on bean varieties and recommended technologies and disseminate them to all actors and users.

The capacity of BP is not enough to supply all the foundation seed that may be required at sufficient levels for the Southern Highlands of Tanzania. A policy of decentralized foundation seed multiplication in each region and or in each district is required to improve production of certified or common grade seed (farmer seed)

The intermediary partners are playing a major role in dissemination of improved bean varieties. The government extension did understand their role in seed dissemination, but they were limited in terms of resources. Government should support extension with resource to enable them to participate in seed production and dissemination and work together with other partners.

Other partners are not doing enough in seed dissemination, because most of them did not clearly understand that it was their responsibility to do so. There is a need to sensitize the partners to work more in seed production and dissemination. They can also sensitize the farmer to engage seed production as business and involve government extension staff to assist in seed production technology and business. Capacity building is needed in seed business at all levels

5) DISCUSSION

Research

The mandate of the ARI-Uyole BBP programme was to develop new acceptable bean varieties and maintain breeders' seed. The strategy is to offer farmers a broad rand of improved varieties for farmers to maintain biodiversity. This is being achieved by releasing several improved varieties to farmers a wide range of improved varieties. The ARI- Uyole BBP has gone beyond their expectations to fill in gaps in foundation seed production, promotion of improved varieties and building farmers' capacity. The added assumed responsibilities, which were also expectations of donor-funded projects, tended to over stretch the ARI- Uyole BBP. For example, currently it is only the ARI- Uyole BBP that produces foundation bean seed which feed into the certified bean seed programme at ARI-Uyole FO, as such this is the only source of start-up material for improved bean varieties in the SHZ. It is reported that the total bean production in the SHZ is 450000 mt (Ref), which translate to 450000 mt of farmer seed. To get this quantity of farmer seed in improved varieties ARI-Uyole should produce 4,500 mt of foundation /certified seed, which is a mammoth task that ARI-Uyole a lone cannot fulfill. The major limiting factors had been lack of adequate resources (infrastructure, personnel and financial). In addition, more partners need to be involved including the Directorate of Crops Development, which has to take the central role and get committed to get seeds of improved varieties to farmers. This might require a clear policy to indicate the roles and responsibilities of the departments and partners in the seed production and dissemination chain. The policy should also advocate decentralized seed systems where various stakeholders including private sector, NGOs CBO FBOs and farmers can participate in the seed production and dissemination processes.

Although the research is filling in the gaps in seed with extension as collaborators, the extension role in seed development and dissemination is still limited. This study found that extension staff understood better their normative roles in organizing farmers and promotion of new varieties, but their actual responsibilities to get involved in seed production and seed dissemination were not clear. It is important to note here that in Tanzania it is the Department of Crops Development, which includes the Department of Extension that releases new crop varieties, but there are no clear mechanisms to ensure that required quantities of foundation and certified seed of the new varieties are made available.

The mechanisms for seed dissemination had not been adequate to reach sufficient number of farmers in the SHZ. The PB only covered a few districts targeting pilot areas. As such there is a need to scale up and out the dissemination process to cover other areas in the pilot areas as well as other districts in the SHZ. The innovative seed system which is used by ARI-Uyole ARI- Uyole BBP enabled them to produce foundation seed in a sustainable manner, because it is a cost recovery system, and that money goes into the seed revolving- fund. However, some farmers and other stakeholders particularly those from distant places found that the purchase of seed directly from ARI-Uyole was expensive, if they bought in small quantities. This also emphasized the need for decentralized seed systems.

ARI-Uyole is also using different mechanisms to promote and disseminate information on improved bean varieties. These include leaflets, posters, radio programmes, seed displays, seed and live plant samples at Nane-Nane national agricultural shows and the WFD.

Although ARI- Uyole BBP is doing a good job in involving farmers in on-farm variety evaluation, their experiences in working directly with farmers indicated that changing farmers' attitudes to adopt improved varieties was a major challenge. This was because farmers did not consider seed supply and dissemination as part of their core responsibility, which limited the seed dissemination to wider community. Similarly, the ARI- Uyole BBP faced major challenges with collaborating partners in the seed supply processes. This was because to many partner organizations, seed supply was not their mandate, but they assumed responsibility to fill the gap. All these, led to poorly coordinated activities, and limited seed production and publicity of the new bean varieties

Service providers

Service providers played a major role in supplying seed to farmers. Some of the service providers for instance, ELCT and LAC had stimulated demand for improved bean seed for some varieties to the extent that demand had surpassed the supply. It is however, noteworthy that once farmers have seed of new varieties in their farmers' seed systems, the demand for such varieties goes down. One good example is the lesson extracted from LAC on U84 and Kabanima. In Rukwa, U84 and Kabanima were disseminated by ARI- Uyole BBP from late 1980s. When LAC started bean seed dissemination programme they included these two varieties among others. They however, got discouraged because farmers did not buy seeds of U84 and Kabanima, but U96 and U98. This led them to stop U84 and Kabanima, but farmers were still growing these varieties and they were popular in the communities – "the power of farmers' seed systems". Therefore there is a need for diversification if one has to take seed multiplication as a business – "One cannot build a seed enterprise based on a single variety" particularly for self-pollinated crops.

From this study we found that farmers particularly under partner organizations had accessed most of the new varieties from ARI-Uyole. However, some varieties (U96 and U98) had more number of sources (partner organizations and fellow farmers) where farmer obtained their seed. These varieties ranked highest in terms of number of farmers who responded to have produced them. Farmers' preferences to these varieties were not only due to their adaptability to different environments, but also their market potential. Hence, many partners, found it easier to facilitate dissemination of these varieties.

Only few partners had their own trained extension staff that could provide proper backstopping for seed production initiatives. These included CARITAS-Mbeya and ASPS. Others relied on general agriculturalist that also had other responsibilities and could not cover the seed aspects in full, because they were over stretched. For example, the LAC extension officer who was involved in seed interventions also had other obligations to deliver within Laela Parish, which covered 25 villages. This made follow-up on bean multiplication activities rather difficult. Others partner organizations relied on government extension staff that provided backstopping in general crop production and management practices. In general, the government extension staff were not adequate to meet their own staff requirement - one village extension worker per village. They also lacked capacity and resources to provide proper backstopping in farmer seed production initiatives. Although government extension staff complained that they had no resources to support seed dissemination, our analysis however, indicated that there was lack of commitment of extension staff in the seed supply chain. In addition, some farmers did not understand the role of extension staff and such that they did not even appreciate their interventions, as such they were unable to demand services from them. They don't have well defined roles and responsibilities in seed supply chain-no targets to deliver**.** There is need to have defined these roles and responsibilities to extension staff in the seed supply chain.

The participatory variety selection (PVS) process is a novel idea that led to the identification of potential bean varieties that met farmers' selection criteria. However, often these PVS processes are conducted by a limited number of farmers in localized pilot sites. Sometimes these pilot sites may not be representative of all sites in the production environment. As such there is need to have more farmers involved and possibly more sites. For example, the experiences from CARITAS-Njombe showed that the varieties that were selected by a few farmers in the pilot sites were not accepted by other farmers who did not participate in the initial evaluation process. This implied that selections made by a smaller group of farmers did not represent the choices of other farmers in the communities where CARITAS-Njombe operated.

There were considerable variations in the strategies and operational arrangements of the intermediary partners with extension staff in the seed supply chains. Most of the organizations were either part of or did involve government extension staff at grass-root level in their operations. Some programmes were well structured **s**uch that they had exit strategies for continuation of the activities after the programme lifespan. One good example was the ASPS in Iringa, which had trained staff and farmers to continue to produce QDS. Others like HIMA which was also in Iringa were not well designed to the extent that there were not able to continue with the operations after the programme had ended. These two programmes were both funded through bilateral support between DANIDA and the Government of Tanzania, and they operated under the Directorate of Crops Development (DCD). Both of them had adequate resources to support seed multiplication by farmers, but ASPS had more capacity development programmes that empowered farmers and service providers, which was a good exit strategy. HIMA possibly did not have a proper exit strategy, hence failed to continue after the programme ended. The interviewed extension staff perceived their failure to continue with the interventions was due lack of resources (transport and funding). Based on the fact extension staff in these two programmes worked under the same Ministry, lack of resources could not be the major factor. Possibly lack of commitment and unnecessary expectations could be the major reason.

Generally, from ARI-Uyole experiences in working with different partners, we found that there were no proper working relationships among some partners involved in the seed supply chain. To some this relationship was not clear, reliable and sustainable. To some partner, the working relationship was found to be reliable and sustainable to support the on-going seed interventions. For example, ELCT-Mlowo, has been effective in supplying seed to different communities they work with, and even to farmers working with other church organizations, for instance Anglican – Mbozi. They have also repaid most of their seed loans from the ARI- Uyole BBP. This calls for proper mechanisms by the ARI-Uyole BBP to effectively capitalize on and actively involve faith based organizations (FBOs) and use their opportunities to sensitize communities where they work to form groups for seed, grain and marketing of beans. For some partners, there was lack of clear working relationship, for instance, ARI- Uyole BBP with CARITAS –Njombe. Generally, lack of clear working relationships among partners has also contributed to limited/constrained sharing of information and experiences on seed interventions among partner organizations, and their effectiveness to deliver seed technologies to farmers. This, calls for better coordination and information sharing among actors in seed supply and dissemination chain. For effective seed interventions there is need for proper policy.

Farmers

Farmers appreciated the skills and knowledge they gained from ASPS seed production programme, which empowered them to multiply and sold seed to other farmers in the communities. However, they found the isolation distance for seed production as a major challenge to farmers involved in the production of QDS, which is not correct because as a self pollinated crop beans do not require a wider isolation distance. This implied that farmers and or extension staff did not adequately capture or were not adequately trained on the appropriate requirements for bean seed production. Another example, which is similar, was captured among farmers in Njombe and Mbozi districts who did not know that bean seed is a self pollinated crop and that their seed could be recycled.

Despite the fact that many varieties had been released by the ARI- Uyole BBP, many farmers including ones from the villages that were contacted through partner organizations, or had direct contact with the ARI- Uyole BBP and the non-contact did not access the varieties in the SHZ. In some villages, for instance, Igenge (Iringa) farmers from the non-contact villages did not know where to source seed of improved bean varieties – which is expected. However, unexpectedly the pattern was similar in the contact villages, implying that the circulation of seed and its information was limited. We expected that contact farmers could have circulated the seed they had accessed from the ARI- Uyole BBP to fellow farmers. This implied that there was limited farmer-to-farmer dissemination of improved bean varieties. Possibly this was due to farmers' tendency to be conservative with new varieties –not willing to share.

Equally, the purchase of small quantities of seed by farmers was found not to be adequate for further dissemination or even for their own use. This could be another factor for limited farmer-farmer seed exchange. Even if they had harvested enough, they would have sold it as grain soon after harvest because many of them are not empowered to keep their harvest and sell it as seed during the planting season. As a result, some of these farmers had continuously returning to ARI-Uyole to buy the seed. All these call for more partner stakeholders who are committed to get involved in the seed production dissemination processes and to scale-up and out the positive lessons generated from the current initiatives in the pilot sites. Participatory stakeholders planning for implementation of the seed systems would be an important empowering tool for them to take seed production and dissemination as their mandate. Their roles and responsibilities need to be spelt out clearly for them to be committed to deliverable.

The PB had used different methods such PVS, demonstrations and promotion functions to sensitize farmers they worked with to actively participate in the seed dissemination. Despite the efforts, this study found that farmers particularly in the wider groups of the communities were not actively involved in the seed interventions. Farmers particularly those in partner and ARI–Uyole BBP contact villages were not empowered to take seed dissemination as a business, which has led to an increase in demand for improved seed varieties. Farmers also lack own initiative to look for seed sources of new bean varieties – partly because bean crop could recycled and they did not see the importance of buying new seed every season. There is still a need to sensitize and empower farmers to be more proactive in demanding services of improved bean varieties and also to them to be able to promote seed of improved bean varieties. This would also need to involve other stakeholders all along the seed supply chains, which are consumers and traders.

Increased farmers’ access to improved varieties depends on their market/trade potential. Currently, traders in the SHZ play a significant role in disseminating improved varieties as they trade within and without the zone, and to neighbouring countries (Malawi, Zambia, D.R. Congo, and Kenya). These traders were in two categories. One group was of small-scale traders who bought grain directly from farmers and sold their commodity to consumers or to medium-scale traders. These usually did not have storage facilities. The other group was the medium–scale traders who bought their commodities either directly from farmers or through small-scale traders and stored them for resale during the season when the supply was lean or moved to distant towns and cities. Some traders have faced different challenges in trading beans across border, which could be possibly due to government bureaucracy. There is a need to improve the situation.

CONCLUSIONS

The study identified 3 functional bean seed supply chains through which seeds of new bean varieties moved from ARI-Uyole BBP to farmers. The first category used free breeders' seed as part of on-farm testing in the variety development process. The second one used foundation seed of approved varieties which individuals or partner organizations bought or loaned directly from ARI- Uyole BBP. The last one used certified seed which was procured from the ARI-Uyole Farm Operation. Although, the seed supply chains were functional, the roles of partners were not clearly defined. For example ARI-Uyole BBP, had a clear mandate of developing acceptable bean varieties, which led to the release of several improved bean varieties and it was able to produce breeders' seed for those varieties. However, because there was a gap in provision of foundation and certified seed, ARI- Uyole BBP and the ARI-Uyole Farm Operations had assumed such responsibilities. This is a commendable intervention, but their capacity is very limited to service the vast SHZ.

The intermediary partners (government extension, NGOs, FBOs) were playing a major role in dissemination of improved bean varieties in the seed supply chains. Their roles and responsibilities in the seed chains were however not very clear. The government extension did partly understand their roles, mostly in seed dissemination, and to organize farmers in the communities. They fell short to understand their mandate to ensure that farmers' get access to seeds of improved varieties, by putting in structures to multiply seeds. The other partners had different mandates, but did get drawn into seed intervention issues, by default**,** as well-wishers, working directly with farmers in the communities. They had no clear defined mandate and their role in the seed supply chains was simply, to fill in the gap, because farmers needed such services.

Farmers make an important link in the seed supply chains, and seem to be involved all along the chains. The levels of involvement however, varied with partners depending on the way their interventions were structured. Many partners involved farmers partially, except ASPS, where farmers were empowered to produce their own seeds – QDS. It was also observed in general, that farmers were not proactive to make demands from service providers for services that would make a difference in their livelihoods. Most of them waited to be offered a service, an attitude which slows down progress in development. Although it was clear that the farmer seed system plays an important role in the seed supply chain, it was noted that when the varieties were very new and their seeds were limited, the flow of new varieties from farmer-to-farmer were limited. This was observed from both, farmers in contact villages through partner organizations as well as ARI- Uyole BBP partner villages.

Traders were involved in the bean seed supply chains and these were of different categories. Some traders played multiple roles, to produce and sell as seed. These included ARI-Uyole ARI- Uyole BBP (foundation), ARI-Uyole FO (certified), Farmer-seed traders under ASPS (QDS) and LAC (farmer seed). The other traders marketed grain beans (farmer seed) which farmers also used as seed during planting time.

The bean breeding program in the SHZ is doing a good job in involving different partners in variety development process and seed dissemination.

Different partners have also played a commendable role in seed multiplication or provision. However, as demand for seeds of improved varieties is increasing and considering the vast size of the zone, more improvement is needed in seed production and dissemination chain

RECOMMENDATIONS

There is a need to set a policy which could allow the decentralization of foundation seed multiplication to make seed easily accessible to farmers. Partners including farmers must get involved.

There is a need to sensitize partners to have effective collaboration with government extension staff in seed production and dissemination to adequately involve many farmers in seed production. Deliberate efforts should be made to find appropriate mechanism to involve traders in all process/stages of been production, multiplication and dissemination so as the released varieties are accepted.

Farmers, extension staff and other service providers should be sensitized and organized to produce seed in a sustainable way for them to continue with seed interventions on their own after the projects phased out.

Research to come up with more varieties to create diversity and they should be marketable palatable with high nutritional quality. Farmers should be empowered to take seed multiplication and dissemination as an agro enterprise. All partner organizations should make effort to increase awareness to farmers on benefits of improved bean varieties by using various promotional materials.

REFERENCES

Census (2002). Population and housing census: [http:// www. Tanzania. go. tz] site visited on 18/ 01/ 2006.

Madata, C.S. and Mussei, A.N. (1998). The role of new beans in enhancing the capacity of women in production and marketing of beans in the Southern Highlands of Tanzania. A paper presented to the SPAAR meeting in February 1998. Arusha, Tanzania.

Mussei, A. N., Madata, C. S., and Mbogollo, M. J (2002). Adoption of new bean varieties and contribution on food and income of smallholder farmers in the Southern Highlands of Tanzania, ARI – Uyole, Mbeya, Tanzania

Mussei, A. N., Mbwile, R. P., Kamasho, J. K., Mayona, C. M., Ley, G. J and Mghogho, R. M. (1999). Agro- ecological zones and farming systems of the southern Highlands of Tanzania. ARI – Uyole, Mbeya.

Wortman, C.S., R.A. Kirkby, Elechu, C.A. and D.J. Allen (1998). Atlas of common bean (*phaseolus vulgaris* L) Production in Africa. CIAT

Appendix 4: Workshop Proceedings

THE UNITED REPUBLIC OF TANZANIA

SEED DISTRIBUTION AND SUPPORTING INFORMATION SYSTEMS FOR PHASEOLUS BEANS IN THE SOUTHERN HIGHLANDS OF TANZANIA

Report of a Stakeholders Workshop Held on 26th September 2005

Agricultural Research Institute, Uyole, Tanzania
Natural Resources Institute, UK, University of Reading UK.

December 2005

Rory Hillocks, NRI/University of Greenwich
Catherine Madata, ARI Uyole, Mbeya Tanzania
Chris Garforth, University of Reading
L.H. Nyange, Farmer Education Unit, MAFS
Rowland M. Chirwa, CIAT/SABRN

Preface

Common bean is an important grain legume in the Southern Highlands of Tanzania for food security and income generation. It has become an important cash crop in recent years. However, yields of bean is still too low due to biotic, abiotic and social-economic problems and slow dissemination of the information on bean technologies.

Bean Improvement Programme at Agricultural Research Institute (ARI) Uyole has developed varieties and other technologies in attempt to improve ban yields. Currently, Natural Resources Institute UK in collaboration with ARI Uyole Bean Breeding Programme have developed and released a new variety "Urafiki" under Project R7569. The variety was introduced to farmers through on-farm evaluations.

The other component of the project, which was under the university of Reading assessed information pathways to assist technology transfer and seed dissemination. The component also developed and produced posters and leaflets for Uyole varieties and other bean technologies collaboration with ARI Uyole Bean Programme and Farmer Education and Publicity Unit of the Ministry of Agriculture and Food Security (MAFS)

The pesent work under Project R 8415 [A1145] aimed multiply and disseminate var. Urafiki in Mbeya, Iringa and Rukwa regions. The variety was disseminated through on-farm demonstrations and provision of starter-up seeds. ARI Uyole Bean Breeding Programme is multiplying breeder seed, which will be used by farmers and Uyole Farm Operations to produce certified seeds.

Laminated posters of Urafiki and other 4 Uyole varieties were produced and distributed in contact villages and at DALDO's offices.

Objectives of he project

1. To Multiply and distribute var. "Urafiki"
2. To disseminate information about "Urafiki".
3. To evaluate information systems for new Agricultural Technologies
4. To evaluate seed delivery system for beans

Stakeholders workshop was held on 26th September 2005 to assess the outputs of the project. The workshop came up with way-forward and resolutions.

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Abbreviations and Acronyms

ARI	Agricultural Research Institute
BCMV	Bean Common Mosaic Virus
BI	Botanical Insecticide
BSM	Bean Stem Maggot
CIAT	Centro International de Agricultural Tropical
CW	Canadian Wonder
DAP	Di-Ammonium Phosphate
DCD	Director of Crop Development
DFID	Department for International Development
DRK	Dark Red Kidney
DTP	Desk Top Publisher
DIVEO	Divisional Extension Officer
FAO	Food and Agricultural Organization
FEPU	Farmers Education Publicity Unit
IRDTF	Ileje Rural Development Trust Fund
LAC	Laela Agricultural Centre
MAFS	Ministry of Agriculture and Food Security
MR	Moderately Rain
MS	Moderately Susceptible
NGO	Non-Governmental Organization
NRI	National Resources Institute
PRA	Participatory Research Action
R	Resistant
S	Susceptible
SABRN	Southern African Bean Research Network
TSP	Triple Super Phosphate
TV	Television
UK	United Kingdom

Acknowledgement

We acknowledge all those who contributed to the success of the workshop. These include DFID/CPP and NRI for funding workshop participants for their valuable contributions and suggestions. The Management of ARI Uyole for the logistical support and the Management of Catholic Youth Centre for hosting the workshop we are also grateful to Ms N. Mwenisongole and Ms W. Mushi for typing the report.

EXECUTIVE SUMMARY

Stakeholders Workshop on Seed Distribution and Supporting Information Systems for Phaseolus Beans in the Southern Highlands of Tanzania was held on 26th September 2005 at Catholic Youth Centre in Mbeya. The Workshop was opened by the Regional Agricultural Advisor for Mbeya region. The workshop was attended by partners from UK, Uyole research, farmer representatives from contact villages, extension, NGOs and representative of Farmer Education Unit (FEU) of the Ministry of Agriculture and Food Security. The objective of the workshop was to discuss seed distribution and supporting information system.

After the key note address, the meeting continued with formal presentations from project members on the objectives, bean varieties and other technologies, information systems and how the information is disseminated and it is used. The role of FEU was also discussed. Farmers and extension also presented their experiences with new bean varieties including Urafiki, production and seed availability. The presentations were both in Swahili and English and translations were made for the benefit of all.

Strength, weaknesses and solutions methodology was used to assess seed supply and access to information by extension, farmers and researchers in separate groups. The main concern from the workshop was a need for wider coverage of bean work in the zone in testing new varieties to meet farmers, consumers and market preferences. There is a need for more information and dissemination of new varieties and other technologies. There is an urgent need to produce more seeds of improved varieties.

There was farmers' display of arrays of seeds which included local mixtures, mixtures of local and improved varieties and pure improved varieties. The bean programme also displayed released varieties, advanced lines and promotional literature.

ARI – Uyole and its bean programme was highly rated and appreciated for its role in developing new varieties, other bean technologies, technology transfer and seed production. The workshop was closed by a representative from CARITAS and promised to work closely with ARI Uyole Bean Programme in technology transfer.

SESSION ONE

OPENING REMARKS

J. Kitangalala, Regional Agricultural Advisor, Mbeya

Honorable Chairman,
Delegates from U.K.
Distinguished participants, Ladies and Gentlemen

May I briefly express my thanks to the organizers of this workshop for inviting me to officiate the opening of this important "Bean Variety Promotion Workshop". Also, I would like to take this opportunity to welcome you participants to this workshop. I hope that you will find the environment good for your deliberations during the workshop It is very much gratifying to learn that this workshop is being held as part of the continuation of the earlier project "Participatory Promotion of Disease Resistant and Farmer Acceptable *Phaseolus* Beans in the Southern Highlands of Tanzania" in which I also officiated its inception workshop on 8-9 August 2000.

Mr. Chairman, we know that bean is an important grain legume for human food and for income generation and it is second to maize. Also it is an important source of protein particularly when animal sources of protein are expensive. The crop is widely grown in the country. Notably, 30% of the total bean production in the country comes from the Southern Highlands. Unfortunately, Mr. Chairman, the bean yields are still low ranging from 300 – 600kg/ha compared to the potential of 2000 – 2500kg/ha, although research has made considerable advances in developing improved technologies. These improved technologies have not yet reached many end-users as expected.

Mr. Chairman, I have been told that one of the major outputs of the first project was the release of a new variety URAFIKI which is high yielding, drought resistant and relatively tolerant to major diseases. The initial work was carried out by the Bean Team at the National Resources International (NRI)/University of Greenwich in the U.K.; and other part of the work was completed at the Agricultural Research Institute Uyole in Tanzania. Other achievements from the project are identification of suitable pathways for technology dissemination; development, promotional materials on released varieties and creating awareness on bean insect pests. This work was done in collaboration with the University of Reading in U.K. The promotional materials have been widely distributed and displayed in well attended occasions like Nane Nane Agricultural shows World Food Day, etc.

Mr. Chairman, as we all know that genetic diversity is very important because farming conditions are ever changing while preferences by farmers and consumers and market demands are strong and diverse. Biotic and abiotic problems are also enormous and ever changing. The Bean Improvement Programme at ARI – Uyole in collaboration with other institutions and various stakeholders have tried to address these challenges by developing more new varieties. In addition to the new varieties, other bean-based technologies like Integrated Pests and Disease Management (IPDM) measures for minimizing damage by important pests and diseases have been developed and verified.

During the current one-year Project on Bean Variety Promotion five varieties including URAFIKI are multiplied on-station and introduced to many village in Rukwa, Mbeya and

Iringa regions. These five varieties were introduced along with posters as promotional materials.

When improved varieties and other bean-based technologies are used in combination by the beneficiaries, positive results such as increased yields can be realized. Research is a very expensive enterprise in time and resources. Some research projects have long gestation periods before outputs are seen. As representatives of different stakeholders, therefore, I urge you to make effective use of the outputs from research, which in fact you collaborated in planning implementation and evaluation. Furthermore, in any crop enterprise good quality seed is one of the primary inputs. Let us find a way to multiply the seeds of the improved varieties as an enterprise of itself. I believe you will come-up with strong recommendations as a way-forward for promotion of bean varieties and bean-based technologies for wider use in the Southern Highlands of Tanzania.

Mr. Chairman, let me take this opportunity to thank all those who contributed to the success of this workshop particularly those who provided finances, manpower and logistics. I thank DFID, Government of Tanzania for funding the project, including this workshop.

Mr. Chairman, it is indeed my pleasure to declarer the workshop open.

Thank you for listening.

**DISSEMINATION OF IMPROVED BEAN VARIETIES IN TANZANIA
OVERVIEW OF THE PROJECT**

By Rory Hillocks, Natural Resources Institute

Project Partners

Rory Hillocks	- Natural Resources Institute - UK
Catherine S. Madata	- Agricultural Research Institute – Uyole, Tanzania
Chris Garforth	- University of Reading - UK
H.L. Nyange	- Farmer Education Unit – MAFS
Rowland M. Chirwa	- CIAT (SABRN)

Project Background

- It is a one year project.
- The previous project developed improved variety 'Urafiki' which was released in 2003.
- The project also developed information campaign to support the 'Uyole' varieties.
- Six posters and three leaflets were produced by the previous project.

Development of variety 'Urafiki'

- It is a cross between UK Canadian Wonder and Kabanima
- Initial disease screening was done at NRI in UK.
- Field selection was done at ARI – Uyole.
- On-farm evaluation of most promising lines were carried out in the Southern Highlands of Tanzania by ARI – Uyole Bean Breeding Pogramme.

Project Objectives

- To multiply and distribute variety 'Urafiki'.
- To disseminate information about variety 'Urafiki'.
- To evaluate information systems for new agricultural technologies.
- To evaluate seed delivery systems for beans.

Description of Variety Urafiki

Origin	Progeny of cross made in UK
Pedigree	UK CW x Kabanima
Growth habit	Type 1 (Bush) with many branches
Flower colour	Pink
Seed type	Medium, DRK
Diseases	Quick recovery
Drought	Resistant
Others	High yields, good cooking quality and good leaves

Promotion of Variety Urafiki

- Laminated Information sheet prepared, multiplied and distributed in Mbozi, Mbeya, Mbarali, Njombe, Mufindi, Nkansi and Sumbawanga districts.
- TV programme

In villages where Urafiki has been adopted, farmers said that, it is high yielding, has good cooking qualities, better leaves and drought resistant.
Urafiki was distributed to contact village to be consistent where it was tested on-farm.
Promotion is taking place in:

- Rukwa region - Nkansi, Sumbawanga urban and Sumbawanga rural districts;
- Mbeya region - Mbozi and Mbarali districts;
- Iringa region - Njombe district

Institutions and Organizations receiving seeds of Urafiki:

- Nkansi district - Mashete Prison, Kate Catholic Mission Kantawa Traders
- Sumbawanga Rural – Laela Agricultural Centre.
- Mbarali district – Simike, Azimio and Mahango Primary Schools
- Ileje district - IRDTF and VECCO
- CARITAS - Mbeya

Examples of Urafiki seed produced:

- Mrs. Salingo of Lyadebwe village produced 40 kg in 2005.
- Pendo Women Bean Production Group at Ilembo village produced 10 kg from 250gms given as starter seeds.
- Some farmers in Lyadebwe village are growing Urafiki in traditional bean mixtures,

The main issues to be considered

- Is supply of breeder seed meet demand?
- Seed multiplication and distribution networks – do they work?
- Do farmers have ready access to information about improved varieties?.

SESSION TWO

OVERVIEW OF IMPROVED BEAN VARIETIES IN THE SOUTHERN HIGHLANDS OF TANZANIA

By C.S. Madata

Agricultural Research Institute – Uyole, Mbeya Tanzania

Introduction

Common bean is an important grain legume in the Southern Highlands of Tanzania. The zone produces about 30% of the beans produced in the country. Bean is an important source of protein and a source of cash. It is grown in all the districts in the zone and in almost all the Agro-Ecological Zones. Due to the high demand, the beans are grown during the two rainy seasons and under irrigation. Beans in this zone are sold in local markets, urban centres up to Mwanza and even to Zanzibar. Beans are also sold to Malawi, Zambia, DRC Congo and Kenya.

Different bean types in seeds, growth habits, leaves and maturity periods are grown in the zone. Most of the beans are traditionally grown in mixtures of different components. Varieties from research are also added into the mixtures. However, the most popular varieties are Kablanketi, Dark Red Kidneys, Calima, Sugar Beans, Yellows, Oranges, Creams and Browns. The preferred seed sizes, particularly for markets, are medium to large, although many small seed types appear in mixtures.

Bean yields are generally low due to many problems which include insect pests, diseases, poor soils, weather and in-availability of good quality seeds, seeds of improved varieties and unaffordable inputs.

Variety Improvement

Bean variety improvement in the SHT started since 1973/74 season where only few varieties were evaluated in comparison with the local varieties. Variety Kabanima, introduced from Uganda, was released in 1979. It is high yielding, tolerant to diseases and adapted to many environments. It has Calima seed type and it is still popular for market in Rukwa region and in parts of Mbeya region. Variety T3, a small red seed type was also released in 1979. However, the variety has lost its popularity since then and is no longer in production.
During the mid 1970's to early 1990's the emphasis in variety selection was on high yields, disease tolerance and good culinary factors. Marketability was not considered because the crop was grown mainly for food security. Thus, the earlier releases like Uyole 90 and Ilomba are no longer in use due to lack of market. Variety Uyole 84, although small seeded, is still popular and can be found in most mixture. It has very high yields, and has very palatable leaves, tolerates drought and bean stem maggot. It is also sold in local markets. It is very popular in Rukwa and Iringa regions..

Emphasis of Consumer Acceptability and Market Demands

The bean crop gradually became an important market crop from early 1990s and thus consumer preference and market demand became a force for farmers' acceptance of the new varieties. The bean programme puts emphasis on yields, tolerance biotic and abiotic stresses together with consumer and farmer acceptability and response to market demands. List of the varieties released and their characteristics is given in Table 1.

The reaction of the released varieties to diseases, bean stem maggot and drought is presented in Table 2. Varieties are recommended for production together with insect and disease control practices through Integrated Pest and Disease Management (IPDM) measures.

Informal Releases

There are also other varieties that have been informally released to farmers or have been retained by farmers in the process of on-farm variety evaluation. Such varieties are $TM27J_1J_2$, MG 38, Sugar 131, BILFA 8, RAO 55, CAL 143 progenies of Uyole 84 x Kablanketi, (EAI 2525 x Chipukupuku)/Sinon, (Kablanketi Uyole 84)/Sinon, (Kabanima x Masusu)/UAC 160 , Kablanketi-2 and others.

Improvement of Elite and Local Varieties

The bean improvement programme has also been active in improving popular local varieties like Kablanketi, Masusu and Chipukupuku. Elite varieties that are being improved are Kabanima, Njano, YC-2, Urafiki and Uyole 84. Promising progenies have already been introduced to the farming communities for evaluation and some of the varieties have been retained by farmers.

Promotion of Bean Varieties and Other Bean-Based Technologies

12 posters describing varieties and pests and 3 leaflets on production technologies and insect control have been developed and distributed to extension, farmers and NGOs. They are also displayed during well attended occasions like Nane-Nane, Farmer Shows, World Food Day and at some of the farmer training sessions and workshops.

Bean Variety Disseminations and Demonstrations

The bean programme has evaluated many varieties in on-farm trials since early 1980's to date, which lead to the releases of the farmer and consumer accepted varieties. On-farm variety evaluation and demonstrations has also served as source of seeds. Some of the locations where on-farm variety work has been conducted is given in Table 3.

Farmer Assessment Plots

Plots of farmer assessment of released and promising varieties have been used for assessment by large groups of farmers. These are planted on-station and at sub-stations of Mbimba and Nkundi and with some of the farmer groups. This exercise has been conducted for the last 4 seasons, where farmers and traders are usually invited. The exercise has been useful in variety release and dissemination. During this occasion, farmers are usually given the seeds of their selected varieties as starter seeds.

Testing Panels

Before varieties are released they are tested for palatability and culinary factors. Thus our new releases are very palatable, fast to cook and are accepted by farmers, consumers and have market demand.

On-farm Seed Multiplication

Some of the farmers have been given starter seeds to produce their own seeds. Other farmers have also been buying seeds. Unfortunately, this exercise is not sustainable because farmers may use the produce for consumption or for sale. It is highly recommended that seed production be taken as an enterprise,

Breeder and Foundation Seeds

These seeds are normally produced at ARI – Uyole for the released varieties. The seeds are sold to the users.

Future work

Variety improvement need to continue to address changing or expanding markets, different consumer preferences, value adding and to changing farming environments. New beans like canning types, snap beans also need to be addressed.

More efforts are needed on acceleration of dissemination of varieties and other bean-based technologies. Market search targeting market demands and market information are needed.

Acknowledgements

We acknowledge the efforts and commitments of all those who contributed to the success of bean work. This includes the government f Tanzania, DFID, farmers, Extension staff, ARI – Uyole Management, NRI and University of Reading.

Table 1: Characteristics and distribution of released and local varieties in the Southern Highlands of Tanzania

Varieties	CHARACTERISTICS										
	Seed size	**Seed colour**	**Growth habit type**	**Maturity period**	**Cooking time**	**Palatability**	**Leaves for relish**	**Market/ food security**	***Yield potential tons/ha**	**Year of release**	**Year of dissemination**	**Locations of dissemination (Regions)**
Kabanima	Med-large	Calima	Bush, 1a	3½	Slow	Fair	Fair	Very high	1.5-2.5	1979	1980-2004	Mbeya, Iringa, Rukwa, Ruvuma
Uyole 84	Small	Cream	Climber, IVb	3¾	Slow	Fair	Excellent	Very high	1.5-4.0	1984	1985-2004	Mbeya, Iringa, Rukwa, Ruvuma
YC-2	Large	Calima	Bush 1b	3½	Slow	Good	Fair	High	1.2-2.0	-	1992-1995	Mbeya, Iringa, Rukwa, Ruvuma
Uyole 94	Large	Red stiped	Semi climber, IIIb	3¼	Fast	Very Good	Excellent	Very high	1.2-2.5	1994	1992-2005	Mbeya, Iringa, Rukwa, Ruvuma
Uyole 96	Large	DRK	Semi climber, IIIb	3¼	Fast	Good	Excellent	Very high	1.2-2.5	1996	1994-2005	Mbeya, Iringa, Rukwa, Ruvuma
Uyuole 98	Medium	Orange	Semi climber, IIIb	3¼	Very fast	Excellent	Fair	Very high	1.5-3.0	1998	1995-2005	Mbeya, Iringa, Rukwa, Ruvuma
Kablanketi	Medium	Purplish	Semi climber, IIIb	3	Fast	Very Good	Poor	Very high	0.5-1.5	Local	Local	Mbeya, Iringa, Rukwa, Ruvuma
Masusu	Large	Brown	Semi climbers IIIb	3½	Fast	Good	Good	Fair	1.0-2.0	Local	Local	Mbeya, Iringa, Rukwa, Ruvuma
Wanja	Large	Khaki	Bush 1a	2¾	Fast	Very good	Good	Very high	1.0-2.0	2002	1998-2005	Mbeya, Iringa, Rukwa,
Urafiki	Medium	Dark red	Bush 1a	3¼	Fast	Very good	Good	Very high	1.2-3.0	2003	2002-2005	Mbeya, Iringa, Rukwa,
Uyole 03	Large	Sugar	Bush 1b	3¼	Fast	Very good	Good	High	1.2-3.0	2003	2001-2005	Mbeya, Iringa, Rukwa,
Uyole 04	Medium	Cream	Semi bush ,IIIb	3¼	Extremely fast	Excellent	Good	Very high	1.5-3.0	2004	2001-2005	Mbeya, Iringa, Rukwa,
BILFA - Uyole	Medium	Calima	Semi bush, 2a	3¼	Ffast	Very good	Good	High	1.2-2.5	2004	2000-2005	Mbeya, Iringa, Rukwa,

Table 2: Reaction of 9 improved, 2 local bean varieties to diseases, bean stem maggot and drought

Varieties	BMC*/ BCMV+	Anthracnose	Rust	Angular leaf spot	Halo blight	Bean stem maggot	Drought
1.Kabanima	T	R	R	MR	MR	S	S
2.Uyole 84	S*	R	MR[a]	MR	R	T	T
3.Uyole 94	S*	MS	T	S	S	S	T
4.Uyole 96	S*	MS	MS	MS	MS	MS	T[c]
5.Uyole 98	S*+	R	R	R	R	S	T
6.Uyole 03	T	R	R	R	R	S	T
7.Uyole 04	S*+	R	R	R	R	S	T
8.Urafiki	S*	MS	T	MS	MS	S	R
9.BILFA-Uyole	T*+	T	MR	MR	MR	S	T
10.Wanja	T*+	S	MR[6]	S	MR	S	T[b]
11.Kablanketi	S*	S	S	S	S	S	T
12.Masusu	S*	S	S	S	S	T	T

a = slow rusting
b = escapes due to early maturity
c = seeds become pale

R = Resistant
MR = Moderate Resistance
MS = Moderately Susceptible (High Recovery)

Table 3: Summary of dissemination of improved bean varieties in selected areas of the Southern Highlands of Tanzania 2000/01 to 2004/05

Season	Region/District	Number of villages	Number of farmers	Varieties
2000/01	**Rukwa** Sumbawanga Rural	3	122	Uyole 96, Uyole 98, Wanja, CAL 143, Uyole 94
	Iringa Njombe	13	137	Uyole 94, Uyole 98, Wanja, Uyole 98, Sinon
2001/02	**Rukwa** Sumbawanga Rural	4	44	Wanja, Uyole 94, Uyole 96, Uyole 98, Kabanima, CAL 143
	Nkansi	5	25	NRI(8L), Uyole 94, Uyole 96, Uyole 98, Uyole 84, CAL 143. Kabanima, BILFA8, Uyole 84 x Kablanketi L.138
	Iringa Njombe	6	45	Uyole 94, Uyole 96, Uyole 98, Kabanima, Kabanima x Masusu, BILFA 8, RAO 55, CAL 143, BILFA 4, NRI (8L)
	Mufindi	5	40	Uyole 94, Uyole 96, Uyole 98, Kabanima, Kabanima x Masusu, G38, Uyole 03, BILFA 8, RAO 55, CAL 143, BILFA 4

Season	Region/District	Number of villages	Number of farmers	Varieties
2002/03	**Rukwa**			
	Nkansi	10	105	Wanja, Uyole 84, Uyole 98, Uyole 84, Uyole x Kablanketi (P.138), Kabanima, Uyole 03, MG 38, TM27J_1J_2, SA Sugar, BILFA – Uyole, Urafiki, Lisa, Bilfa 8
	Iringa			
	Njombe	1	43	Uyole 96, Uyole 98, Urafiki
	Mufindi	1	20	Uyole 94, Uyole 96. Uyole 98, Uyole 03
	Mbeya			
	Mbarali	3	85	Uyole 94, Uyole 96, Uyole 98
2003/04	**Rukwa**			
	Nkansi	8	97	Wanja, Uyole 96, Uyole 98, Uyole 03, MG 38, Urafiki, Uyole 84, BILFA 14, BILFA - Uyole, TM27J_1J_2 CAL 143, BILFA 8, Uyole 94, Sinon
	Mbeya			
	Mbozi	10	40	Uyole 96, Uyole 98, Uyole 03, Uyole 04, Wanja, BILFA – Uyole, BILFA 8, Kablanketi-2, Urafiki
	Mbarali	3	142	EAI x Chipukupuku, CIM 9406, CIM 9411, BILFA 4, Uyole 96, Uyole 98, Uyole 03, Uyole 04, Sugar 131, Urafiki, Wanja
	Iringa			
	Kanaan	2	43	Uyole 04, BILFA – Uyole, Uyole 98, Uyole 03, Wanja
	Mufindi	3 groups	15	Uyole 04, BILFA – Uyole, Uyole 98, Uyole 03, Wanja
2004/05	**Rukwa**			
	Nkansi	8	52	Kabanima, wanja, Uyole 03, Uyole 98, Uyole 84, Uyole 04, Urafiki, BILFA 8, BILFA - Uyole
	Sumbawanga Rural	1	Variable	Kabanima, Wanja, Uyole 03, Uyole 98, Uyole 84, Uyole 04, Urafiki, BILFA 8, BILFA - Uyole
	Mbeya			
	Mbozi	5	54	Chipukupuku improved, Uyole 96, Uyole 98, Wanja, Uyole 04, BILFA 4
	Chunya	-	-	

(-) Not yet submitted

BEAN INSECT PESTS OF THE SOUTHERN HIGHLANDS OF TANZANIA

By D. Kabungo
Agricultural Research Institute – Uyole, Mbeya, Tanzania

Most important bean insect pests in Southern Highlands Tanzania (altitude; 500 - 2500 m.a.s.l):

1. Bean stem maggot
   i. *Ophiomyia spencerella* – most prevalent
   ii. *Ophiomyia phaseoli* – common in low altitude areas
2. Bean Black Aphids: *Aphis fabae*
3. Bean Folige Beetle: *Ootheca spps*
4. Pod Borers: *Helicoverpa armigera*
5. Bean Bruchids: *Acanthoscelides obtectus*

1. Bean Stem Maggot: The most important bean insect pest

Research already done:

- Species composition and distribution
- Population dynamics during the season
- Insecticides evaluation trials:
  - Sprays
  - Seed dressings
  - Botanical Insecticides – Tephrosia, Vernonia
- Importance of soil fertility improvement
- Earthing-up
- Bean varietal resistance/tolerance
- Several parasitoids observed emerging from the BSM puparia

What remains to do:

- Dissemination of the technologies to farmers – need more promotion
- Alternate hosts: only Soyabean has so far been observed as an alternate host but there may be other perennial plants.

2. Bean Bruchids: One species is the most important in storage

What has been done/observed:

- **Evaluation of various storage insecticide:**
  - Actellic Super Dust – standard
  - Botanical insecticides:
    - Pyrethrum powder
    - Tephrosia ;leaf powder and *Neuratanenia mitis* tuber powder
- Varietal Resistance? – On-going
  - Kablanketi most susceptible however, none has been observed to be resistant among the varieties available in the Southern Highlands.
  - Some promising arcelin lines from SUA are being screened.

What remains to be dome:

- Screen more Botanical Insecticides (BI), which have shown the potential on other pests.

- Determine the toxicity levels of these BIs especially on stored produce and vegetables as well.

3. Bean Aphids

- Most damage is reported/observed on late planted or off-season crops where over 90% crop loss can be observed.
- Another important aspect is the transmission of Bean Common Mosaic Virus (BCMV) – the disease is gaining importance in recent years and in late planting and under irrigation where moisture stress is common.

4. Bean Foliage Beetle: *Ootheca bennigseni*

What has already been done/observed:

On-farm experiments carried out in Ileje and Mbozi districts includes:

(1) Crop Rotation
(2) Post harvest ploughing
(3) Delayed sowing
(4) Insecticides application
(5) Untreated control

- Farmers and Primary School teachers and pupils have been taught ecology and the biology of *Ootheca* through participatory discussions with the researchers. After these discussions, farmers and pupils were able to suggest very constructive IPM components.
- One important alternative host collected (*Lonchocaropus capassa* Rolfe).
- *Ootheca* problem, although localized in some places only, it seem wide spread as reported by Shilanga Farmers Group in Ihanda village, Mbozi district.

5. Bean Pod Borers: *Helicoverpa armigera*

Helicoverpa armigera is among the most polyphagous insect on various crops. Though still important in beans and has caused an alarming damage in certain years, no specific research ever done on this apart from observations and adopted recommendation. Control measures from literature are available although they have not been verified in the zone. However sprays with common insecticide like Thiodan or Thionex, Selecron, etc, can be used effectively.

BEAN DISEASES MANAGEMENT TECHNOLOGIES

By F. Mwalyego

Agricultural Research Institute – Uyole, Mbeya, Tanzania

Introduction

Depending on the location, weather and nature of cultivars grown, the bean crop can be attacked by a number of diseases which cause economic damage. Poor perception of disease symptoms by most growers often lead to their effects being ascribed to soil, insects or weather problems. Proper diagnosis warrants effective control.

Important fungal diseases encountered in the Southern Highlands Zone are angular leaf spot, anthracnose, rust, aschochyta, scab, floury leaf spot and powdery mildews. The common bacterial diseases are holo blight and common bacterial blights and the main viral disease is bean common mosaic virus (BCMV). Except rust and floury leaf spot, most of the other diseases are seedborne and mainly transmitted through infected seeds and trash. Hence seed health case is vital in the course of their management especially in view of farmers recycling their harvested seed from season to season.

Various cultural and chemical means of seed management have been developed but none is likely to be fully practicable under severe disease situations. Use of resistant varieties which seems to be the most effective means of control by farmers is mitigated by lack of acceptable varieties with adequate levels of multiple resistances to cope with a compound of diseases encountered at farm level. An integrated disease management approach utilizing all possible control options within farmers' reach is advocated.

Technologies

The following technologies have been recommended for integrated use with disease resistant cultivars for efficient disease control. Deliberate efforts to create awareness of economically important diseases in the farming communities will enhance control. Suggested practices to minimize disease spread are:

1. Seed sorting to eliminate diseased ones which visually may appear stained, wrinkled, discoloured or smaller in size.

2. Production of clean seed for planting – can be achieved through selection of clean pods for seed harvests, well managing separate seed multiplication plots under dry land conditions or chemical protection. Copper based fungicides (cu-hydroxide) appear among others easily available in markets can be applied routinely to seed plots to protect plants from infection.

3. Rogueing of severely infected seedlings after germination and virus infected plants in field.

4. Avoid seed from a previously heavily infected field.

5. Planting beans in clean fields. Rotation of bean fields with non-legume crops to avoid building up of innoculum in soils is recommended.

6. Planting at optimum time to avoid peak disease periods and moisture stress for the locality.

7. Use of recommended spacing depending on growth habit; staking of indeterminate types.

8. Seed dressing with fungicides such as benlate T-20 and others locally available especially for large scale producers.

9. Proper sun drying of seed stocks before storage – minimize survival rate of pathogen in theseeds.

10. Early weeding to avoid creating microclimates conducive to disease development.

Dissemination

Promotion of these technologies have been through on farm trials, field days, zonal and national Nane Nane agricultural shows and farm visits. On farm trials involving farmer groups have been conducted in Zelezeta and Haterere villages in Mbozi district. These research farmer groups have continued to disseminate the knowledge to others in their neighborhoods. Farm visits in response to disease problems accompanied by discussion with farmers have been conducted alongside insect pest management strategies in Shilanga, Umalila and Santilya Wards

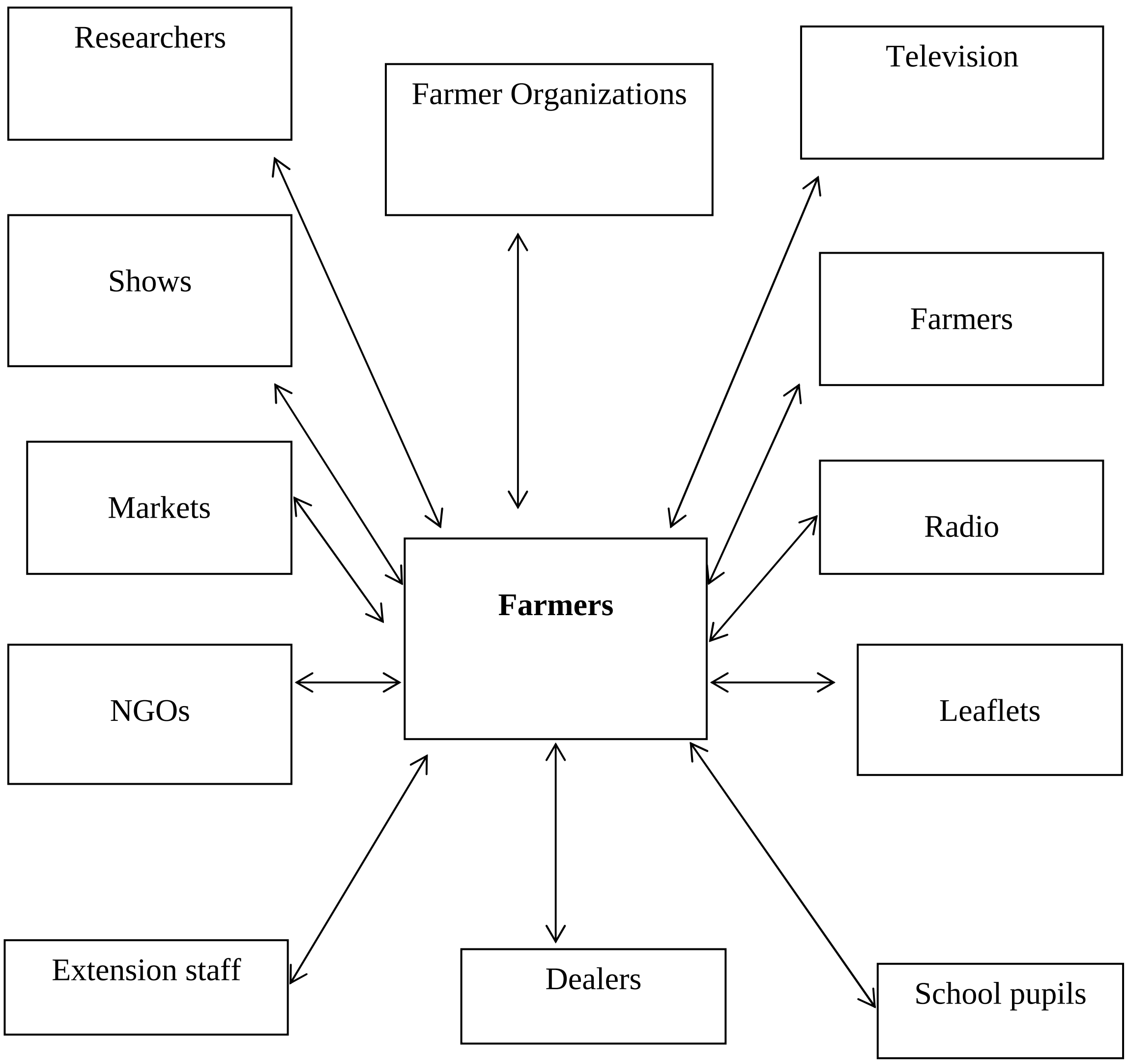
FARMERS' BEAN INFORMATION SYSTEMS IN SOUTHERN HIGHLANDS OF TANZANIA

By: Chris Garforth

University of Reading, U.K.

Research:
- Develops technology, in participation with farmers;
- Gives information to extension, NGOs, mass media
- Gives/sells seed for farmers to try and produce.
- Promoted varieties and technology and shows, field days, field sites.

Figure 1: SOURCES OF FARMERS' INFORMATION



Farmers assess trust, credibility of sources

Study villages: Azimio, Mahango, Ilembo, Isango, Hatelele, Shiwinga, Lyadebwe, Mayali

Types of farmers

a) contact with Uyole bean programme, directly or indirectly
b) in same villages, but not in contact with Uyole bean programme
c) in villages with no contact with Uyole bean programme

Table 4: Number of farmers interviewed in different categories

	Farmers		
Category	**Female**	**Male**	**Total**
a)	29	12	41
b)	15	20	35
c)	7	10	17
Total	**51**	**42**	**93**

Demand for information of:

- New bean varieties with following characteristics:
  -drought resistant
  -good market
  -high yield
- Market information on:
  -prices
  -locations
  -market requirement
- Pest/disease control
- Print material
  -farmers are ready to buy leaflets
  -farmers want information sheets
  -these extension literature stimulates discussion

Sources of information on beans

- Group members
- Bwana shamba/DALDO
  -seminars
  -activities in village
- Contact farmer
- Other farmers
- Radio
- ARI – Uyole
  -field activities (on-farm. etc.)
  -leaflets
  -posters

Sources than can work together

- Radio and posters can:
  -create awareness
  -prompt farmers to seek information, ask questions
- Groups can:
  -facilitate learning
  -be focus for non-members to get information, see new varieties
- Contact farmer can:
  -be a two-way link between research/extension and farmers

Information found in the villages

- Village Offices
  -education
  -HIV/Aids
  -Civics education's
  -Local planning
  -Not much on agriculture
- Information sheets on beans
  -not widely known
  photographs of seeds provoke interest and discussion
  -A4 format easy to copy
  -lamination makes them durable

Gaps found at village level

- Information does not flow automatically but through people
- Social networks"
  -allow flow of information
  restrict flow of information
- Links between village through friends, relatives.

Information and Knowledge

- Information is what someone tells us, e.g:
  -recommended spacing
  -this variety is drought resistant
- Knowledge is what we know, e.g:
  -we know how to plant our traditional varieties
  we don't know the variety is drought resistant until we try it
- Information interacts with knowledge
- Science can help refine farmers' knowledge, e.g.:
  -preparation and application of utupa.

Conclusion

- Several complementary sources of information
- Knowledge comes from trying new varieties on-farm
- Extension/NGOs can stimulate learning by doing
- Demand for more information, mass media and extension/NGOs can help bridge gaps in local information networks.
- ARI – Uyole is a focal and respected part of bean information system and intermediaries are key players

THE ROLE OF THE MINISTRY OF AGRICULTURE IN INFORMATION AND DISSEMINATION WITH REFERENCE TO FARMERS EDUCATION AND PUBLICITY UNIT (FEPU)

By H.L. Nyangi and M. Simbeye

Ministry of Agricultural and Food Security

1.0 Introduction

The history of FEPU dates back to 1955 when the “Ukulima wa Kisasa” magazine was first published in the Lake (Victoria) zone. The paper was specifically for educating and developing agricultural interests to young farmers. As the paper became popular, it was taken up by the Department of Agriculture and moved from the lake zone to Dar es Salaam.

From mid 1960s to 1970s the paper played a key role not only in educating farmers, but also in the national literacy campaign of the rural community as it was the only paper which penetrated the rural areas. With popularity and technological development in mass media the Farmer Education activities expanded to include Radio programmes (1965), Leaflets and booklets production (1975).

Films/Cinema (1970) and Video/TV programmes production 1991).
The production of Video/TV programmes and Desk Top Publishing (DTP) techniques were started by the National Agricultural Extension Project under the World Bank Credit Loan between 1989 – 2001.

2.0 Objectives

2.1 General objective

The general objective of FEPU is to educate and inform farmers on all matters related to agricultural development and sustainability with a view of raising the national economy.

2.2 Specific objectives

To inform farmers and public in general on various agricultural issues such as:

- Crop and Livestock marketing.
- Diseases/pests control campaigns
- Environmental issues
- Inputs supply
- Agricultural credits

3.0 Management and Location

FEPU is the Extension Unit in the Department of Crop Development (DCD managed under) of the Ministry of Agriculture and Food Security (MAFS). Its office is located in Dar es Salaam City Centre at Car and General House along the Garden Avenue.

FEPU is managed by an Officer in-charge
It is organized into five major sub-units

- Radio Video/Television programmes
- Visual Aids Unit
- Editorial
- Printing Press with Desk Top Publishing (DTP) facility
  Farmer Training and Gender issues in Agriculture

4.0 Facilities and Services

- Professional Audio Tape Recorders
- High quality DTP equipment
- High volume printing machines and accessories
- Audio studio with 8-channel mixer
- Still picture cameras – Digital
- Video Cameras – Digital, SVHS.
- Professional Audio Visual Equipment
- Video projectors
- Overhead and slide projectors.

5.0 Services

Based on the facilities outlined above, FEPU offers the following services:

- Print media design and production. – Leaflets, Posters, Booklets, Newsletters, Calendars etc.
- Film/video Episode production. – Script writing, Video shooting and editing.
- Radio programme planning and production
- Photographing
- Mobile video shows using Mobile video and Compact Mobile units
- Planning and conducting campaigns through mass media.

6.0 Staff

FEPU has professionally trained staff in the following descriptions:

- Training methods in extension including the recent approaches such as:
    - Participatory Reflection and Action (PRA)
    - Farm Field Schools (FFS)
- Radio/TV program production
- Design and production of print media.
- Social Marketing and Research methods.
- Development of Communication strategies.
- All agricultural subjects including environmental issues.

7.0 Outputs

7.1 Radio Programmes

Currently FEPU produces the following programmes:

- Mkulima wa Kisasa – Crops under the Ministry of Agriculture and food Security aired every Monday at 05.45 – 06.00p.m. by Radio Tanzania Dar es Salaam (RTD).
- Mkulima wa Kisasa – Livestock under the Ministry of Water and Livestock Development aired every Tuesday at 05.45 – 06,00 p.m. by Radio Tanzania Dar es Salaam (RTD)
- Pamba Yetu – Tanzania Cotton Board aired through RTD

7.2 Ukulima wa Kisasa Magazine Issued after every two months (Bimonthly paper)

7.3 Video Episodes

Several of them have been produced as listed in Table 5

Table 1: List of Video episodes produced by FEPU

Subject	Client	Year
Jisaidie Usaidiwe	Ministry of Agriculture and Food Security	1995
Matumizi Bora ya Pembejeo za Kilimo	Ministry of Agriculture and Food Security	1998
Hifadhi ya Nafaka	Ministry of Agriculture and Food Security	1998
Kilimo cha Uyoga	Ministry of Agriculture and Food Security	2000
Matumizi na gharama za maji (Maji week)	Ministry of Water and Livestock Development	2003
Hifadhi ya Vyanzo ya Maji	Ministry of Water and Livestock Development	2003
Sera ya Maji (Maji week)	Ministry of Water and Livestock Development	2003
Mpango wa Mandeleo wa Elimu ya Msingi – Part I	Ministry of Education and Culture	2003
Mpango wa Maendeleo wa Elimu ya Msingi – Dramatization of Information	Ministry of Education and Culture	2003
Mpango wa Maendeleo wa Elimu ya Msingi – Dram/Song Part II	Ministry of Education and Culture	2004
Hifadhi ya Vyanzo vya Maji	Ministry of Water and Livestock Development	2004
Sera ya Maji	Ministry of Water and Livestock Development	2004
Matumizi na gharama za maji	Ministry of Water and Livestock Development	2004
Maadhimisho ya miaka 30 ya Mradi wa Heifer International (T)	Heifer International (T)	2004
East Coast Fever	FAO	2005
Nane Nane (Farmers Day)	Ministry of Agriculture and Food Security	2003,2004, 2005

7.4 Posters and Leaflets

FEPU has an annual Farmers Day (Nane Nane)poster and leaflet which are produced jointly by FEPU and the Tanzania agricultural Society (TASO). Besides the two annuals, FEPU produces a number of posters and leaflets depending subjects and demand from the farming community.

7.5 Booklets

A number of booklet titles on crops and livestock subjects have been produced and distributed to farmers. Among the recent ones are the following titles:

- Kilimo Bora cha Mboga
- Ufugaji Bora wa Kuku
- Ufugaji Bora wa ng’ombe wa Maziwa
- Kilimo na Ukimwi
- Ufugaji Bora wa Nguruwe
- Teknolojia sahihi kwa matumizi ya Jamii n.k.

SESSION THREE

PRODUCTION OF BEANS IN MBEYA RURAL DISTRICT

By: Mr. C. Mtono (DALDO)

Mbeya Rural District

Bean is produced in most parts of the district. The crop is regarded both as food and cash crop. Moreover, bean is the main source of protein that is cheap and easily available compared to other sources of protein. The district consists of 3 divisions, 17 wards of which all produce beans.

History

In the district, beans production started many years ago.

Altitude

The crops grows well in moist areas from 900 – 2000 m.a.s.l

Time of planting

In most parts of the district, bean is produced in two seasons.

- 15th November – December
- February – March

Bean varieties

Farmers in the district produce na wider range of bean varieties which is a result of good partnership with ARI – Uyole. Some of the grown varieties include; Kablanketi, Masusu, Uyole 94, Uyole 98, Uyole 84. Uyole 96, Wanja, BILFA and Urafiki.

Bean Planting

Bean is planted in rows to facilitate planting, fertilizer placement and weeding. It is grown as a sole crop or intercropped with other crops basically maize. Advantage of intercropping is to harvest more than one crop from the same area in the same season. On the other hand there is an increased disease incidences.

Fertilizer

Some of the farmers apply industrial fertilizers such as TSP and DAP at planting, while others use farmyard manure and compost.

Weeding

The majority of farmers in the district do bean weeding twice

a. First weeding is done at the second – third week after germination.
b. Second weeding is at flowering stage.
C. Some farmers use herbicides.

Harvesting

Harvesting is done after drying before shattering

Pests
In the field, the bean crop is attacked by a number of pests such as bean stem maggot, bean aphids, bollworm and cut worms. Promotion of control of these field pests is done in collaboration with ARI – Uyole.

Diseases
The crop is susceptible to a number of diseases including bean rust, angular leaf spot, anthracnose, halo blight and others.

(i) I would like to thank researchers from ARI – Uyole for the great efforts done in bean improvement in releasing several bean varieties, insect and disease control hence increase farmer's income.

(ii) I also thank workshop organizers for inviting us to share experience in bean production.

INFORMATION ON DISITRIBUTION OF POSTERS AND SPREAD OF VARIETY "URAFIKI" IN NKANSI DISTRICT

Ulindula M. Msomba DIVEO (Kate) Nkansi district, Rukwa region

Village meeting

Meetings were held in seven villages in Nkansi district in August 2005. The number of participants for each village is given in Table 1. The agenda of the meeting was discuss the types of bean varieties in the villages , to teach bean production technologies, to make plans for 2005.06 season for bean work to discuss the poster and display them in the villages and to collect data on variety Urafiki.

Table 1: Number of farmers who attended the meeting

Date	*Village*	Participants		
		Male	Female	Total
14.8.2005	Kipande	13	5	18
19.8.2005	Nkundi	2	3	5
	Kalundi	10	4	14
22.8.2005	Milundikwa	2	3	5
	Kasu	3	3	6
	Katani	3	4	7
23.8.2005	Kantawa	3	8	11
	Total	**36**	**30**	**66**

Information on production Var. Urafiki

NRI lines and Urafiki were first introduced in 2002 season and more introductions continued up to 2004 in the villages mentioned in Table 2. However, introduction of NRI lines in Rukwa region started in 2000/2001 up to 2005 in other villages. The production trends of Urafiki is given in Table 2.

Table 2: Production trend of var, Urafiki in 4 villages in Nkansi district

Village	Name	Year of introduction	Starter seeds (kg)	Seeds obtained (kg)	Production 2005	
					Amount produced (kg)	Available seeds (kg)
1. Kasu	1. Lyidia Kalolo	2003	0.5	2	20	20
	2.Josephat Mbunda	2003	0.5	2	22¾	23
2. Katani	1. Evarist Sumuni	2004	1	2	5	10
	2.Veronica Mwenda	2004	1	1.5	20	20
	3.Kostazia Kusongwa	2004	1	1.5	5	5
	4. Matrida Malazu	2004	1	3	10	10
	5. Linusi Manyika	2004	1	3.5	10	10
	6. Edward Isaya	2003	1	20	240	180
3. Kantawa	1. Conrad Msagala	2002	0.5	4	40	5
	2. Kikundi biashara I	2004	0.5	1	15	1
	2. Kikundi biashara II	2002	0.5	2	20	10
4. Kipande	Ulindula Msomba	2003	1	3	15	6

Farmers' opinion for producing var. Urafiki

- It tolerates diseases (seeds are not discoloured).
- It tolerates drought and seeds are not pale under moisture stress
- It is not very much affected by rain quick recovery when condition improve seeds are not discoloured).

Reasons for producing var. Urafiki

- Very palatable and cook fast
- High yielding

Distribution of posters

4 Sets of posters for 5 varieties including Urafiki were distributed in Kipandi, Matai, Mwazye and Katani villages.

PRODUCTION OF IMPROVED BEAN VARIETIES FROM ARI – UYOLE IN KATANI VILLAGE, NKANSI DISTRICT

Edward Isaya (Farmer)
Katani village, Namanyere, Nkansi district, Rukwa Region

Introduction

Production of new bean varieties from ARI – Uyole (Agricultural Research Institute, Uyole) started in 2003 season in Katani village, Namanyere Division in Nkansi district in Rukwa region. Although small quantities of seeds were initially introduced for observations and evaluations varieties have started spreading. Consumers and traders have began to know and accept them including bean users and buyers from nearby villages and as far as from Kirando. The new varieties have shown good results in yield, consumer and market preferences. Results are shown in Table 1. Total yield produced for 8 varieties was about 1620kgs.

Table 1: Beans produced (kg) in Katani village, Nkansi district during 2003 season

	VARIETIES							
Farmers' Name	**Uyole 94**	**Uyole 96**	**Uyole 98**	**DRK 124**	**NRI**	**CAL 143**	**TM**	**Wanja**
Lautes Mxagala	5	10	-	20	-	-	10	15
Evarist Sumuni	15	10	-	5	10	-	10	5
Veronica Mwenda	15	5	5	10	5	5	10	10
Kostasia Kusongwa	5	10	-	10	5	5	-	-
Auleria Sumuni	10	5	15	10	-	-	-	10
Matrida Marazu	5	5	-	10	10	-	-	5
Jojina Tembwe	10	5	-	-	-	-	5	5
Protas Mapema	-	-	15	-	-	-	15	-
Paschalia Kawala	-	-	-	-	-	-	-	-
Gaudioza Issaya	120	80	80	600	360	-	180	140

(-) Did not have seeds

Farmers distributed the seeds among themselves and planted the varieties in their own plots in December 2003 and harvested a total of 1964 kgs. The varieties are spreading fast in the village. Insect pest damage is one of the main problems for low production.

More seeds were provided and planted in March 16, 2004 as shown in Table 2. Yield was very poor due to drought and average yield obtains was 1.5 kg per variety. Farmers shared the beans among themselves as shown in Table 3 and planted in their own individual plots in. Only 5 members planted beans in their group plot in mid-January 2005 (Table 4). Farmers are growing new bean varieties in groups or in individual plots and varieties are spreading fast.

Table 2: Farmers and the bean varieties planted in March 2004

No	Farmer	Bean varieties
1	Zesius Kanoni	SINONI
2	Zenobia Sekomani	BILFA 16
3	Auleria Sumuni	UYOLE 98
4	Stellah Kayanza	UYOLE 98
5	Gaudioza Issaya	BILFA 8
6	Auleria Kanoni	CAL
7	Kostazia Kasongwa	UYOLE 96
8	Veronica Mwenda	NRI Urafiki
9	Aseria Chambanenge	BILFA 16
10	Jojina Maembe	UYOLE 84
11	Protas Mapema	WANJA & TM $27J_1J_2$

Table 3: List of farmers and varieties planted on individual plots January 2005

No.	Farmer	Bean varieties
1	Tabia Maduhu	UYOLE 94
2	Eliza Sita	WANJA & $TM27J_1J_2$
3	Mazozo Ntenghnena	UYOLE 98
4	Justa	BILFA 16 & $TM27J_1J_2$
5	Joseph Mahashi	KABANIMA & $TM27J_1J_2$
6	Polepole Chendela	BILFA 8 & $TM27J_1J_2$
7	Tungu Mikomangwa	TM & KABANIMA
8	Ngoko Charles	$TM27J_1J_2$
9	Masanja Machiya	WANJA & $TM27J_1J_2$
10	Alfred Kanoni	UYOLE 98, Uyole 03

Table 4: List of farmers and varieties planted in group plot, January 2005

No	Farmer	Bean varieties
1	Linus Kanyuka	UYOLE 96
2	Juma William	URAFIKI (NRI)
3	Charles Kanyepo	WANJA
4	Bonoza Lukwa	$TM27J_1J_2$
5	Lusia Mwanambuu	KABANIMA

A BRIEF REPORT OF BEAN WORK IN LYADEBWE VILLAGE, NJOMBE DISTRICT, IRINGA REGION

Mario P. Mgeni (Farmer)

Lyadebwe Village, Njombe, Iringa Region

The group started its bean work in collaboration with bean research at ARI - Uyole, in 2001/02 season with 10 team members. The group was given 13 varieties where each member was given 6 varieties. The group was also taught bean production technologies. Technologies taught are planting beans including recommended spacing, insect pest control and different bean varieties.

Varieties evaluated in on-farm work were Wanja, BILFA 16, BILFA 8, BILFA 4, RAO 55, Uyole 94, Uyole 96, Kabanima, Uyole 98, 4 NRI lines and CAL 143 whereby each member was given 0.25 kg or each of 13 varieties in different combinations. Each member harvested an average of 1kg per variety. Varieties that showed tolerance to drought were Wanja, NRI line (Urafiki), BILFA lines and Uyole 96; other varieties were susceptible. Some of the varieties are susceptible to diseases when conditions are favourable and are also attacked by field and storage pests.

The most palatable varieties are Wanja, Uyole 98 and Urafiki. Traders like variety Wanja, BILFA lines, Kabanima, Urafiki, Uyole 94, Uyole 96 and Uyole 98. Traders from Makambako buy beans at harvest. At planting time, farmers buy seeds and sometime member give seeds to their relatives as shown in Table 6.

Table 1: Bean sales and seed distribution by group members to various individuals, 2005

Name of Member	Number of buyers	Buyers from Makambako	Number received as gift	Outside the village
Mario Mgeni	5	3	1	-
Talita Nduye	7	6	2	1
Rehema Kidimba	9	5	4	1
Rehema Msigwa	3	2	2	-
Magadelena Mtokoma	2	-	1	-
Betwery Mgeni	1	-	1	-
Elizabeth Mabena	1	-	1	-

In conclusion the group thanks ARI – Uyole Bean Breeding for providing seeds of different bean varieties which have been very useful for food and income generations. The group also request new bean varieties, which described in new posters (The request was hanoured by giving more seeds for 2005/06 season).

DISSEMINATION OF NEW BEAN VARIETIES IN MBOZI DISTRIC, 2003- 2005

Joseph Mwampashi (Farmer)

Ivwanga Village, Mbozi, Mbeya Region

Introduction:

New bean varieties were disseminated together with knowledge on bean production technology, particularly soil fertility management and bean stem maggot control. The work was done in collaboration with farmers, extension, ADP Mbozi and churches.

List of villages the seeds through on-farm variety evaluation and bean production technologies from ARI – Uyole is shown in Table 1.

Table 1: List of villages which participated in on-farm bean variety evaluation and introduction 2003 – 2005, Mbozi district:

Village	Wards	Villages	Wards
Ivwanga	Mlowo	Ichesa	Igamba
Mlowo	Mlowo	Igamba	Myovizi
Nambala	Mlowo	Mbulu	|Myovizi
Msanyila	Igamba	Isansa	Isansa
Hatelele	Igamba	Old Vwawa	Vwawa
Shiwinga	Igamba	Isangu	Vwawa
Hasamba	Vwawa	Ichenjezya	Vwawa
Ilembo	Vwawa	Ilolo	Vwawa

Churches that participated in bean variety dissemination and bean technologies are Evangelical Lutheran Church of Tanzania (ELCT) - Mlowo, Calvary Church - Hatelele and Anglican Church - Ilembo.

Bean varieties introduced

16 bean varieties were introduced into to the villages through on-farm variety evaluation in collaboration with farmers, EO, churches and research staff since 2003. Varieties introduced were Wanja, RAO 55, Uyole 03, CIM 9411-4, BILFA No.4 UBR25, Sugar 131, Kablanketi No.1 (local) Kablanketi No.2, Kablanketi No.3. BILFA No.8, BILFA No.16 (BILFA – Uyole), Uyole 98, Uyole 98 Pale (Uyole 04), Uyole 94 and NRI (Urafiki).

After harvest, beans were assessed by farmers, traders and consumers for culinary factors, seed types, general performance and market. Varieties selected as the best choice from the results were Wanja, Urafiki, BILFA No.16 (BILFA – Uyole), Uyole 96, Uyole 03, Uyole 04 and BILFA No.4.

After field observations, evaluation of culinary factors and cooking time, the 12 groups who participated requested seeds to increase production. Each group was given 20kg of their chosen variety. Variety Uyole 96 was planted in Vwawa, Ichenjezya and Msanyila villages while variety Uyole 98 was planted in Old Vwawa, Isangu, Hatelele, Ichesa, Mlowo, Ilolo and Ivwanga villages. Uyole 03 and Urafiki were planted in Ilembo and Wanja was planted in

Hasamba villages. Farmers also multiplied seeds of their other varieties because the bean programme was not able to supply more seeds.

Distribution of additional 400 kg of seeds provided through DALDO's office.

The bean programme also supplied to DALDO a total of 400 kgs of varieties Uyole 96 (200kgs), Uyole 98 (100kgs) and Wanja (100kgs) in March 2005. The seeds were distributed to 10 wards as shown in Table 2.

Table 2: Distribution of 3 bean varieties and the average yields obtained in 10 wards in Mbozi district.

S/No	Ward	Bean Variety	Amount distributed (kg)	Average yield obtained per acre (kg)
1	Vwawa	Uyole 96 Uyole 98 Wanja	19 6 19	300 300 300
2	Halungu	Uyole 96 Uyole 98 Wanja	30 5 5	300 300 300
3.	Isandula	Uyole 96 Uyole 98 Wanja	2 2 2	400 400 400
4	Nyimbili	Uyole 96 Uyole 98 Wanja	10 10 10	200 200 200
5	Ruanda	Uyole 96 Uyole 98 Wanja	20 13 0	200 200 200
6	Isansa	Uyole 96 Uyole 98 Wanja	47 18 58	400 400 400
7	Mlowo	Uyole 96 Uyole 98 Wanja	2 16 2	200 200 200
8	Ihanda	Uyole 96 Uyole 98 Wanja	20 20 2	200 200 200
9	Msia	Uyole 96 Uyole 98 Wanja	20 10 10	300 300 300
10	Msangano	Uyole 96 Uyole 98 Wanja	30 10 10	Beans lost due to drought

Achievements in Bean Production

Since the bean variety evaluation, introduction and dissemination programme started in 2003 with ARI – Uyole, average bean yields per acre has increased from 120 kg to 400 kg. Farmers have also started buying seeds rather than expecting offers. Amount of seeds sold through ELCT (Mlowo) was 1200kgs of Uyole 96, 300kgs of Uyole 98 and 100kgs of Wanja in 2005 planting season.

Assessment of spread of Uyole Bean Varieties

Study on spread of Uyole bean varieties was conducted in Vwawa, Mlowo and Tunduma markets in July 2005. Results have shown that some of the varieties like Uyole 96, Uyole 98 and Wanja are sold in the markets.

SESSION FOUR

DISCUSSION, GROUP WORK, RESOLUTIONS

Research, farmers and extension groups discussed strengths, weaknesses and solutions for access to information and seed supply. All the points given were presented and discussed as shown below.

A. RESEARCHERS GROUP

Access to Information

STRENGHTS	WEAKNESS	SOLUTIONS
1. On-farm trials	1. Low coverage 2. Expensive 3. Weather fluctuations	• Involve more stakeholders • Solicit more funding • Water harvesting • Emphasis on drought tolerant cultivars.
2. Leaflet and Posters	1. Expensive 2. Poor distribution 3. Unreliable information centres	• Involve stakeholders • Use mass media • Produce more copies
3. Agricultural shows	1. Limited numbers and are localized in urban areas 2. Difficult to show growing plants.	• Conduct at different levels. • Bi-manual • Flexibility in Timing
3. Exchange visits and field days	Few and expensive	• Sensitize beneficiaries to take more roles. • Cost sharing combined with other activities.
5. VEO's	1. Few 2. Lack of new information	• Involve other actors e.g. NGOs & farmers. • Use FFS • Continuous training of more VEO's

Seed Supply

STRENGHTS	WEAKNESS	SOLUTIONS
1. Foundation seed supply	1. Expensive inadequate supply. 2. Uncertainties in marketing 3. Limited foundation seed farms 4. Weather fluctuations	• Solicit more funding • Involve other stakeholders • Up to-date market information (Internal and External for produce) • Irrigation facilities, disease and drought tolerant varieties.
2. Stakeholders, District Councils, NGOs, Farmer Groups	1. Weak coordination among stakeholders	• Strengthen coordination by streamlining roles
3. On-farm trials	1. Few – limited coverage 2. Inadequate funds	• Involve other stakeholders • Increase research budgets
4. Agricultural shows	1. Private sector have not taken advantage.	• Private sector to take more active part

FARMERS GROUP
Seed Supply

Strength	Weakness	Solutions
Seed available	Difficult supply of seeds	• Linkages between researchers, extensionist and farmers • Establish on-farm seed multiplication • Establish field school for seed multiplication
	Droughts affects bean production	• Constructions of irrigation dams • Grow drought resistant varieties.
Access to Information		
	Information does not reach many farmers	• Leaflets can reach many farmers
	Unreliable beans market.	• Farmer groups information • The government should look for markets in, and outside the country

EXTENSION GROUP
Seed Supply

Strength	Weakness	Solutions
1. Extensions are available	1. No working facilities 2. Few extensionists 3. Extensions are not responsible for controlling agricultural inputs	• Supply of motorcycles, vehicles etc. • Councils to employ enough extensionist • Extensionist to be given tasks/responsibilities to control farm inputs e.g. seeds.
2. Researchers are available	1. Few visits to farmers	• Researchers should be facilitated in order to visit farmers frequently.
3. Seed suppliers/ stockists are available	1. Delay of seed supply	1. Early supply of seeds 2. Extensionists should be allowed to inspect seeds.
Information Systems		
1. Presence of Radio	1 Use only one radio (RTD)	1. Use many radios (RTD, RFM, Radio Maria, Radio One, etc.)
2. Linkages between Extensionist and researchers	2 Lack of working facilities	2. Extensionist and researchers facilitated transport
3. Availability of magazine, leaflets, posters and booklets	3 Few and difficult to reach clients.	3. Improve supply of magazine, leaflets, posters and booklets.
4. Interactions among farmers	4 Inefficient of new technology transfer	4. Educate farmers
5. Farmers training centres	5 Not used effectively.	5. Facilitate them financially.

QUESTIONS AND ANSWERS

Q1. What is the yield potential of Wanja under Mbozi condition

A: Generally Var. Wanja can yield 1.5 – 2.0 t/ha under research conditions and 1.0 – 1.5 t/ha under farmers conditions.

Q2. Farmer wanted to know the programme for water harvesting and building of dams

A: The water harvesting issue was regarded as a policy issue

Q3. Farmer from Mbarali district requested for help is for funds and technology in construction of dams

A: Farmers were advised to present the problem to the council to be included in development programmes like the example for Njombe district

Advise was given

RESOLUTIONS

1. Continue using improved bean seeds
2. Produce beans for business by using improved new technologies
3. Researchers and other stakeholders work together to supply information of improved seeds.
4. Need of forum to involve other stakeholders to share (Cost sharing) and exchange experiences on beans production.
5. Means of rain water harvesting given more priority.
6. Researchers to produce foundation seeds and promote to farmers.
7. Establishment of farms for seed production
8. Strengthening of marketing groups.

CLOSING REMARKS OF THE WORKSHOP

A.A. Kisengo

The Workshop was closed by representative from CARITAS, Mbeya by thanking all the participants for their valuable contributions and observations to the workshop. More collaboration between all the stakeholders was stressed.

Appendix 1: TIME TABLE - BEAN VARIETY PROMOTION WORKSHOP 26/9/2005 YOUTH CENTRE

Time	Activity	Responsible	Repotour	Chair Person
8.00 – 8.30	Participants Arrive/Registration	Mosses & L. Majaliwa	F.Mosses & L. Majaliwa	
8.30 – 9.15	Registration +(Submit receipts)	Mosses & L. Majaliwa	F.Mosses & L. Majaliwa	
9.15 – 9.30	Opening Remarks	RAA Mbeya	D. Kabungo	ZDRD
9.30 – 9.45	Self Introduction	Participants	A. Magelanga	
9.45 – 10.30	Overview and Project Objectives	Dr. R. Hillocks		
10.30 –11.00	TEA BREAK & VIEW DISPLAYS	M.Kilango and Bean Technicians		
11,00-11.15	Overview of Bean Varieties	Dr. C.S. Madata		
11.15-11.30	Overview of IPDM	F. Mwalyego		
11.30-12.00	Farmers' bean information systems	Prof.C. Garforth		
12.00-12.30	Farmer Education	Ms. Mary	M. Kilango	
12.30 – 12.50	Seed systems: experience in Njombe	Makafu	A. Magelanga	ZRC
12.50 –1.10	Extension in Tech.Transfer	DALDO(MbR)		
1.10 – 1.40	Farmers Experiences	J. Mwampashi		
1.40.2.40	LUNCH AND VIEW DISPLAYS	Bean Technicians		
2.40 – 3.20	Group Work On The Way Forward Farmers, Extension. Research, NGO's, Farmer Education	All Groups	F. Mwalyego	Ag. HSEU
3.20 – 4.00	Group Presentation	All Groups	D. Kabungo	(J. Mwakasendo)
4.00 – 4.30	Discussions	All		
4.30 – 5.00	Resolutions	ZRELO 1 Farmer Dr. C.S. Madata		
5.00 – 5.15	Closing remarks	CARITAS		

Appendix 2:

BEAN SEED PROMOTION WORKSHOP – 26TH SEPTEMBER 2005

ATTENDANTS

S/No.	Name	Designation	Location
1.	D. Kabungo	Researcher	ARI - Uyole
2.	F. Mosses	Field Officer	ARI – Uyole
3.	A. Magelanga	Researcher	ARI – Uyole
4.	Gaudens Masebo	Ag. Manager	Laela Agric. Centre
5.	Juma Mwampiki	Farmer	Usangu/Mbarali
6.	Hawa Bakari	Farmer	Usangu/Mbarali
7.	Getruda Mwalyambi	Farmer	Iyawaya/Igawilo
8.	W. Mtinde	Farmer	Iyawaya/Igawilo
9.	Nicholaus Mbogamchungu	Farmer	Nkansi
10.	Ulindula Msomba	Divisional Executive Officer	Nkansi
11.	Dr. C.S. Madata	Researcher	ARI – Uyole (Bean Breeder)
12.	J.A.Kamasho	Researcher	ARI – Uyole
13.	Michael Kilango	Researcher	ARI – Uyole
14.	Julius Sanga	Field Officer	ARI – Uyole
15.	C. Kabungo	Researcher	ARI – Uyole
16.	Tenes Kapufi	Farmer	Farmer Rukwa
17.	Joseph Mwampashi	Farmer	Farmer Mbozi
18.	Dr. M.A.M. Msabaha	Zonal Director	ARI – Uyole
19.	M.O. Mhando	Extensionist	Mbeya Municipal
20.	E.D.Y. Kiranga	Researcher	ARI – Uyole
21.	F. Mwalyego	Researcher	ARI – Uyole
22.	O.M. Mwakalindile	Field Officer	ARI – Uyole
23.	F.C. Mlowe	DALDO	Nkansi
24.	P.S. Asilia	Extensionist	Mbeya Municipal
25.	L.A. Majaliwa	Field Officer	ARI – Uyole
26.	Rehema Kidumba	Farmer	Farmer Njombe
27.	A.A. Kisengo	CARITAS	Mbeya
28.	Naftali A. Mvado	DALDO	Njombe
29.	C.E. Mtono	DALDO	Mbeya
30.	Pius Mwashikumbulu	DALDO	Mbozi
31.	Lebi Gabriel	ADP	Isangati
32.	Peter Shukwa	Farmer	Iyawaya
33.	Lyson Mbwaga	Field Officer	ARI - Uyole
34.	Pendo Nkoswe	Farmer	Mbozi
35.	Renato Makafu	Divisional Extensionist	Njombe
36.	R.S. Kiboko	Field Officer	ARI - Uyole
37.	Mario P. Mgeni	Extensionist	Njombe
38.	J.S. Kitangalala	Regional Agric. Advisor	Mbeya
39.	Mariam D. Kazi	Extensionist	Mbozi
40.	Charles Mwanzandaje	Farmer	Mbozi
41.	Edward Mogha	Farmer	Mbarali
42.	Haribu Ismail Zuberi	Field Officer	ARI - Uyole

Appendix 5. Working Paper A1145/2

Phaseolus bean improvement in Tanzania, 1959 – 2005.

R. J. Hillocks[1], C. S. Madata[2], R. Chirwa[3], E. M. Minja[4] and S. Msolla[5].
[1]Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent ME4 4TB. [2]Uyole Agricultural Research Institute, PO Box 400, Mbeya, Tanzania. [3]CIAT [Malawi], Chitedze Research Station, Box 158, Lilongwe, Malawi. [4]CIAT Arusha, P O Box 2704, Arusha, Tanzania. [5]Sokoine University of Agriculture, PO Box 3010, Morogoro, Tanzania.

Key words: *Phaseolus vulgaris*, common bean, improvement, breeding

Summary
Common bean is an important source of dietary protein and starch in Africa and a primary staple in parts of the Great Lakes Region. Tanzania remains one of the worlds' major bean producing countries. The main international bean improvement programmes are run by CIAT from Colombia and by the CRSP Bean improvement Programme, co-ordinated by the Land Grant Universities in the USA. CIAT also maintains the world's largest collection of *Phaseolus* germplasm. The National Bean Programme in Tanzania is supported by both CIAT and CRSP. Collaboration between these international programmes and the National Programme has resulted in the release of more than 20 improved bean varieties. The paper reviews the development of bean improvement programmes in Tanzania since 1959, the contribution made by the international programmes and the strategies used to develop high-yielding beans with resistance to pests and diseases and tolerance to some edaphic stress factors.

Introduction
The common bean [*Phaseolus vulgaris* L.] is one of the principle food and cash crop legumes grown in the tropical world and most of the production takes place in developing countries (Pachico, 1989). Beans are a major staple in eastern and southern Africa, where they are the second most important source of dietary protein after maize and the third most important source of calories after maize and cassava. Although beans are grown largely for subsistence and mainly by women farmers, about 40% of the total production from Africa is marketed, at an average annual value of USD 452 million (Wortmann *et al*., 1998). In some parts of Africa, annual per capita consumption is higher than the average for Latin America (Kirkby, 1987). The high protein content of common bean supplements diets based on cereals, root and tuber crops and banana. Beans contain 20 – 25% protein, mainly in the form of phaseolin. Phaseolin is deficient in methionine but most cereals have adequate levels of sulphur amino acids [although deficient in lysine], and a balanced diet can be obtained if cereals and legumes are consumed in the ratio 2:1 (Broughton *et al*., 2003). The leaves can be consumed as a green vegetable and in some areas including southern Tanzania, this is an important consideration in the varieties grown.

Beans are the main grain legume crop grown in Tanzania, where they are often intercropped with maize. Cultivation of beans can be seen in most areas of Tanzania, but the crop does not tolerate prolonged periods without rainfall, and to obtain a reliable yield in the drier areas requires irrigation. The main areas of production are therefore the mid to high altitude areas of the country, which experience more reliable rainfall and cooler temperatures. The most suitable areas for bean cultivation in Tanzania are in the northern zone particularly Kilimanjaro and Arusha Regions, the Great Lakes region in the west and in the Southern Highlands. Most of the bean production in Tanzania is carried out by smallholders for their own consumption, with around 20% surplus being marketed. In Kilimanjaro and Arusha Regions, where there is a suitable climate for commercial bean cultivation [and access to an international airport], beans are grown for export, either as seed for northern producers, haricot beans for the canning industry, or as fresh green beans. Tanzania is among the top twenty largest producers of dry beans in the world and the second largest producer in sub-Saharan Africa, after Kenya [Table 1.]. In 2004 the country produced 270,000 Mt. (According to C. Madata, this may be an underestimate). There was a large increase in bean production between 1960 when 80,000 Mt were produced, and 1980 when production reached 282,000 tonnes [FAO, 2005]. In the same period, the Tanzanian population grew from 11 million to around 20 million and by 2005, the population had reached 38 million. Between 1960 and 1980 therefore, increases in bean production more than kept pace with population increase, but since

1980, based on FAO statistics, total bean production has remained static while the Tanzanian population has almost doubled.

Average bean yields in Tanzania are around 500 kg/ha although the potential yield under reliable rain-fed conditions is 1500 – 3000 kg/ha, using improved varieties and proper crop and land husbandry. The main reasons for the poor yield obtained by most smallholders are; poor seed quality, poor performance of the local landraces, mainly due to their susceptibility to pests and diseases, low soil fertility, drought and poor crop management, such as late weeding.

The bean crop may be attacked by a wide range of insect pests, diseases and nematodes. Many of these are a major cause of yield loss in East Africa (Table 2.). Insect pests attack all parts of the bean plant from the roots and lower stem, through to the pods and seeds. One of the major bean insect pests in East Africa is the beanfly or bean stem maggot, *Ophiomyia phaseoli* and *O. spencerella*. During the seedling stage the chrysomelid beetle, *Ootheca bennigseni* and *O. mutabilis* may seriously damage the leaves and the larvae damage the roots. Aphids (*Aphis fabae, A. craccivora*) are sometimes a problem on beans during dry spells, especially in the early stages of crop growth. The most serious of the pod borers in Tanzania are *Maruca vitrata* and *Helicoverpa armigera*. The most important insect pests in stored beans are the bean bruchids (*Acanthoscelides obtectus* and *Zabrotes subfaciatus*) (Schwartz and Pastor-Corrales, 1989; Allen *et al*., 1996).

Of the large number of diseases that can affect beans in the tropics, the most important in Tanzania are angular leaf spot [ALS](*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*), halo blight (*Pseudomonas phaseolicola*), rust (*Uromyces phaseoli*), and *Bean common mosaic virus*[BCMV] (see Allen, 1983; 1995; Allen and Lenne, 1998). In warmer areas, damage due to common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) may be substantial. On sandy soils the root-knot nematodes *Meloidogyne incognita* and *M. javanica* can be a problem (Ijani *et al*., 2000). Depleted soil fertility is associated with an increase in root rot diseases caused by *Pythium* spp. and *Fusarium* spp.

Besides crop losses to biotic constraints, further loss of yield potential may be attributed to edaphic constraints, even in developed countries (Boyer, 1982). In Tanzania much of the agriculture is rainfed and low-input, resulting in low yields. Drought remains the single most important factor affecting food security in sub-Saharan Africa. In the past few years the northern mid-altitude highlands of Tanzania and other major bean production areas have experienced a series of droughts, which have resulted in reduced bean production. Higher temperatures associated with global climate change are likely to exacerbate these more frequent droughts (IPCC, 2001).

Some of the major bean production areas such as the Usambara and Uluguru Hills in Tanzania, have acid soils with pH $\leq$ 5.5, which limit crop productivity (Wortmann et al 1998). Under increasing population pressure, acid soils are now rapidly being brought into cultivation in many parts of Africa, including Tanzania. Most published research however, focuses on individual abiotic stress factors, but multiple edaphic stresses often occur simultaneously in farmers' fields. For example, drought is often accompanied by high temperature and high photosynthetically active radiation, and can be exacerbated by subsoil Al toxicity, which reduces root elongation, limits water and nutrient use by crops, and magnifies the effects of moisture deficit (Rao and Cramer, 2003). If due to climate change these problems intensify as is predicted, the interaction of drought and Al toxicity will become more acute.

Phaseolus gene pools

There are about 50 – 60 wild *Phaseolus* species found in the South American Centre of diversity. Five of these have been domesticated; common (*P. vulgaris*), yearlong (*P. polyanthus*), scarlet runner (*P. coccinueus*), tepary (*P. acutifolius*) and lima (*P. lunatus*). Each domesticated species constitutes a primary gene pool with its wild ancestral form. Wild beans dispersed northwards and southwards to form two geographically distinct gene pools in Mesoamerica and the southern Andes (Broughton *et al*., 2003). Domestication gave rise to several domesticated races in each of the two gene pools; races Mesoamerica, Durango, Guatemala and Jalisco in the Mesoamerica genepool and races Nueva Granada, Peru and Chile within the Andean gene pool (Sing *et al*., 1991; Chacon *et al*., 2005). The two distinct gene pools may be regarded as sub-species on the basis of their partial reproductive isolation resulting from F_1 lethality. As a consequence, it has proved difficult to transfer traits between gene pools. Where success has been achieved in transferring qualitative traits such as pest and disease resistance from wild species, this has been done by inter-racial crosses within the same gene pool (Kelly, 2004). However, the use of inbred backcross breeding and molecular markers is making it possible to exploit the variability in wild species by identifying quantitative traits that contribute to yield enhancement and which were previously masked by undesirable morphological characteristics. CIAT maintains a collection of over 13,000 wild *Phaseolus* accessions and there are over 11,000 in the USDA Plant Germplasm System. A full evaluation of these collections for economically useful traits is only just beginning, but it is already known that the wild accessions are a source of resistance to several pests and diseases. Resistance to bruchid was found in wild accessions of *P. vulgaris*, while tepary bean (*P. coccineus*) is a source of resistance to anthracnose, white mould and root rots, common bacterial blight and bruchids (Kelly, 2004).

Biotechnology for bean improvement

Marker-assisted selection

Genetic linkages between desirable traits and markers that can be detected using PCR-based techniques such as Random Amplified Polymorphic DNA [RAPD], are now being exploited in bean breeding programmes (Kelly et al., 2003). To improve reproducibility of RAPD markers, sequence characterised amplified region (SCAR) markers, derived from corresponding RAPD markers, have become the basis for the indirect selection of economically viable traits in bean breeding (Kelly, 2004). For instance, markers linked to race specific disease resistance genes form the basis for indirect selection for major gene resistance. Marker-assisted selection (MAS) offers a way to overcome problems of masking of hypostatic genes and inadequate inoculation techniques, resulting in disease escape in conventional screening. It has also been possible to identify linkages between markers and quantitative trait loci controlling complex traits such as stress tolerance (Schneider *et al*., 1997).

Two RAPD markers linked to major rust resistance genes have been identified in contrasting DNA bulks (Johnson *et* al., 1995). Common bacterial blight resistance loci have been mapped using RAPD markers (Jung *et al*., 1995). RAPD markers flanking the ‘ARE’ anthracnose resistance gene have been identified in both Andean and Mesoamerican bean populations (Young and Kelly, 1996). A number of other RAPD markers linked to major gene resistance have been identified in common bean (Kelly and Miklas, 1998, Kelly *et al*., 2003) (Table 3).

Genetic transformation

Transformation of large-seeded leguminous species is often difficult (Broughton *et al*., 2003). Aragao *et al*. (1996) obtained transgenic bean plants using particle bombardment and the transformed plants were reported to be stable and some of the traits to be heritable. Aragao *et al*. (2002) used the same method to obtain herbicide-tolerant plants although only 0.5% of the regenerated plants carried the trait. The same laboratory claims to have genes for resistance to abiotic stress (Svetleva *et al*., 2003). A number of laboratories have reported successfully carrying out genetic transformation of *P. vulgaris* using *Agrobacterium*-mediated methods for whole plants, or using protoplasts (*e.g.* Svetleva *et al*., 2003). A protocol for developing transgenic bean plants expressing the Cry2 gene from *Bacillus thuringiensis* [Bt], using *A. tumefaciens* was described by Suresh *et al*. (2000), but the production of stable transformed plants by this method has proved difficult. Transformation is easier with tepary bean than with common bean (De Clerq *et al*., 2002) and it should be possible to introduce genes from *P. vulgaris* into *P. acutifolius* by this method and then backcross into *P. vulgaris* (Broughton *et al*., 2003).

Important selection criteria in bean breeding programmes

Breeding primarily for enhanced yield is a strategy that works better for advanced agriculture than for low-input smallholder agriculture. Yields obtained by the average smallholder in Tanzania are well below the genetic potential of improved varieties currently available. Therefore, it follows that new varieties are unlikely to be adopted if they offer only the expectation of higher yields under optimum conditions. Although it has been recognised for many years by scientists that damage caused by pests and diseases contributes greatly to poor smallholder bean yields, disease resistance alone is not attractive to smallholders who may have a poor understanding of aetiology. Communities in the main bean-growing areas in Tanzania commonly grow a mixture of local ‘land races’ and may add improved varieties to the mixture. Although many of the local land races are inherently low-yielding, each component of the mixture will have an attribute that prevents the whole crop from being lost to particular biotic and edaphic constraints (Bisanda, 2000). A combination of multiple attributes such as, yield enhancement and disease and pest resistance or tolerance to drought and low soil fertility, are required to develop bean varieties that are adapted to a wide range of bean production agro-ecologies. Such biological attributes however, must be combined further with other traits that make a bean variety attractive to smallholders; desired seed colour and size, suitable taste and good cooking qualities such as forming a thick broth, and short cooking time. The absence of a combination of a few of these attributes is considered to be a major factor in low adoption rates of improved varieties (Sanchez, 2002). This has resulted in a change in emphasis in bean breeding programmes for smallholders in Africa, shifting towards selection for improved performance under adverse conditions, using more participatory approaches to variety selection, ensuring that new varieties meet the culinary and organoleptic requirements of the end-users. The ideal smallholder bean variety must meet these socio-economic criteria, as well as being able to produce higher yields than the local varieties under conditions of low soil fertility, periodic drought and attack by an array of pests and diseases.

Disease resistance

Breeding beans for disease resistance up to 1990 is well reviewed by Beebe and Pastor-Corrales (1991) and is updated by Allen *et al*, (1998) and by Kelly (2004). It is summarised briefly below. More information particular to Tanzania can be found below in the section on bean improvement programmes.

Anthracnose - There is strong evidence for co-evolution of many of the bean pathogens with their host within the two centres of origin for *P. vulgaris*. Varieties that are resistant to races of *C. lindemuthianum* from Central America are susceptible to those from the Andean Region (Beebe and Pastor-Corrales, 1991). Until it proved susceptible to races of the pathogen from Europe and Latin America, Cornell line 49-242 was the main source of resistance. The ARE resistance genes from 49-242 are still used in combination with other resistance genes for more stable resistance (Graham and Ranalli, 1997). When 20,144 bean accessions were evaluated by CIAT in Colombia, 350 of them were found to be resistant to Andean and Mesoamerican isolates of the anthracnose pathogen e.g. Mex 222, Ecuador 299, PI207262, G2333, G811 and G2641 (Pastor –Corrales *et al*., 1994). G2333 of Mexican origin has for many years continued to exhibit resistance to anthracnose and is a valuable source of resistance (Allen *et al*., 1998). Cultivar G2333 has resistance to 380 isolates of *C. lindemuthianum* conferred by three independent dominant genes. Due to the variability of the pathogen, durable resistance to anthracnose requires a combination of genes. Such gene pyramiding is difficult to achieve with conventional breeding due to the need to inoculate with a wide range of races. In the absence of effective selection due to lack of differentiating races, epistatic interactions between resistance genes prevent the identification of masked alleles which may be lost from breeding populations (Kelly and Miklas, 1998). Marker-assisted selection enables hypostatic genes to be retained in the breeding population. Chinook, a light red kidney cultivar and Red Hawk, a dark red kidney cultivar, carry both the *Co-1* and *Co-2* anthracnose resistance genes (Beaver *et al*., 2003). The gene *Co-4*^{2} confers resistance to 97% of American races of the pathogen (Balardin and Kelly, 2001). Ten major genes conditioning resistance to anthracnose have been characterised and markers linked to six independent dominant genes have been identified (Vallejo and Kelly, 2001).

Angular leaf spot – There is considerable pathogenic variability in *Phaeoisariopsis griseola* and a set of six differential cultivars have been identified (Allen *et al*., 1998). Fifty-six resistant genotypes were selected from a collection of 13,000 accessions screened at CIAT (Schwartz *et al*., 1982). These formed the basis of an international nursery containing several sources of broad-based resistance to the disease. CAL 143 was one of the first Andean beans to be identified with resistance to ALS and has proved to be resistant in Malawi, South Africa and Tanzania (Aggrawal *et al*., 2004).

Halo blight – There are at least 9 races of *Pseudomonas phaseolicola* recognised, infecting a range of legume species (Taylor *et al*., 1996a,b). Races 1,2 and 6 of the halo blight bacterium are found worldwide, while races 3,4, 5 and 8 were confined to eastern and southern Africa. Races 1(45%), 2 (52%) and 3 (3%) were reported from common bean in southern Tanzania (Mabagala and Saettler, 1992). Genes used in breeding for halo blight resistance are derived from two main sources: cv. Red Mexican (resistant to race 1) and PI 150414 (resistant to races 1 and 2).

Rust – U. appendiculatus is a macrocyclic rust pathogen with numerous races and changes in virulence are frequent (Alexander *et al*., 1985). Race non-specific resistance has been reported in bean populations (Mmbaga and Steadman, 1992) and would offer a more durable approach than race-specfic resistance. A wide range of rust-resistant germplasm has been produced and tested since 1984, but none has remained resistant across all sites and seasons. Some of the more resistant cvs are Mexico 309, Ecuador 299, Relands Greenleaf, Turrialba 1 and 4 and Puerto Rico 5 (Allen *et al*., 1998). Efforts are currently being made to identify the rust races in East Africa. The Andean *Ur-4* gene for rust resistance is ineffective against African races, *Ur-3* confers resistance to most African races and to all known African rust races when combined with *Ur-5* (Beaver *et al*., 2003)

Common bacterial blight – X. campestris pv. *phaseoli* has a wide host range among legume species. Although isolates vary in pathogenicity, physiologic specialisation on *P. vulgaris* is unknown. It has not proved possible to find high levels of resistance to bacterial blight in *P. vulgaris* and out of 12,000 accessions screened at CIAT, only 39, mainly from the Andean gene pool, were found with moderate resistance (Allen *et al*., 1998). Resistant lines such as Great Northern Nebraska 1 and PI207262, bred in temperate programmes are useful as sources of resistance but are poorly adapted agronomically and unsuitable for use in the tropics. The tepary bean, *P. acutifolius*, has proved to be a good source of resistance to CBB. Lines XAN 159, 160 and 161 are highly resistant to CBB and were selected during the early 1980s, from populations derived from crosses with tepary bean PI319433 (Thomas and Waines, 1984). Lines such as XAN 112 suffer little crop loss from CCB in Africa and resistance is quantitative and is expected to be durable (Opio *et al*., 1992; 1996). There is great potential for the use of markers to assist breeders to distinguish between resistance loci. The pyramiding of qualitative genes from common and tepary bean will contribute to more effective durable resistance to CBB in the future (Kelly *et al*., 2003).

BCMV – Bean common mosaic virus is aphid-transmitted and can be seed-borne, facilitating spread over long distances. There are two serotypes of the bean mosaic virus that are now recognised as separate viruses. Strains in Serotype A types do not cause symptoms of root necrosis, known as 'black root' and are classified as BCMV. Strains in Serotype B cause black root in bean cultivars carrying the 'I' gene for resistance, and are classified as *Bean common mosaic necrotic virus* (BCMNV). BCMNV is predominant in eastern and southern Africa (Spence and Walkey, 1991; 1995) and therefore cultivars carrying the 'I' gene are prone to black root. This problem can be overcome by combining I-gene resistance with recessive resistance genes that prevents the systemic necrosis reaction (Mukoko *et al*., 1994). Markers linked to the I gene have been used to develop enhanced germplasm with the I + *bc-3* gene combination (Kelly, 2004).

Multiple disease resistance – in most bean growing areas of Tanzania, bean yield is affected by at least three diseases and if improved varieties are to be successful, multiple disease resistance is required. Four genotypes were identified in the 2004 CIAT bean project with resistance to ALS, anthracnose and ashy stem blight (*Macrophomina phaseolina*) and several HGA lines were identified with combined resistance to rust, CBB, anthracnose and ALS (CIAT, 2005b).

<u>Insect resistance</u>
Bruchids - the bruchids *A. obtectus* and Z. *subfasciatus* are widespread in Africa. In Tanzania. *A. obtectus* is the more prevalent bruchid in the south and west but in warmer, lower altitude areas, *Z. subfasciatus* is the more prevalent. The importance of *A. obtectus* has been underestimated in the past due to seasonal variations in the relative occurrence of the two bruchids (Nchimbi-Msolla and Misangu, 2001; Myers *et al*., 2001). Bruchid resistance has been identified in wild *P. vulgaris* from Mexico (Schoonhoven *et al*., 1983). Resistance to *Z. subfasciatus* has been associated with the presence of a seed protein, arcelin (Osborne *et al*., 1986, 1988). Since 2004, lines containing arcelin alleles have been evaluated for bruchid resistance in several African countries, including Tanzania. The arcelin alleles Arc 2 and Arc 4 have been transferred into locally adapted, high yielding varieties, conferring resistance to both types of bean bruchids. A polysaccharide in the wild accession G12953 is suggested as another factor responsible for resistance to *A. obtectus*. A CIAT accession of *P. acutifolius*, G40199, was reported to show a high degree of resistance to *A. obtectus* at SUA (Nchimbi-Msolla and Misangu, 2001). Resistance to bean bruchid has also been identified by CIAT in Colombia, in progeny from interspecific crosses between *P. vulgaris* and *P. acutifolius* (CIAT, 2005b).

Beanfly – Bean varieties with tolerance to beanfly have been reported (Kornegay and Cardona, 1998) and this is often related to their ability to recover from attack by producing adventitious roots. High levels of resistance to *O. phaseoli* have been found in *P. coccineus* germplasm and progeny from interspecific crosses with *P. vulgaris* have proved to be resistant (Kornegay and Cardona, 1998).

One of the major challenges in bean breeding for resistance to bean fly is to develop a systematic screening procedure that provides a consistent bean fly population exerting pressure uniformly on each genotype. A mass rearing technique has been developed by scientists in South Africa that provides for a steady population of bean flies that can be used under controlled conditions in screening for resistance. Its practical application is however, yet to be documented. Using natural bean stem maggot population, CIAT-Tanzania identified a few lines (Mlama 49, Mlama 127, G22501, ZPv 292, SINON, PAD3, IKINIMBA) that showed some resistance to bean fly. Some of them are currently used as sources of resistance in both ECABREN and SABRN regional bean breeding programmes (Chirwa *et al*, 2003).

<u>Drought tolerance</u>

It has been estimated that about 40% of bean production in Africa takes place in environments subject to moderate to severe mean water deficit (Broughton *et al*., 2003). Attempts to breed beans for drought tolerance have been hampered by the lack of clearly defined selection criteria, as the trait is likely to be based on a number of different mechanisms. Drought tolerance must be distinguished from drought escape due to early or late maturity. Nevertheless, some success has been achieved by CIAT breeders simply by selecting for yield under dry conditions (White and Singh, 1991). Drought tolerant lines SEA 5 and SEA 13 were developed at CIAT using this approach (Sing *et* al., 2001). CIAT cultivars BAT477 and RAB96 have performed well under drought conditions and were recommended in Brazil for breeding programmes (Guimaraes *et al*., 1996). In the CIAT bean project in 2004, RAB 650 and SEA 23 were two lines from the breeding programme with outstanding adaptation to water stress (CIAT 2005). Genetic variability for drought tolerance is low in *P. vulgaris* but the tepary bean, *P. acutifolius* has superior tolerance. Crosses with tepary bean have been recovered at CIAT using ‘embryo rescue’ techniques (White *et al*., 1998).

Bean improvement programmes in Tanzania

<u>Early History 1959 - 1980</u>

The first bean improvement programme in Tanzania was initiated at Tengeru Agricultural Research Institute [TARI], near Arusha, in 1959 to produce white haricot beans for the canning industry. The production of navy beans for export in northern Tanzania had started around 1937 and by 1952, 2500 Mt were being exported. As more, and inexperienced producers became involved, declining quality began to threaten the viability of the trade. In response, the cv. Michigan Pea was introduced from the USA, but proved to be highly susceptible to rust, unlike the cv. it replaced, Comptesse de Chambord (Allen *et al*., 1989). More care was then taken to ensure that introduced material was screened for local adaptability. Mexico 142 proved to have good rust resistance and became one of the most widely grown navy bean varieties in E. Africa. Eighty-two accessions were introduced into the breeding programme at TARI from around the world in 1960/61 (McCartney, 1966). The first varieties to be released from that programme were Tengeru 8 and 16 (T8, T16), both of which were resistant to bean rust. Unfortunately, T8 proved to be highly susceptible to anthracnose (Shao and Teri, 1985).

In the Southern Highlands and Great Lakes regions of Tanzania, landraces of mixed seed types are grown. These are bush types and mainly consumed by the producing households as ‘dry beans’. Although the yield potential of most of these land races is low, they provide the farmer with a reliable yield under low input adverse conditions. In 1971 the first National Bean Improvement Programme in Tanzania, began breeding to improve the quality and yield of dry beans(Karel *et al*, 1981).When the Tengeru bean programme ended in 1965, it was several years before the new bean improvement programme was initiated at the Uyole Agricultural Centre (UAC), Mbeya. The main objectives of this programme were to determine the reasons for poor bean yields among smallholders in the Southern Highlands and to select high-yielding cultivars. Disease was identified as the major yield-limiting factor and disease resistance became the main thrust of the programme. By 1975 a total of 1046 germplasm lines had been collected at three centres; UAC in the south, Ilonga Agricultural Research Institute in the Centre and Lyamungu Agricultural Research Institute [LARI] in the north (Karel *et al*., 1981).

The bean improvement programme was extended in 1975 under the National Grain Legume Research Project, now with Ilonga as the main centre and LARI and UAC as sub-stations. The first improved bean varieties for smallholders, T3 and Kabanima, were released from this programme in 1979/80. Both were resistant to rust and ALS. The national programme was further strengthened when in 1979, the Ministry of Agriculture inaugurated a new phase of bean improvement, based at LARI, with UAC and Ilonga as sub-stations.

From the 1046 accessions that were introduced during the early 1970s, preliminary screening reduced the number to 56 lines that were disease resistant with suitable agronomic and yield characteristics. These were further evaluated at Ilonga and LARI during 1977 and the best 20 lines were evaluated in multi-locational trials in 1978 and 1979. Canadian Wonder [CW] was included as a check and the only variety to significantly out-yield CW was P311-A.L. P113 was fast-growing and disease resistant, but it had a black seed coat colour which was not popular with farmers or local consumers, so it was retained as a breeding line. Lines that performed well during the late 1970s and 80s and have similar seed colour and maturity to CW, were T23, YC-2 and P692-A.

<u>Regional networks</u>
The national bean research programmes in eastern and southern Africa are now linked through the Pan-African Bean Research Alliance [PABRA] consisting of two networks; the Eastern and Central African Bean Research Network [ECABREN] and the Southern Africa Bean Research Network [SABRN]. The networks receive funding from several government and donor organisations, including the Canadian International Development Agency [CIDA], the Department for International Development [DFID], UK, the Swiss Government, the United States Agency for International Development [USAID] and the Rockefeller Foundation. These networks are members of two regional organisations; the Association for Strengthening Agricultural Research in Africa [ASARECA] and the Food, Agriculture and Natural Resources (FANR) network, which operates under the umbrella of Southern Africa Development Community [SADC].

<u>International Programmes</u>
In 1980, The Canadian International Development Agency [CIDA] established the Selian Agricultural Research Institute [SARI] Centre near Arusha, as part of the Tanzania-Canada Wheat Project. Since 1989 SARI has been designated as the Zonal Headquarters for Agriculture and Livestock Research and Training for the Northern Zone of Tanzania. The National Bean Programme was then moved from LARI to SARI and UAC remains as an important sub-station for bean research.

Sokoine University of Agriculture [SUA] was from 1969 the faculty of agriculture of the University of Dar es Salaam. It became a fully fledged university in 1984. The Department of Agriculture at SUA has become another centre for research on *Phaseolus* bean and is the Regional Centre for the Bean/Cowpea Collaborative Research Support Programme [Bean/Cowpea CRSP] – East Africa. SUA is also the national centre for improvement of beans suited to low altitude growing areas of Tanzania.

CIAT Regional Bean Programme
The Centro Internacional de Agricultura Tropical [CIAT] was inaugurated in 1967 and the legume crops component of the Agronomic Systems Programme began work in 1969. CIAT has the global mandate within the CGIAR system for *Phaseolus* improvement. A bean research team has worked at CIAT since 1973, but it was not until 1977 that the Bean Programme was formally initiated. From 1997 bean research has been based on two projects; Project IP-1, Bean Improvement for Sustainable Productivity, Input Use Efficiency & Poverty Alleviation and Project IP-2, Meeting Demand for Beans in sub-Saharan Africa in Sustainable Ways. The first Regional Programme for beans in Africa was in the Great Lakes Region. It was based in Rwanda and launched in 1984 with support from CIDA and USAID. Later, another program for East Africa was initiated, and this was based in Uganda, covering several countries in East Africa. The third program started in 1987, and was based in Arusha, northern Tanzania, which covered countries in the Southern Africa Development Community (SADC). In the mid-90s, the Great Lakes and the

East Africa regional programmes merged, to form one network called East and Central Africa Bean Research Network (ECABREN) operating from Arusha, Tanzania, under the umbrella of the Association for Agricultural Research in East and Central Africa (ASARECA). Simultaneously, the SADC-CIAT program changed to the Southern Africa Bean Research Network (SABRN), which moved it's Headquarters from Arusha in Tanzania to Chitedze Research Station in Malawi, operating under the umbrella of Food Agriculture and Natural Resources (FANR), within the SADC secretariat based in Botswana. The two networks are linked through the Pan-Africa Bean Research Alliance (PABRA) where CIAT is a coordinating partner, and they implement the same PABRA log frame across the member countries. Tanzania, is a large country that cuts across the two agro-climatic environments; bimodal rainfall in the central and northern parts which fall under ECABREN, and uni-modal rainfall in the south which falls under SABRN.

Since 1984 CIAT have introduced improved bean seeds from tropical America into breeding programmes for the mid-altitude and highland areas of central, eastern and southern Africa. The first varieties introduced were climbing types of Mexican origin and have been widely adopted in Rwanda. Climbing beans are being slowly adopted across the region where they are well adapted to maize/bean intercropping.

Sixteen bean varieties have been released in Tanzania since 1980 and several of these have been CIAT lines or were selections made in Tanzania from CIAT crosses (Table 4, 5.) (CIAT, 2005).The earlier improvement programmes selected mainly for disease resistance but more recently, there has been an emphasis on tolerance to drought, low fertility and micronutrient deficiency. In Africa, beans are often produced on soils that are acid, low in available phosphorus [P] and high in aluminium. Symbiotic nitrogen fixation is adversely affected by low P availability. In some areas beans are grown on alkaline soils where iron availability is low and local inhabitants often suffer from iron deficiency (Broughton *et al*., 2003).

One of CIAT's priorities has been to develop PCR-based markers, mainly sequence characterised amplified regions [SCAR] and simple sequence repeats [SSRs]. These markers have been used to tag genes of agronomic importance and selection in marker-assisted breeding programmes. All new markers are mapped onto CIATs principle mapping population which now contains 500 markers. Several mapping populations have been developed at CIAT to tag quantitative trait loci, including tolerance to abiotic stress, micronutrient content and pests and disease resistance. For example, quantitative trait loci [QTLs] have been mapped for low phosphorus tolerance, agronomic performance and disease resistance in a population derived from the cross G19833 x DOR364. The Andean variety G19833 is tolerant to low P and has resistance to anthracnose, ALS and Ascochyta blight. DOR364 is a high yielding variety from Central America (Broughton *et al*, 2003).

MAS has been implemented in East Africa to improve resistance to BCMV and anthracnose in climbing beans. Five SCAR markers have been evaluated for selection of two resistance genes for BCMV; ROC11 for the *bc-3* gene and SW13 for the dominant *I* gene; and three resistance genes for anthracnose; SAS13 and SBB14 for the Co-4 gene and SAB3 for the Co-5 gene (Blair *et al*., 2005).

Conventional breeding methods were used by CIAT in East Africa to develop a population from multi-parent crosses among 51 genetically diverse lines from Andean and Mesoamerican gene pools. Several new lines were selected with combined resistance to ALS, root rot, low soil N, low soil P and low soil pH. These lines are being evaluated in seven countries in the region, including Tanzania (Kimani *et al*., 2005)

ALS is the disease that most affects yield in Tanzania. The CIAT variety CAL 143 (red mottled) has proved to be resistant to ALS when grown in Tanzania, although it is susceptible to one of the races of the pathogen present in Uganda (Aggarawal *et al*., 2004). Some of the lines recently screened in the breeding nursery at Chitedze in Malawi, have out-yielded CAL 143 by up to 18% and perform well in soils with low fertility. CIAT has identified various sources for resistance to ALS (Mexico 54, AND 277, AND 279), which are used in generating crosses within the regional bean breeding programs in Africa, including those by the network partners in Tanzania.

In 2000, CIAT together with the two regional networks in Africa, ECABREN and SABRN, and the collaborating national programs, including Tanzania, developed a bean breeding strategy that focuses on market-led approaches. The types of markets vary from local to regional. Preferences for bean types differ with markets and countries, reflected in the diversity of varieties in the region. The size of markets differs for different bean types. For example, markets for red mottled and reds account for about 50% of the total production in Africa. However, some grain market types (cream mottled, red mottled, dark red kidney, cream, small red and small white), although representing smaller proportions of the total bean market, are popular across several countries and there are great opportunity for their regional marketing. The regional breeding programmes have taken the responsibility to coordinate and technically support breeding activities in these major market classes. Some of the NARS breeding programmes have also been assigned responsibilities for specific market classes, where they have comparative advantage. Within the SABRN, the programmes and collaborating countries are as follows:

<u>1. Red Mottled:</u>
Lead countries: Malawi
Support country RSA – can supply some lines
Important constraints: ALS, low P, BSM (MW)
Anthracnose (Southern Highlands of Tanzania)
Collaborating NARS: Mozambique, Angola and Zambia

<u>2a. Dark Red Kidney :</u>
Lead countries: Zimbabwe
Important constraints: ALS, low P, BSM (Malawi)
Collaborating NARS: Zambia, Mozambique

<u>2b. Small Red beans:</u>
Lead country: Southern Highlands of Tanzania
Important constraints: ALS, Anthracnose, low P and CBB
Collaborating NARS: Zambia, Congo

<u>3. Browns: Yellow, Brown and Tan:</u>
Lead country: Zambia and Southern Highlands of Tanzania
Important constraints: - ALS, CBB, low P;
Collaborating NARS Angola, DRC and Lesotho

<u>4. Cream – Sugar:</u>
Lead countries: South Africa
Important constraints: ALS, CBB, Rust, low P, BSM
Malawi to support in low P and BSM screening
Collaborating NARS: Zambia, Mozambique, Swaziland, Lesotho and Angola

<u>5a. White: Navy (small-white)</u>
Lead country: RSA
Important constraint: Rust, ALS, CBB, BSM (Malawi)
Collaborating NARS: Southern Highlands of Tanzania, Democratic Republic of Congo

<u>5b. White Large:</u>
Lead country: South Africa (Where and when available)
Important constraint: Rust, ALS, CBB, BSM (Malawi)
Collaborating NARS Zimbabwe, Southern Highlands of Tanzania, Zambia, Democratic Republic of Congo

<u>6 Purples:</u>
Lead country: Southern Highlands of Tanzania:
Important constraints: Low P, ALS, CBB
Support country: Zambia

Currently, the CIAT/NARS strategy is to develop improved bean varieties for major market classes, using participatory approaches. The major stakeholders are involved at all stages from problem identification and the development desired solutions, through product identification, promotion and dissemination. The resulting improved bean varieties combine various attributes, ranging from resistance to biotic constraints (diseases and pests) and edaphic constraints (drought and low soil fertility) to culinary and organoleptic characteristics (reduced cooking time, improved nutritive value and market preferences, taste, shelf life after cooking). The strategy recognizes the challenges of incorporating multiple traits in a single cultivar, but it is hoped that as molecular biology tools become more readily available, some biotic and edaphic traits will easily be combined in is a single variety, by use of marker assisted selection.

The main priorities for the bean breeding program are:

- Focus on specific market classes (red mottled, cream mottled, dark red kidney, reds (small and large), small whites (small and large), yellows
- Yield improvement
- Identification, characterization of useful sources of resistance to major biotic constraints (angular leaf spot, common bacterial blight, bean common mosaic virus, rust, anthracnose)
- Identification, characterization of useful abiotic constraints in the pilot site (drought, low P, low N and low pH)
- Identify useful germplasm for productivity in maize-bean intercrop, and for dual purpose legumes (grain and soil fertility improvement)
- Develop germplasm for fast cooking
- Develop germplasm with increased nutritive content (protein, Fe and Zn)
- Develop germplasm for early maturity and better appeal in competitive markets
- Select germplasm that perform well under use of organic and farmyard manures as a means of improving soil fertility, for improved bean production
- Use more innovative means (e.g. PPB), by involving various partners in variety development and selection processes, for intensification and diversification of crop varieties in the farming systems.

CIAT and SABRN are working with NARS partners in Tanzania in developing these new bean varieties, by providing training to develop capacity for generating and handling diverse germplasm. Other partners from the extension services, NGOs and farmer groups are involved in participatory plant breeding (PPB), or participatory variety selection (PVS), including organoleptic tests. Partnerships with the private sector, traders, processors and farmers in product processing or marketing are equally important and these partnerships are proving critical in ensuring seed supply, input and output markets and dissemination of germplasm.

The Bean/Cowpea CRSP

In 1975 the Collaborative Research Support Programme [CRSP] was created by the US AID to focus the capabilities of U.S. Land Grant Universities to carry out the international food and agriculture research mandate of the U.S. Government. The CRSPs are expected to interact with and complement the activities of the National and International Agricultural Research Institutes. The Bean/Cowpea CRSP began in the late 1970s with a research agenda that was to meet the needs of smallholders in countries of East and West Africa, the Caribbean and Latin America. The first grant ran from 1980 to 1986 and the second from 1986 to 2002. The current phase of the Bean CRSP based at SUA in collaboration with Oregon State University and Washington State University, is scheduled to cover the period from 2002 to 2007. The programme also operates from Malawi for southern Africa from a base at Bunda College of Agriculture, near Lilongwe.

CRSP-supported work in East Africa led to the discovery of BCMNV as a separate virus from BCMV (Beaver *et* al., 2003). Two improved bean varieties were released in Tanzania from the earlier grant periods of CRSP. SUA 90 has a khaki seed colour and was released in 1990. ‘Rojo’ is a red kidney type released in 1997. Rojo contains the I gene for BCMV resistance in combination with recessive genes creating a more durable form of resistance without showing ‘black root rot’. Both of the varieties developed in collaboration with the CRSP programme at SUA, are adapted to low and mid-altitude (300 – 1500m) bean agro-ecologies, are high yielding under smallholder conditions (up to 2000 kg/ha) and are resistant to rust, ALS, BCMV and BCMNV. Both varieties show some tolerance to drought, and beanfly [observations in farmers’ fields in northern

Tanzania], are early-maturing (65 – 74 days) and cook more quickly than most local varieties (CRSP, 2005).

Since the release of cv. Rojo, the CRSP at SUA has undertaken further crosses with the following objectives:

- Backcrossing to transfer Arcelin genes to SUA lines to incorporate resistance to bruchid.
- Crosses and backcrossing to improve the popular ‘Kablanketi’ bean types.
- Crosses to incorporate root-knot nematode resistance for beans grown on sandy soils.
- Crosses to decrease the cooking time of some of the best SUA lines.
- Crosses to incorporate disease resistance: ALS, CBB, BCMV and BCMNV

The new Bean/Cowpea CRSP Programme running from 2002/03 – 2005/06 is entitled; Regional Bean/Cowpea Consumption and Production in Africa and Latin America. The programme places a stronger emphasis than previously on improving quality and developing markets for beans and value-added products. In the Programme for Eastern and Southern Africa, three projects are concerned specifically with breeding for bean improvement:

1. Edaphic constraints to bean production in Eastern Africa: The selection of bean cultivars and *Rhizobium* having tolerance to low N and P and ability to grow at acid pH.

2. Developing bean cultivars for eastern and southern Africa with enhanced resistance to diseases and insects.

3. Using marker-assisted selection to improve selection efficiency in East and Southern Africa and US programmes.

Project No 2 above has the following objectives:

- Evaluate promising bean lines with resistance to ALS and BCMV in on-farm field trials and multiply seed: 15 most promising lines selected from three populations developed by the National Bean Breeding Programme at Uyole.
- Evaluate germplasm and preliminary and advanced lines for resistance to diseases and abiotic stress: Advanced lines were obtained from crosses between the local variety ‘Kablanketi’ and SUA 90 or ‘Rojo’, that were backcrossed to Kablanketi. These were evaluated at SUA and Selian Centre. Ten drought resistant lines were identified at SUA and have been evaluated in on-farm trials.
- Incorporate and evaluate arcelin alleles to protect against bruchids and to release arcelin-protected materials: SUA to evaluate Rojo with Arc2 and Arc 4 alleles for resistance to bruchid.
- Obtain germplasm and make crosses to elite materials to incorporate disease resistances: Crosses made between wide range of disease resistant germplasm and the improved varieties SUA 90, Rojo, Kablanketi breeding lines and selected yellow varieties. Marker-assisted selection will be used.

DFID, UK- Crop Protection Programme
During the period 1997 – 2003 the Crop Protection Programme of the UK’s Department for International Development [DFID] supported two collaborative projects involving the Natural Resources Institute [NRI] and Horticulture Research International [HRI] in the UK and UAC, to develop and promote, improved bean varieties. Disease resistant lines from two crosses were screened at HRI and at UAC.

The original crosses were; 'Kabanima' selection (5060/6) x Canadian Wonder and 'Small Masasu' (5082/2) x Canadian Wonder. 5060/6 is a bean mixture component selected from one of several bean mixtures collected from the Southern Highlands by NRI and UAC scientists in 1991. It was identified as having very rare resistance to angular leaf spot. Canadian Wonder was selected as a parent because of its good size and deep red colour. It is however, susceptible to several diseases. The progeny of this cross [F6] were selected to combine the phenotypic characteristics of Canadian Wonder, which is a type that is popular with farmers and consumers in Tanzania, with the disease resistance characteristics of 5060/6. Small Masasu (5084/2) was a selection from a mixture component collected from Mrs Fides Benson of Tukuyu village in 1991. It was found to have almost unique resistance not only to all known races of halo-blight (race non-specific resistance), but also showed resistance to the four races of anthracnose against which it was tested (D. Teverson and C. S. Madata, unpublished).

Thirty-two lines from these crosses were screened down to 8 which were evaluated in participatory selection plots on-farm in 2002. The most promising line was 7068/2, derived from the Kabanima cross and was released in 2003 as the variety 'Urafiki'.

The DFID, UK- Crop Protection Programme has also supported an on-going regional project through CIAT in eastern (Uganda, Kenya and Tanzania) and southern (Malawi) Africa, on the promotion of integrated pest management for major insect pests on beans for the past four years. Host-plant resistance is a key component of the IPM strategy. The project adopted a participatory farmer group approach in which target communities and active partners (district extension personnel, NGOs, policy makers, private sector) have been involved. Both indigenous and improved pest management technologies were selected by farmers and partners, tested and promoted by participating farmer groups in northern and the southern highlands of Tanzania (Minja *et al.*, 2005). Service providers (researchers, extension personnel, local community leaders, NGOs and the private sector) have supported the efforts of the farmer groups.

Among the improved technologies being promoted are the use of improved bean varieties including 'Urafiki' in the southern highlands, high yielding beanfly-tolerant beans (such as SUA 90, G1106 -climber, Sinon and Wanja- G22501), other bean varieties demanded by farmers in the north and southern zones, in combination with the application of Minjingu rock phosphate fertilizer and animal manure in the northern zone, row planting, multiple crop intercropping, pest scouting, timely weeding and pest control, timely harvesting and clean storage. Farmers have selected indigenous pest control and soil fertility management strategies including the use of selected botanical crude leaf and tuber extracts (*Vernonia* spp., *Tephrosia* sp., *Neuratanenia* sp.), animal products such as cow urine and cow shed slurry, mixed crop and livestock farming and use of wood ash in the field and in grain storage.

Integration of these strategies in different combinations has helped farmers increase bean yields for food security and household income. Farmer training sessions, demonstrations, field days and farmer exchange visits enabled farmers and partners to learn from each other. Farmers have adopted different strategies depending on the suitability to their local area conditions.

The present Tanzanian National Programme

The National Bean Programme has been fragmented somewhat by the decentralisation of agricultural research, whereby agricultural research institutes in each of the seven agro-ecological zones have considerable autonomy. National co-ordination is often difficult, partly due to shortage of funding and the long distances between the research centres. This has become less significant as Zonal Agricultural Centres install effective e mail communications. Co-ordination of bean research in the region and within Tanzania is facilitated to some extent by the regional networks, CIAT centres at SARI in Tanzania and at Chitedze in Malawi, and also by the Bean-CRSP programme at SUA. Within the National Agricultural Research System, the National Bean Research Programme is co-ordinated from SARI with SUA and UAC as sub-centres and these three centres are responsible respectively, for developing varieties adapted to medium, low and high altitude ecologies. Beans are grown in most of the Zones but mainly in the Northern, Western and Southern Highlands Zones, although each zone contains areas that are at high, medium and low elevation.

Bean improvement programme for the mid altitude areas

In the mid-altitude bean growing areas of Tanzania, mainly in Arusha and Kilimanjaro Regions, in addition to navy bean production for export and canning, bush types are grown by smallholders for their own consumption and for market. Since the mid 1980s the objective has been to produce improved bean varieties for smallholder farming systems that meet consumer demand. Six varieties have been released since 1985 (Table 4) beginning with Lyamungu 85, followed by Lyamungu 90. Lyamungu 90 had a yield potential more than double that of the popular local variety at the time, Masai red (Limbu, 1999). Selian 94 and Selian 97 were released in the mid 1990s when the programme shifted from Lyamungu and the most recent release for the mid-altitude areas is 'Jesca'. All of these varieties except Selian 94, were derived from CIAT accessions.

Bean improvement programme for the high altitude areas

UAC is located at Mbeya in the Southern Highlands and is the centre for the National Bean Programme for high altitude areas. UAC is also the Zonal Agricultural Centre for the Southern Highlands Zone with very diverse agro-ecologies from below 1000 m to above 2500 m in elevation. The bean programme at UAC therefore has to evaluate beans for all three agroecologies and this is reflected in the range of varieties released from Uyole since 1980: Uyole 84, Uyole 94, Uyole 96, Uyole 98, Urafiki, Uyole 03, BILFA-Uyole and Uyole 04 (Table 4). The main objectives of the high altitude breeding programme are to produce beans adapted to agro-ecologies at altitudes above 1500 m that have acceptable cooking and eating qualities and for which there will be market demand. New varieties require resistance to the main diseases, angular leaf spot and anthracnose. Some local communities prefer particular seed types but most grow beans as mixtures with a range of seed colours. The programme aims to develop improved varieties of each of the main seed types. The new varieties have higher yield potentials than the local varieties and some of them have faster cooking times (Table 5). There is considerable variation in the response of the improved varieties to the main diseases but several show a high level of resistance to anthracnose, ascochyta, rust and BCNMV (Table 6). Few of the improved varieties show much resistance to insect pests (Table 6) and this is now being addressed,

Bean improvement programme for the low altitude areas

SUA has the mandate for bean breeding for low altitude areas and this part of the National Programme is supported largely by the CRSP. Low altitudes environments are usually hotter and drier than those at higher altitudes and therefore less suitable for bean cultivation. It is challenging to develop bean varieties that outperform locally adapted ones in harsh environments. Only two improved varieties have been released in the last 15 years and have been widely adopted. SUA 90 was derived from a CIAT accession and 'Rojo' which is a cross between CIAT germplasm and an accession from the Prosser Irrigated Research Station in the USA.

Seed production and distribution

It is estimated that less than 10% of seeds planted by smallholders in Africa are derived from the formal seed sector. Crops are largely planted with farmer-saved seed and smallholders exchange seed with friends, relatives and neighbours. If additional seed is required, it may be purchased from local market traders who deal in seed as food not specifically as seed.

The formal seed sector in Tanzania, as in most of the other countries in the region, has been unable to produce and distribute improved seed at an affordable price. With a few exceptions, seed of improved varieties has been adopted by smallholders following crop failures of natural disasters, or, because free seed has been made available by donor-funded research projects and NGOs. Some of the more progressive smallholders engage in commercial bean production and their output is sold to traders to supply the towns and cities.

Now that it is clear that the formal seed sector has failed to deliver improved varieties to smallholders and the private sector does not see a market for seed of self-pollinated crops such as legumes, bean breeding programmes are now beginning to develop projects to foster links between the formal and informal seed sectors. This requires a more participatory approach, but the challenge is to develop schemes that have long-term sustainability in the absence of donor support.

One of the projects in the current phase of the Bean CRSP is:

‘Development of cost-effective and sustainable seed multiplication and dissemination systems for improved bean cultivars that meet the need of limited-resource bean farmers’.

This project works with District Councils and NGOs as extension providers using farmer to farmer and farmer field school approaches to provide information and training to smallholders in seed multiplication (CRSP, 2005).

David *et al*. (2002) have pointed out that poor seed availability has often been ignored in studies of variety adoption and that seed dissemination strategies aimed at smallholders should re-supply seed over several seasons until new varieties become established in the informal sector.

Participatory breeding
Although it has long been recognised by researchers that disease susceptibility is a major factor that limits the yield of land races, smallholders do not have a good understanding of diseases. They recognise that some varieties are more prone to ‘rain damage’ than others, but it is difficult to get smallholders to value disease resistance, if culinary and organoleptic qualities are less good than in their existing varieties.

Crop improvement programmes at government research stations are seen as remote from the needs of smallholders. One way to address the issue of low levels of adoption of improved varieties, is to involve farmers in the process of crop improvement at an early stage in the process, through participatory selection. Some of the bean improvement programmes are only just beginning to accept that too much emphasis may have been given to breeding for increased yield, without enough attention to performance under adverse conditions and to cooking and organoleptic qualities.

Participatory selection is carried out by farmers groups in villages chosen to represent the spectrum of agroecologies and socio-economic circumstances to be found in the target region. The farmers groups would be supplied with seed of advanced lines that had already undergone some preliminary screening and multiplication on-station. Sufficient seed has to be available to supply the farmers groups. Those varieties that are preferred by farmers would then be replanted in the village. Varieties that perform well over two seasons may then go forward for multiplication by seed farms, NGOs and community organisations. The requirement for compulsory certification of seed crops is an impediment to wider development of community-based seed production. A category of ‘quality declared seed’ has been defined by FAO which requires less stringent inspection than that required for ‘certified seed’.

While there is general agreement that participatory selection may be a speedy way to produce improved varieties that farmers want to grow, the main obstacles to the adoption of this approach by national programmes are:

- Wide variation in agro-ecologies within each region.
- Wide variations in taste and cooking quality preferences
- The need for a large number of participating communities to take account of points 1 and 2.
- The large number of selection sites requires large quantities of seed at an early stage of the selection process.
- The need for researchers/supervisors to visit a large number of sites incurs high costs in terms of vehicle fuel and maintenance and travel and subsistence allowance, which leads to donor dependence.

However, although widespread adoption of PPB might be more expensive than the traditional approach, if the PPB/PVS is well organised, it might turn out to be more cost effective than the conventional breeding, variety testing and seed delivery process. Cost savings would be expected because of:

- Reduced time period from initial crosses to variety release and adoption, because farmers are already aware of, and approve of, the varieties.
- Partners and communities take over some of the responsibility of variety testing from researchers
- Communities get access to seed of new varieties at an early stage, and they can organise their own seed multiplication
- Farmers own the varieties, so they can promote them and pass the seed from farmer to farmer, resulting in rapid dissemination and adoption

One of the issues to be addressed by the New Partnership for Africa [NEPAD] and the Forum for Agricultural Research in Africa [FARA] is how to develop sustainable funding mechanisms to develop innovative and participatory approaches to problem identification and problem solving for agricultural research and to improve access to technologies. Access to seed of improved varieties will be fundamental to economic growth based on smallholder farming.

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References

Aggrawal, V. D., Pastor-Corrales, M. A., Chirwa, R. M. and Burachara, R. A. 2004. Andean beans with resistance to the angular leaf spot pathogen (*Phaeoisariopsis griseola*) in southern and eastern Africa. Euphytica 136: 201 – 210.

Allen, D. J. (1983) *The pathology of Tropical food Legumes: Disease Resistance in Crop Improvement.* John Wiley & Sons, Chichester, UK, 413 pp.

Allen, D. J. 1995. An annotated list of diseases, pathogens and associated fungi of the common bean (*Phaseolus vulgaris*) in eastern and southern Africa. Phytopathological Papers No 34, CAB International, Wallingford, UK, 23 pp.

Allen, D. J., Burachara, R. A. and Smithson, J. B. 1998. Diseases of common bean. In: Allen, D. J. and Lenne, J. M.[eds.] (1998) The Pathology of Food and Pasture Legumes. CAB International, Wallingford, UK, pp. 179 – 265.

Allen, D. J., Dessert, M., Trutman, P. and Voss, J. 1989. Common beans in Africa and their constraints. In: H. F.Schwartz and M. A. Pastor-Corrales [eds.] Bean Production Problems in the Tropics. CIAT, Cali, Colombia, pp. 9 – 31.

Allen, D. J. and Lenne, J. M.[eds.] 1998. The Pathology of Food and Pasture Legumes. CAB International, Wallingford, UK, 750 pp.

Allen, D. J., Ampofo, J. K. O. and Wortmann, C. S. 1998. Pests Diseases and Nutritional Disorders of the Common Bean in Africa. CIAT, Colombia, 131 pp.

Alexander, H. M., Groth, J. V. and Roelfs, A. P. 1985. Virulence changes in *Uromyces appendiculatus* after five sexual generations on a partially resistant cultivar of *Phaseolus vulgaris*. Phytopathology 75: 449 – 453.

Aragao, F. J. L., Barros, L. M. G., Brasileiro, A. C. M., Ribeiroa, S. G., Smith, F. D., Sanford, J. C., Faria, J. C. and Rech, E. L. 1996. Inheritance of resistance of foreign genes in transgenic bean co transformed via particle bombardment. Theor Appl Genet 93: 142 – 150.

Aragao, F. J. L., Vianna, G. R., Albino, M. M. C. and Rech, E. L. 2002. Transgenic dry bean tolerant to the herbicide glufosinate ammonium. Crop Sci 42: 1298 – 1302.

Balardin, R. S. and Kelly, J. D. 1998. Interaction between *Colletotrichum lindemuthianum* races and gene pool diversity in *Phaseolus vulgaris*. Journal of the Am Hortic Soc 123: 1038 – 1047.

Beaver, J. S., Rosas, J. C., Myers, J., Acosta, J., Kelly, J. D., Nchimbi-Msolla, S., Misangu, R., Bokosi, J., Temple, S., Arnaud-Santana, E. and Coyne, D. P. 2003. Field Crops Res 82: 87 – 102.

Beebe, S. E. and Pastor-Corrales, M. P. 1991. Breeding for disease resistance. In: Schoonhoven, A. van and Voyest, O. [eds] Common Beans – Research for Crop Improvement. CIAT, Cali, Colombia, pp. 561 – 617.

Bisanda, S. 2000. *In situ* conservation and the role of the farmer and natural selection in changing the components of bean landrace mixtures. PhD Thesis, University of Greenwich, Chatham ,UK. 300 pp.

Blair, M W., Kimani, P. M., Buenida, H. F., Garzon, L. N., Chirwa, R. and Tohme, J. 2005 [Abstr.]. Novel climbing bean genotypes developed through conventional breeding and marker-assisted selection. Paper presented at the 2nd General Meeting on Biotechnology, Breeding and Seed Systems, Nairobi, Kenya, 24 – 27 January 2005.

Boyer, J.S., 1982. Plant productivity and environment. Science 218: 443-448.

Broughton, W. J., Hernandez, G., Blair, M., Beebe, S., Gepts, P. and Vanderleyden, J. 2003. Beans (*Phaseolus* spp.) – model food legumes. *Plant and Soil* 252: 55 – 128.

Chacon, S. M., Pickersgill, B. and Debouck, D. G. 2005. Domestication patterns in common bean (*Phaseolus vulgaris* L.) and the origin of the Mesoamerican and Andean cultivated races. *Theor Appl Genet* 110: 432 – 444.

Chirwa, R. Kimani, P.,Buruchara, R. and Pyndji, M. 2003. Bean Breeding in Africa–Where are we? A paper presented at the Bean Biofortification Workshop, held at Great Rift Valley Lodge, Naivasha, Kenya.

CIAT 2005a. CIAT in Africa website http://www.ciat.cgiar.org/africa

CIAT 2005b. Annual Report 2004. http://www.ciat.cgiar.org/beans/pdfs

CRSP 2005. Bean/Cowpea Collaborative Research Support Programme website. http://www.isp.msu.edu/CRSP/home.htm

David, S., Mukandala. L and Mafuru, J. 2002. Seed availability, an ignored factor in crop varietal studies: a case study of beans in Tanzania. J of Sust Agric 21: 5 – 20.

De Clerq, J., Zambre, M., Van Montagu, M., Dillen, W. and Angenon, G. 2002. An optimised Agrobacterium-mediated transformation procesdure for *Phaseolus acutifolius*. Pl Cell Reps 21: 333 – 340.

FAO (2005) FAOSTAT website. http://faostat.fao.org/faostat/collections?subset=agriculture

Gatehouse, A. M. R., Dobie, P., Hodges, R. J., Meik, J., Pustzai, A., and Boulter, D. 1987. Role of carbohydrates in insect resistance in *Phaseolous vulgaris*. *J of Insect Physiol* 33: 943 – 950.

Graham, P. H. and Ranalli, P. 1997. Common bean (*Phaseolus vulgaris* L.). Field Crops Res 53, 131 – 146.

Guimaraes, C. M., Stone, L. F. and Brunini, O (1996) Adaptation of dry bean (*Phaseoluis vulgaris*) to drought: II Yield and agronomic components. *Pesquisa Agropecuaria Brasileira* 31: 481 – 488.

Ijani, A. S. M., Mabagala, R. B. and Nchimba-Msolla, S. 2000. Root-knot nematode species associated with beans and weeds in the Morogoro region, Tanzania. *Af Pl Protect* 6: 37 – 41.

IPCC. 2001. Climate change 2001: the scientific basis. Contribution of working group I to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC). J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden and D. Xiaosu (eds). Cambridge University Press, Cambridge, UK.

Johnson, E., Miklas, P. N., Stavely, J. R. and Martinezcruzado, J. C. 1995. Coupling phase and repulsion phase RAPDs for marker assisted selection Theor Appl Genet 100: 659 – 664.

Jung, G., Coyne, D. P., Skroch, P. W., Neinhuis, J, Arnaid –Santana, E., Bokosi, J. Ariyarathne, H. M., Steadman, J and Beaver, J. S. 1995. Construction of a genetic linkage map and locations of common blight, rust and web blight resistance loci in *Phaseolus vulgaris* using random amplified polymorphic DNA (RAPD) markers. Hortic Sci 30: 820.

Karel, A. K., Ndunguru, B. J., Price, M., Semuguruka, S. H. and Singh, B. B. 1981. Bean production in Tanzania. In: *Potential for Field Beans in Eastern Africa, Proceedings of a Regional Workshop,* Lilongwe, Malawi, March 1980. CIAT, Cali Colombia, pp. 124 – 154.

Kelly, J. D. 2004. Advances in common bean improvement: Some case histories with broader applications. *Acta Hortic* 637: 99 – 121.

Kelly, J. D., Gepts, P., Miklas, P. N. and Coyne, D. P. 2003. Tagging and mapping of genes and QTL and molecular marker-assisted selection for traits of economic importance in bean and cowpea. *Field Crops Res* 82: 135 – 154.

Kelly, J. D. and Miklas, P. 1998. The role of RAPD markers in breeding for disease resistance in common bean. Molec Breed 4: 1 – 11.

Kimani, P. M., Burachara, R., Muthamia, J., Mbikayi, N., Namayanja, A., Otsyula, R and Blair, M. 2005 [Abstr.]. Selection of marketable bean lines with improved resistance to angular leaf spot, root rot and yield potential for smallholder farmers in eastern and central Africa. Paper presented at the 2nd General Meeting on Biotechnology, Breeding and Seed Systems, Nairobi, Kenya, 24 – 27 January 2005.

Kornegay, J. and Cardona, C. 1991. Breeding for insect resistance in beans. Breeding for disease resistance. In: Schoonhoven, A. van and Voyest, O. [eds] Common Beans – Research for Crop Improvement. CIAT, Cali, Colombia, pp. 619 - 648.

Limbu, F. 1999. Agricultural technology economic viability and poverty alleviation in Tanzania. *Proceedings of the Structural Transformation Policy Workshop*, Nairobi, Kenya, 27 – 30 June 1999. Michigan State University Press

Mabagala, R. B. and Saettler, A. W. 1992. Races and survival of *Pseudomonas syringae* pv. *phaseicola* in northern Tanzania. Pl Disease 76: 678 – 682.

McCartney, J. C. 1966. The selection of haricot bean varieties suitable for canning. E African Agric Forest J 32: 214 – 118.

Minja, E. M., Mziray, H.A., Ulicky, E., Madata, C.S., Kabungo, D.A. and Matosho, G.A. 2005. The role and significance of farmer participation in IPM technology dissemination in Tanzania. Paper submitted to the Sixth Scientific Conference of the Tanzania Entomological Association (TEA), Arusha, Tanzania, 28-30 November, 2005. Tropical Pesticides Research Institute (TPRI).

Mmbaga, M. T. and Steadman, J. R. 1992. Nonspecific resistance to rust in pubescent and glabrous common bean genotypes. Phytopath 82: 1283 – 1287.

Mukoko, O. Z., Galwey, M. W., and Allen, D. J. 1994. Developing cultivars of the common bean (*Phaseoluis vulgaris)* for southern Africa: bean common mosaic virus resistance, consumer preferences and agronomic requirements. Field Crops Res 40: 165 – 177.

Myers, J. R., Davis, J. and Kean, D. 2001. Backcross breeding to introduce arcelin alleles into improved African bean cultivars. *Proceedings of the Bean Seed Workshop, Arusha*, Tanzania, 12 – 14 January, 2001. Bean/Cowpea Collaborative Research Support Program –East Africa, 8 pp.

Nchimbi-Msolla, S. and Misangu, R. N. 2001. Seasonal distribution of common bean bruchid species in selected areas in Tanzania. *Proceedings of the Bean Seed Workshop*, Arusha, Tanzania, 12 – 14 January, 2001. Bean/Cowpea Collaborative Research Support Program –East Africa, 5 pp.

Opio, A. F., Allen, D. J. and Teri, J. M. 1992. Assessment of yield losses caused by common bacterial blight of beans. Ann Rept Bean Improv Coop 35: 113 – 114.

Opio, A. F., Allen , D, J. and Teri, J. M. 1996. Pathogenic variation in *Xanthomonas campestris* pv. *phaseoli*, the causal agent of common bacterial blight. Pl Pathol 45: 1126 – 1133.

Osborn, T. C., Blake, T., Gepts, P. and Bliss, F. A. 1986. Bean arcelin2: genetic variation, inheritance and linkage relationships of a novel seed protein of *Phaseolus vulgaris* L. Theor Appl Genet 71: 847 – 855.

Osborn, T. C., Alexander, D. C., Sun, S. S. M., Cardona, C. and Bliss, F. A. 1988. Insecticidal activity and lectin homology of arcelin seed protein. *Science* 240: 207 – 210.

Pachico, D. 1989. Trends in world common bean production. In: H. F.Schwartz and M. A. Pastor-Corrales [eds.] Bean Production Problems in the Tropics. CIAT, Cali, Colombia, pp. 1 - 8.

Pastor-Corrales, M. A. Erazo, O. A., Estrada, E. I. and Singh, S 1994. Inheritance of anthracnose resistance in common bean accession G2333. Pl Dis 78: 959 – 962.

Rao, I. and G. Cramer 2003. Plant nutrition and crop improvement in adverse soil conditions. In: M. Chrispeels and D. Sadava (eds). **Plants, Genes, and Crop Biotechnology.** ***Published in partnership with the American Society of Plant Biologists and ASPB Education Foundation. Jones and Bartlett Publishers, Sudbury, Massachusetts, USA, pp 270-303.***

Sanchez, P. A. 2002. Soil fertility and hunger in Africa. Science 295: 2019 – 2020.

Schneider, K. A., Brothers, M. E. and Kelly, J. D. 1997. Marker-assisted selection to improve drought resistance in common bean. Crop Sci 37: 51 - 60

Schoonhoven, A. van, Cardona, C. and Valor, J. 1983. Resistance to the bean weevil (Coleoptera: Bruchidae) in non-cultivated common bean accessions. J Econ Entomol 76: 1255 – 1259.

Schwartz, H. F. and Pastor-Corrales, M. A.[eds.] 1989. Bean Production Problems in the Tropics. CIAT, Colombia, 654 pp.

Schwartz, H. F., Pastor-Corrales, M. A. and Singh, S. P. 1982. New sources of resistance to anthracnose and angular leaf spot of beans. Euphytica 31: 741 – 754.

Shao, F. M. and Teri, J. M. 1985. Yield losses in *Phaseolus* beans induced by anthracnose in Tanzania. Trop Pest Manage 31: 60 – 62.

Singh, S. P., Gepts, P. and Debouck, D. G. 1991. Races of common bean *Phaseolus vulgaris* L., Fabaceae. Econ Bot 45: 379 – 396.

Singh, S. P., Teran, H. and Gutierrez, J. A. 2001: Registration of SEA 5 and SEA 13 drought tolerant dry bean germplasm. Crop Sci 41: 276 – 277.

Spence, N. J. and Walkey, D. G. A. (1991) Identification of strains of bean common mosaic virus occurring in different regions of Africa. Ann Rept Bean Improv Coop 34: 5 – 6.

Spence, N. J. and Walkey, D. G. A. 1995. Variation for pathogenicity among isolates of bean common mosaic virus in Africa and reinterpretation of the genetic relationship between cultivars of *Phaseolus vulgaris* and pathoypes of BCMV. Pl Pathol 44: 527 – 546.

Suresh, K. Y., Weerawadena, T. E. and Bandara, J. M. R. S. 2000. Agrobacterium-mediated transformation of common bean (*Phaseolus vulgaris*) var. topcrop. Trop Agric Res 12: 64 – 74.

Svetleva, D., Velcheva, M. and Bhowmik, G. 2003. Biotechnology as auseful tool in common bean (*Phaseolus vulgaris*) improvement. Euphytica 131: 189 – 200.

Taylor, J. D., Teverson, D. M., Allen, D. J. and Pastor-Corrales, M. A. 1996a. Identification and origin of races of *Pseudomonas syringae* pv. *phaseicola* from Africa and other bean growing areas. Pl Pathol 45: 469 – 478.

Taylor, J. D., Teverson, D. M. and Davis, J. H. C. 1996b. Sources of resistance to *Pseudomonas syringae* pv. *phaseicola* races in *Phaseolus vulgaris*. Pl Pathol 45: 479 – 485.

Thomas, C. V. and Waines, J. G. 1984. Fertile backcross and allotetraploid plants from crosses between tepary bean and common bean. J Hered 75: 93 – 98.

Vallejo, V. and Kelly, J. D. 2001. Development of a SCAR marker linked to the CO-5 locus in common bean. Ann Rept Bean Improv Coop 44: 212 – 122.

White, J. W. and Singh, S. P. 1991. Breeding for adaptation to drought. In: Schoonhoven, A. van and Voyest, O. [eds] Common Beans – Research for Crop Improvement. CIAT, Cali, Colombia, pp. 501 – 560.

Wortmann, C. S., Kirkby, R. A., Eledu, C. A. and Allen, D. J. 1998. Atlas of Common Bean in Africa. CIAT, Cali, Colombia.

Young, R. A. and Kelly, J. D. 1996. RAPD markers flanking the ARE gene for anthracnose resistance in common bean. J Am Soc Horti Sci 121: 37 – 41.

Table 1. Top 10 producers of dry bean in SSA in 2004 [FAO]

Country	Production [Mt]
Kenya	535,000
Tanzania	270,000
Uganda	255,000
Burundi	220,218
Rwanda	198,224
Cameroon	170,000
Ethiopia	116,000
Congo DR	109,340
Benin	105,000
Malawi	79,000
SSA total	2,447,325
World	18,724,766

Table 2. Pest, disease and edaphic constraints to bean production in East Africa ranked in order of estimated yield loss (Source: modified from CIAT Atlas of Bean Production)

Constraint	Causal organism
Angular leaf spot	*Phaeoisariopsis griseloa*
N deficiency	-
Anthracnose	*Colletotrichum lindemuthianum*
P Deficiency	-
Stem maggot	*Ophiomyia* spp.
Root rot	*Pythium* spp. and *Fusarium* spp.
Bruchid	*A. obtecrus* and *Z. subfasciatus*
Exchangeable bases	-
Common bacterial blight	*Xanthomonas axonopodis* pv. *phaseoli*
Bean common mosaic	BCMV
Aphids	*Aphis* spp.
Ascochyta blight	*Phoma* spp.
Halo blight	*Pseudomonas savastanoi* pv. *phaseolicola*
Water deficit [mid season]	-
Rust	*Uromyces appendiculatus*
Water deficit [late season]	-
Al/Mn toxicity	-
Pod borer	*Helicoverpa armigera*
Floury leaf spot	*Mycovellosiella phaseoli*
Leaf beetles	*Ootheca* spp.
Pod borer	*Maruca testualis*
Water deficit [early season]	-
Brown bug	*Clavigralla* spp.
Fusarium wilt	*Fusarium oxysporum* f. sp. *phaseoli*
Thrips	*Megalurothrips sjostedii*
White mould	*Sclerotinia sclerotiorum*
Charcoal rot	*Macrophomina phaseolina*
Scab	*Elsinoe phaseoli*
Web blight	*Thanatephorus cucumeris*

Table 3. RAPD markers linked to major gene resistance in common bean (Kelly and Miklas, 1998)

Resistance gene	Source	Gene pool	Pathogen
Co-1	Michigan DRK	AND	Anthracnose
Co-2	Cornell 49-242	MA	Anthracnose
Co-4^{2}	SEL1308	MA	Anthracnose
	G2333		
Co-5	TU, G2333	MA	Anthracnose
	SEL1308		
Co-6	AB136	MA	Anthracnose
	Catrachita		
I	Seafarer	MA	BCMBV
	Montcalm	AND	
bc-3	B85009	MA	BCMV
	MCM3031	MA	
	MCR2205	AND	
bgm-1	Garrapato	MA	BGMV
	A429		
Mp-1	BAT477	MA	*Macrophomina*
Mp-2	BAT477	MA	
Ur-3	NEP II	MA	*Uromyces*
Ur-3	PI 181996	MA	*Uromyces*
Ur-4	Early Gallatin	AND	*Uromyces*
Ur-5	Mexico 309	MA	*Uromyces*
Ur-9	Pompadour	AND	*Uromyces*
	Checa		

Table 4. Bean varieties released in Tanzania since 1980
[Source: modified from information on the CIAT website]

Year	New Name	Original ID code	Type of* germplasm
2004	Uyole 04	7068/2	7
2004	BILFA-Uyole	CIAT	3
2003	Uyole 03	DRK124	2
2003	Urafiki	Kabanima x Can Won	5
2003	Wanja	A197	2
1999	Uyole 98	Bred at Uyole	6
1998	Selian 97	TMO110 x PVA782	3
1997	Rojo	EP2-2	4
1996	Uyole 96	CIAT	6
1996	Jesca	G13369	1
1996	G13374	G13374	1
1994	Uyole 94	DRK 6	2
1990	Lyamungu 90	G5621	1
1990	SUA 90	G5476	1
1990	Uyole 90	CIAT	6
1990	Ilomba	Local line	6
1985	Lyamungu 85	G5621	1
1984	Uyole 84	CIAT	6
1980	Kabanima	Ugandan accession	5

**Type of germplasm:*
1 = CIAT accession
2 = CIAT line
3 = CIAT cross selected locally [BILFA = Bean lines for low fertility in Africa]
4 = NARS cross with CIAT parent
5 = Var or advanced line from NARS distributed through CIAT network
6 = Selection of local variety or land race
7 = Can Wonder x local landrace

CIAT accession codes:
A = Advanced line for America
DRK = Dark red kidney
PVA = Pre-VF, Andean beans

Table 5. Characteristics of some improved bean varieties in Tanzania

Varieties	Seed size	Seed Colour	Habit	Maturity	Cooking Time	Palatability	Leaves	Yield	Dissemination
Kabanima	med-large	Calima	bush	3.50	slow	fair	fair	1.5 - 2.5	1980
Uyole 84	small	Cream	climber	3.75	slow	fair	excellent	1.5 - 4.0	1985
Uyole 94	large	red stripe	semi-climber	3.25	fast	v.good	excellent	1.2 - 2.5	1994
Uyole 96	large	DRK	semi-climber	3.25	fast	good	excellent	1.2 - 2.5	1996
Uyole 98	medium	Orange	semi-climber	3.25	v.fast	excellent	fair	1.5 - 3.0	1998
Wanja	large	Khaki	bush	2.75	fast	v. good	good	1.0 - 2.0	1998
Urafiki	medium	dark red	bush	3.25	fast	v.good	good	1.2 - 3.0	2002
Uyole 03	large	Sugar	bush	3.25	fast	v.good	good	1.2 – 3.0	2003
Uyole 04	medium	Cream	semi bush	3.25	v.fast	excellent	good	1.5 – 3.0	2004
BILFA-Uyole	medium	Calima	semi bush	3.25	v.fast	v.good	good	1.2 – 2.5	2004
Kablanketi	medium	Purple	semi-climber	3.00	fast	v.good	poor	0.5 – 1.5	local
Masasu	large	Brown	semi-climber	3.50	fast	good	good	1.0 – 2.0	local

Table 6. Reaction to diseases and pests of improved bean varieties released from Uyole

Variety	Diseases								Drought tolerance	Pests		
	ANC	ALS	HB	CBB	ASC	RUST	BCMV	BCNMV		Beanfly	Pod borers	Bruchid
Uyole 04	1	2	2	2	4	1	6	9	4	S	SS	S
BILFA Uyole	1	3	2	?	1	4	?	1	?	S	S	S
Uyole 03	1	2	3	?	1	8[V]	4	1	4	S	S	S
Urafiki* 4	4	4	4	2	5	6		?	2	S	S	S
Wanja**	7	7	3	?	1	4	1	1	2[escape]	S	S	S
Uyole 98	1	3	3	?	2	1	7	?	5	S	SS	S
Uyole 96	7	7	7	?	2	7	6	1	5	S	S	S
Uyole 94	5	5	9	?	1	4	8	1	4	S	S	SS
Uyole 84	1	5	2	?	7	5	8	1	2	T	S	T
Kabanima	1	4	4	?	2	1	5	?	6	SS	S	S

Disease scale: 1 – 9 where 1 – 3 is considered resistant and 7 – 9 as susceptible
? = unknown at present, V = variable response
Pests: S = Susceptible, SS = highly susceptible, T = has some tolerance
*Urafiki may show a high incidence of diseases in wet weather, but recovers quickly in drier conditions so that yield may not be much affected.
**Wanja is very early maturing and can escape the effects of drought by being harvested before the end of the rains.

Appendix 6. Working Paper A1145/3

Seed supply systems for self-pollinated crops in sub-Saharan Africa with special reference to Tanzania.
Rory Hillocks

Introduction
Seed is the most fundamental of agricultural resources, containing the genetic potential of the plant. The extent to which that potential is realised depends on access to basic resources of good soil and water, additional inputs such as fertiliser and on standards of crop husbandry and crop protection. Increases in agricultural output in Africa over the last decade or so have been achieved mainly through an expansion of the cultivated land area, often into marginal areas. Food production increases have failed to keep pace with population increases and it is generally recognised that further increases in agricultural output will be required, and that this must come from increased yields, rather than further expansion of crop production into marginal zones. This can be achieved by improved yield potential through plant breeding or improvements in standards of land and crop management. In practice both of these are required, as the yield potential for most crops is rarely reached in smallholder farming systems due to poor management and/or low soil fertility and poorly distributed rainfall.

During the 20th Century, great improvements have been made in the genetic potential of crop species through plant breeding. In Africa, international and national agricultural research centres have produced improved varieties of all the main staple food crops; maize, rice, sorghum, millet, cassava, banana and beans. Until perhaps, the 1980s, it was the function of research to breed varieties primarily for increased yield and their task was considered complete after multi-locational trials and the production of breeder seed. The task of seed multiplication [certified seed] and certification was to be carried out by state and para-statal seed companies, while the extension services were responsible for dissemination of the seed and the supporting crop management information. Numerous reports bear witness to the failure of this system to achieve widespread adoption of new crop varieties (Muliokela, 1998). State seed companies were generally inefficient and unable to deliver seed at a realistic price to attract smallholders in sufficient numbers to make the enterprise self-financing. The extension services in Africa were under-resourced and under-manned from the outset. Individual officers were [and still are] expected to provide an effective service to large numbers of farmers scattered over a wide area, using only a bicycle.

The 1990s saw the era of structural adjustment and deregulation of agricultural services. The provision of agricultural inputs and seed production was opened to the market and numerous national and multinational companies now operate as seed producers in African countries. However, the private sector has so far been reluctant to invest in seed production of crops for which the perceived demand is low, particularly the self-pollinated food crops. They have concentrated on hybrid and some open-pollinated maize varieties and horticultural crops, with some investment in sorghum, sunflower and a limited number of bean varieties for the export market in green beans. In the absence of access to subsidies or microfinance for the purchase of inputs adoption rates even for hybrid maize soon began to decline, despite the efforts of private seed companies. In Zambia for instance, hybrid seed sales fell to 3,400 tonnes from an annual average of 8000 tonnes between 1981 – 1993 (Muliokela, 1998).

Without some form of subsidy, which presently takes the form of donor-funded projects, commercial seed companies are unlikely to become producers of self-pollinated legume crops for which farmers recycle their own seed. The way to change this would be if the market for seed of improved varieties of these crops became more economically viable. This would require two changes; firstly, research institutes would have to increase the rate at which new varieties became available to seed producers. This would be an essential first step because farmers would only buy the initial stock and emergency replacement in case of crop loss. Secondly, the purchase of seed of new varieties by smallholders would have to greatly increase. In the short-term this is unlikely to happen and multiplication and dissemination of legume crops and open-pollinated cereal crops will have to take place on-farm through the informal sector. Regardless of the mechanism of initial seed supply, increased uptake of improved varieties by farmers requires that new varieties are conspicuously superior [as judged by farmers own criteria] to those already in use, that they are easily accessible when and where they were required, and, that there is greater awareness among farming communities of the new material available and the potential benefits.

Participatory variety improvement
Often plant breeding programmes focus on selection for high yield under good management and /or improvement in pest and disease resistance. Donor-funded research to develop improved bean varieties has mainly focused on disease resistance and pest control. There is now clear evidence that while smallholders may complain that some of their local bean varieties are spoiled by rain [researchers know that this usually means disease susceptibility], disease rarely appears among their main perceived production constraints. Few farmers have the education to understand the concept of 'disease resistance'. If disease resistant varieties are to be adopted they will have to be superior to the local varieties in terms that the farmer and

his household recognise – mainly good taste and cooking quality including short cooking time. These are the characters that farmers look for in new varieties. They are also the qualities, combined with certain colour preferences that the market demands. Consumers and traders are not interested in yield. Yield is of interest to the farmer growing for market, but high yield of an unmarketable variety is of less use than lower yield of a highly marketable variety. Also, high yield may be of little use if the variety is particularly vulnerable to drought, for instance. The smallholder family growing beans for their own consumption, wants varieties that are of short duration, tolerant of poor soil and drought with good taste and cooking qualities. In some bean-growing areas tender leaves suitable for eating is also highly valued. If a variety has those qualities and is also high yielding, so much the better. Without incorporating these other qualities, the emphasis on yield in breeding programmes is unlikely to deliver varieties that farmers will be willing to purchase and they can be disseminated only with the support of donor-funded projects. Farmers are willing to participate in projects which make seed available to them, and appear to adopt the varieties, but this is often because it is a means of accessing free [or low cost] seed. In these cases, dissemination of the new varieties ceases when the project ends. However, there is an increasing awareness in the research community, of the need to develop varieties adapted to the requirements of both the growers and consumers [they may be the same]. This is particularly evident in the current bean improvement programmes of CIAT and CRSP in their projects to produce improved varieties for stressed and low-input environments.

One solution to the problem of breeding varieties that farmers would be willing to purchase seed of, is to involve the farmer at a much earlier stage than is common at present, through participatory breeding programmes. The difficulty with this approach is in finding ways to make it sustainable. Variety preferences among farmers vary greatly according to individual tastes and agro-climatic variables. This means that participatory variety selection has to take place at a large number of locations. A major limitation is in the availability of sufficient seed at line stage of development to meet this requirement. The main problem, however, is the high cost of multi-locational selection. Participatory breeding projects are presently highly donor driven which is unsustainable. It may be possible to fund such selection programmes if research institutes were able to sell their varieties to the seed companies, but it is doubtful if sufficient revenue could be generated. National Research Institutes that have a mandate for research on export crops have been able to fund their activities through export levy and in some cases these funds may be sufficient to subsidise research on non-export crops. Costs can be kept to a minimum by careful selection of participating villages to represent the biological and socio-economic variables in the region served by the research institute. Another way to reduce the costs of participatory breeding programmes is to limit the number of visits made by researchers. This depends on being able to work with reliable representatives of the farming community to provide proper management of the field in the absence of frequent visits by the research team. The research team may wish to supervise planting to be sure that precious seed is not wasted. Then, the minimum requirement would be a mid-season visit and a visit at harvest to record yields and conduct cooking and taste tests. The visits could be further reduced if no data was to be collected other than qualitative information from the participating households at the end of the season, giving a comparative score to each line for yield, cooking quality and taste. The lines chosen by the farmers groups would then be planted out again by them the following season. The lines chosen most frequently in the participating villages, in both years, would then be taken forward to produce quality declared seed. If the commercialisation of seed production is the desired outcome then, free distribution of seed must cease as it will hinder the development the commercial market for seed. At present few national research institutes in developing countries have the manpower resources, vehicles and funding to run fully participatory breeding programmes for their mandate crops.

Formal Seed Sector

The formal seed sector in SSA encompasses all plant breeding, seed production and certification, quality control and extension and has private sector and public sector components. With the exception of some export crops such as cotton, coffee and cashew, the public sector, consisting of breeding programmes at research institutes, seed multiplication and distribution net works, is almost entirely donor-funded. The private sector is relatively small and deals mainly with maize. The small-scale enterprises that it was hoped would emerge after liberalisation, to produce and distribute seeds and other agricultural inputs have failed to develop. Tanzania has a well developed national research system that produces basic seed of improved crop varieties. There are seed multiplication farms and a seed quality control organisation. Nevertheless certified seed [other than maize] is not reaching most of the farming community. Mtolera (2001) identified some of the reason for this:

- Removal of subsidies has made certified seed unaffordable by smallholders.
- Credit facilities are less available in rural communities since the demise of most of the co-operative societies.
- Decreasing demand for certified seed of OP crops has led to seed companies concentrating on hybrid maize.
- Although new varieties are being produced by national and international research institutes, there is no commercial mechanism for seed multiplication.

Informal Sector
It is common practice throughout the world for the farmer to retain his own seed for self-pollinated crops such as beans. In the US it is estimated that 75% of seed planted in any single year is self-saved (FAO, 1998). A farmer will not be willing to purchase new seed if he is satisfied with the quality and performance of the seed he harvests himself. In Africa, where the majority of farmers are smallholders living at subsistence or near-subsistence level, this figure for self-saved seed is more like 90% (Lanteri and Quagliotti, 1997). The informal seed sector comprises all seed production, distribution and marketing that is outside the Government-regulated system. The main seed producers and distributors in the informal sector are farmers themselves, but also includes community-based organisations, market traders and NGOs.

During the 1990s non-governmental organisations [NGOs], became increasingly involved in on-farm seed multiplication and variety testing (Maredia *et al*., 1999). NGOs are now regarded as a component of the informal seed sector, as they often operate unregulated seed multiplication and distribution programmes. One important distinction between NGOs and farmers or 'grass roots' community organisations, is that most NGOs are donor-funded and their schemes are therefore often unsustainable in the absence of their input. It has been argued that because many of the NGOs distribute seed without charge, their activities undermine the development of a sustainable commercial seed system for self-pollinated crops. Where NGOs help to build local capacity in on-farm seed production, the level of sustainability is raised. The local NGO, Community Enterprises Development Organisation [CEDO] in Uganda for example, supported the Bulyana Womens Group to supply bean seed to private seed companies, through an out-grower scheme. The group members received training in improved crop management, marketing and other skills required to organise and manage the group's finances (New Agriculturalist, 2004).

Farmers multiply seed for their own use but may also give seed to friends and neighbours and sometimes seed for which there is a high demand may be sold. In the case of beans in the southern highlands, it is common for farmers to maintain a wide range of 'local' varieties as seed mixtures. The different characteristics of the mixture components provides some degree of buffer against crop loss to pests and disease. When a new variety is adopted it will be added to the mixture with little evidence of biodiversity loss (Bisanda, 2001). Single varieties of beans may be grown when they are being produced commercially but there is also a market for mixtures of varieties with different seed size and colour.

Dissemination of new crop varieties through the informal system has proved to be very slow. After the initial introduction of seed to a selected farmer or farmer group, on average it takes three years before substantial quantities of seed begin to get distributed within and outside the village. Distribution of improved bean varieties from Uyole Research institute in the Southern highlands of Tanzania began in the early 1980s with the release of 'Kabanima'. There have been many seed releases since then, yet Kabanima is still poorly distributed in some areas, despite its being highly demanded by traders. The most widely grown and best known bean variety among the villagers of Mbeya Region is a 'local' variety known as Kablanketi. Research by Bisanda (2000) using timelines with farmers groups in the SH revealed that Kablanketi was first introduced in Sumbawanga before the First World War, but it did not reach farmers interviewed near Iringa, 200 miles away, until 1979. The origin of several other 'local' varieties in the SH could be traced back more than 50 years.

Other farmers are the main source of seed for most smallholder households in Africa. However, there does appear in some areas at least, to be a decline in farmer seed networks. David and Sperling (1999) report that in Uganda seed is being increasingly viewed by farmers as a saleable resource. This may be particularly true for beans due to increasing demand due to total production remaining static in most countries in e. and s. Africa, while populations have doubled over the last 20 years.

There are many reasons why smallholders in Africa are reluctant to purchase seed and therefore why there is little trade in seed of open-pollinated crops:

- Smallholders farm in a high risk environment where any investment in crop production may be lost due to adverse weather conditions, particularly drought.
- Lack of capital assets and low purchasing power.
- Poor access to credit and where credit may be available, repayment terms do not fit with agricultural investment.
- The majority of smallholders are living at subsistence or near-subsistence level and grow food crops to feed their families and do not participate in commercial agriculture. New varieties are of little interest if they already have satisfactory local varieties.
- Smallholders in remote areas with a poor communication infrastructure, do not receive information about new varieties and their benefits.
- Many smallholders have a poor level of education and are unable to plan for entrepreneurial activity, even if there was a potential market and capital was available.

- Seed of self-pollinating crops can be retained by the farmer for many years without significant deterioration in varietal characteristics. So that in the absence of seed loos due to drought for instance, there is little incentive to purchase seed on a regular basis.
- The economic advantages of high quality seed are not necessarily apparent to smallholders due to poor prices paid for the produce, partly due to poor road infrastructure and high transport costs that have to be borne directly by the farmer or are passed on to the farmer in low prices offered by the trader.
- In bean producing areas, almost everyone grows beans so there is little local market. The main markets are in the towns and cities, often many miles away and most of the profit is made by traders.

The circumstances under which seed will be sought from the formal system might be as an emergency measure, when disaster has destroyed crops and seed stocks have been consumed, or the farmer is growing for market. In the former case, seed is more likely to be purchased from a local market where seed is on sale as food and therefore is not part of the formal regulated system.

The extent to which planting seed will be purchased varies considerable among different communities. In areas where beans form an important part of the diet, much of the harvest is likely to be consumed. In the Great Lakes Region, a major bean-consuming region, it was reported that a large proportion of farmers [70% in Burundi] purchased all their bean seed in at least one season (David and Spurling, 1999).

Informal seed production suffers from several disadvantages:

- Crop yields are low and therefore seed multiplication rates are low.
- Crop loss is common due to drought, insect damage and disease.
- Little capacity for seed storage
- Poor knowledge and lack of information on seed production and storage.
- Farmers may be forced to consume the seed as food due to food scarcity.
- Villages are often a long way from potential markets that might otherwise encourage commercial crop production.

There was a tendency in the past to believe that the development of seed systems depended on a transition away from the informal to the formal sector. The formal sector has evolved away from state subsidy and towards expansion of the private seed sector. Access to improved varieties of most of the African food crops will require integration of the formal and informal sectors (Maredia *et al*., 1999).

Seed regulation

Seed certification in Tanzania is carried out by TOSCA but the organisation is under resourced and too centralised. In order to address this issue and the belief that certification regulations were too stringent for on-farm seed production, a new category of ‘quality declared seed’ [QDS] was introduced by FAO. The requirement for QDS is that only 10% of the crop has to be independently inspected. But even this may be an impediment to development of the informal sector and some have argued that compulsory certification should be abolished altogether (Maredia *et al*., 1999).

Seed distribution

<u>Sale of certified seed</u>

In the deregulated formal seed sector, private seed companies produce seed that must be certified by TOSCA inspectors. The seed is then distributed through a chain of agents for retail to the farmer. It is estimated in Tanzania that only about 5% of maize seed is obtained by smallholders in this way and the bulk of the maize crop is derived from farmer-saved seed of open-pollinated varieties. If this is the case with maize, the proportion of bean production deriving from certified seed purchased from traders must be very small indeed.

<u>Public sector research institutes</u>

The main source of basic seed [foundation seed] of legume crops is the research institutes [NARIs] responsible for the development of improved varieties. Once the variety has been officially passed for release by the variety committee, the NARI will produce breeder seed. By this time the variety is likely to have been distributed to contact villages during the earlier evaluation phase. Farmers’ groups participating in the evaluation will have multiplied the seed and passed it on to neighbours and friends. The problem now arises of quantifying demand. Farmer to farmer dissemination of new varieties is slow and it may take several years from initial introduction of a new variety until it is well known in the area. For self-pollinated crops the NARI is the only source of seed but they will be wary of over-production of Foundation Seed and will produce only small amounts initially until they are able to assess the demand. Foundation seed will then be distributed in several different ways. During the early stages of promotion it may be necessary to distribute seed direct to villagers, extension offices NGOs and community-based organisations without charge. Once the variety becomes more widely known and it is sufficiently popular, traders, NGOs and a few individual farmers will buy the seed direct from the NARI farm.

Farmers networks

Farmer to farmer dissemination is by far the most common channel for seed used by African smallholders. This takes place independently of involvement by outside agencies. Some of their surplus seed may be given [sometimes sold] to friends neighbours and relatives within the village and to relatives in other villages.

Private traders

Stockists of agricultural inputs are to be found in major towns but elsewhere they are scarce in SSA. There may be an agricultural supplies store in some of the smaller towns but they are likely only to stock small quantities of hybrid maize and perhaps vegetable seed. Local entrepreneurs are as risk-averse as their customers and will not stock seed for which there is uncertain demand.

When farmers need to purchase seed because theirs has been consumed or due to drought-induced crop failure, they may purchase new seed from the produce stalls on the local market, especially if the variety they seek is easily recognisable. The risk is that a large proportion of the seed may be weevil-damaged and germination rates will be poor.

Seed fairs

In 1997/98 in southern Tanzania seed fairs were devised as a way of introducing farmers to new varieties, to encourage seed exchange and to bring together farmers, traders, extensionists and researchers. The fairs were held in selected villages in nine districts and organised by the local research institute. Seed of improved varieties were available at cost price in small packs of 5 – 200g. Seed of lines still under trial were made available free of charge on the understanding that there would be feed-back on their performance. In addition farmers were encouraged to exchange seed between themselves and with research where they brought unusual seeds. It is estimated that more than 200 farmers and other stakeholders visited the fairs (Mponda et al., 1997; Nathaniels and Mwijage, 2000).

Case studies

Cotton in Uganda

Cotton variety development in Uganda takes place in the state sector through the National Agricultural Research Organisation at Serere Agricultural & Animal Research Institute [SAARI]. SAARI is responsible for variety development and the production of breeder and foundation seed. Foundation seed then as ‘basic seed’ becomes the property of the Cotton Development Organisation [CDO], responsible for the production of certified seed. Certified Seed is produced on farms in areas designated the first stage of seed production [SEG 1] which are located on fingers of land bounded by Lake Kyoga, such that they offer a degree of isolation from other cotton. For each new seed issue, the area of cultivation expands with each cycle of multiplication until there is sufficient seed to meet the total demand. A new variety may leave SAARI and enter the first stage of seed multiplication after or before the previous variety has reached saturation level. This is known as the ‘wave’ system of seed multiplication and variety introduction. The responsibility for ensuring the supply of high quality seed to cotton farmers falls to CDO who must ensure that ginneries make enough seed available to meet the planting requirement. After separation of lint from seed at the ginnery the seed that is to be used for planting must be delinted and then dusted with chemical for the control of bacterial blight and seedling diseases. Seed is still [2005] given free to cotton farmers although the costs incurred by CDO have to be recovered through a ginning levy and this amount together with losses to the ginnery from not selling the seed for oil extraction have to be recovered through the price paid to farmers on delivery of their seed cotton. The main problems with this system centre around the seed being free at the point of delivery to farmers. The view of the ginning companies is that the seed is not properly valued by farmers who use unnecessarily high seed rates and some may even fail to plant it at all. In the longer-term the plan is to introduce charges for cotton seed but at the moment, this is seen as a disincentive to grow cotton at a time when the Government and the ginning companies are trying to increase cotton growing in the country. This will become a much more important issue when Bt cotton is introduced.

Phaseolus beans in the Southern Highlands of Tanzania

The National Agricultural Research System in Tanzania is administered by the Department of Research & Development within the Ministry of Agriculture & Food Security. Research has been decentralised with considerable autonomy being devolved from central government to the office of the Zonal Director of Research at the lead research institute in each of seven agroecological zones. The lead institute for the Southern Highlands Zone is Uyole Agricultural Research Institute [ARI-Uyole] which has the mandate to produce new bean varieties for the Southern Zone and is the National breeding centre for bean varieties suited to high altitude cultivation. ARI-Uyole is responsible for variety development and the production of breeder and foundation seed sufficient to meet the demand in the Southern Zone. Beyond the stage of foundation seed produced on the Uyole farm, there is no formal system for producing certified seed or beans or other self-pollinated crops. Further seed production takes place in the informal sector through community multiplication schemes run by districts councils NGOs and community-based organisations.

Individual farmers who have received seed through the informal multiplication system carry out their own multiplication and often disseminate new varieties by gift of seed to or exchange with neighbours and relatives. Smallholders are unable to meet the stringent standards required for full certification. In order to address this situation a category of 'quality declared seed' has been defined by FAO which requires less stringent inspection than that required for 'certified seed'.

Farmers may also access seed of new bean varieties or replace seed that has been lost or consumed by purchasing seed from produce markets, seed traders or at seed fairs and farmers shows. However, it is a common complaint from farmers groups that they cannot obtain seed of new varieties except if they are able to participate in evaluation trials organised by research. This is a problem of both supply and demand. There is a shortage of seed traders outside the main towns but also a reluctance on the part of farmers to pay for seed when they are used to recycling their own seed. Replacement occurs only when their seed stock is lost. One solution to this problem is to use participatory selection to involve farmers at an early stage in variety development, so that when the new variety emerges, they know where it has come from, they have a sense of ownership and it is superior by their own criteria to the dominant local varieties.

At present the main source of seed of improved varieties is ARI-Uyole but they are only able to produce limited quantities of foundation seed. They are not permitted by Government to produce larger amounts of certified seed. This regulation is in place because of the belief that to allow the government sector to produce certified seed for sale to the public would act as a disincentive for private sector initiatives.

Sesame in Tanzania

Variety development for sesame in Tanzania is the responsibility of Naliendele Agricultural Research Institute [NARI] in the Southern Zone. The sesame breeding programme at NARI has produced a number of varieties that out-yield the local varieties. Recent improved varieties are white-seeded which command a higher price on the world market than the lower quality local varieties that are sold as 'mixed' types. A number of export crops in Tanzania are supported by commodity boards that ensure quality standards and seed supply. These boards such as the Cashew Board are funded through export levy and part of the levy goes to support research and development for the crop. At present in Tanzania there is no commodity board for Sesame. This results in under-resourcing of sesame research and an absence of any support for seed supply. This has made it difficult to establish cultivation of 'white sesame' in preference to the local types. This situation illustrates a wider problem of agricultural development in SSA. Commercial activity in the smallholder agriculture sector is highly risky. It is risky for farmers because of the challenges of drought and pest attack. It is risky for private sector commodity trading companies because the same factors make the supply unpredictable. Against this background, companies buying sesame in southern Tanzania settle for buying what is available at a low price and selling on the world market at a low price. Although the traders could sell white sesame at a higher price they are reluctant to pay a price premium to farmers because a minimum volume of pure white sesame would need to be sold before the company could access the higher price. In the early stages of a transfer to white sesame, the volumes would be too little and it would not be worthwhile for the trading company to sort the seed into white and local types. So there is little demand from farmers for the white varieties and they continue to grow their local varieties and recycle their seed.

NARI is able to produce some foundation seed but does not have the resources to meet the potential demand. Additional community-based multiplication is carried out in some of the villages with financial support from District Councils and NGOs. If the production levels of white sesame were to increase to the point where it would be economic for trading companies to pay a price premium, a system of seed production would be required that was able consistently to meet the demand. The other factor required to produce high quality seed is the need for an insecticidal seed dressing to protect against sesame flea beetle, in order to remove one of the main risks to the farmers' investment. The cost to the farmer of purchasing the treated white seed would then have to be more than off-set by the price premium.

Seed Projects in Tanzania

The international programmes for bean improvement that operate in Tanzania are CIAT and the Bean Collaborative Research Support Programme [CRSP] which is funded by US AID. In addition to supporting bean breeding programmes, CIAT and CRSP support the multiplication and distribution of the varieties developed. CRSP worked with farmers and

NGOs to develop village-based seed schemes for two varieties adapted to low altitude bean-growing ecologies (Miles, 2001).

Under the Agricultural Sector Programme Support [ASPS II], DANIDA funds the Seed Unit in the Ministry of Agriculture and Food Security to implement the Smallscale Seed Production Programme. This programme supports NGOs and CDOs to develop community-based seed multiplication schemes.

ICRISAT (2001) compared three community seed supply strategies for sorghum and millet implemented during the late 1990s in Iringa, Dodoma and Singida Regions of Tanzania. The first project was the On-farm Seed Production Programme funded under ASPS I. The second project was the Primary School Seed multiplication Programme, implemented by regional agricultural and education authorities with financial and technical assistance from ICRISAT. The third project was the sustainable Seed Multiplication Programme, implemented by the Diocese of Central Tanganyika [DCT] with support from the Christian Council of Tanzania [CCT]. All three programmes aimed to produce QDS with inspection by TOSCA. The seed was to be sold locally but this proved to be difficult and only the DCT programme assisted their farmers to market their seed outside the village. This meant that most farmers were left with at least some unsold seed and some complained that they had not met their production costs. Most of the local farmers preferred to buy lower quality seed from the produce markets at 102 Tsh/kg rather than pay 300-500 Tsh.kg for the QDS.

Regional initiatives

African Seed Network[ASN]

ASN was formed under the auspices of FAO at the Seed Policy and Programme Meeting for Sub-Saharan Africa, held in Abidjan in 1998. Six ‘profiles’ were identified;

- Strengthening seed industries in SSA through networking
- Seed information management
- Regional harmonisation of seed regulation
- Support to improve quality seed production and distribution systems
- Building farmers’ capacity to restore seed systems after disasters
- Capacity building through training in seed production and management

Sub-Saharan Africa Seed Initiative [SSASI]

The formation in 1997 of the SSASI was co-ordinated by the World Bank under the auspices of the Special Programme for African Agricultural Research [SPAAR]. As part of this initiative the Sub-Regional Action plan in southern Africa emerged from a workshop held in Lusaka in February 2000. The ensuing strategy document reviews seed policy and systems in four countries in the SADC region, Mozambique, Zambia, Malawi and Zimbabwe, and makes recommendations that aim to improve farmer access to improved seed.

SADC Seed Security Network [SSN]

SSN was launched in 2001 and the initial phase was supported by the Austrian Government through FAO and by GTZ through the Small-Scale Seed Production by Self-Help Groups project. The main objectives were:

- Strengthen on-farm seed production
- Establish a regional database for seeds in SADC
- Establish a seed security and early warning system
- Promote regional seed trade
- Facilitate harmonisation of seed regulations

The network produces a newsletter – SADC Seed Update.

Some recommendations

1. Greater participation by farmers in the crop breeding process through participatory on-farm selection.

2. Less weight should be given to yield advantage in making selections intended for smallholders and more emphasis on taste, cooking qualities and drought tolerance.

3. On-farm seed multiplication requires capacity building among smallholders and their organisation into effective groups with legal status to ensure sustainability of initiatives in the absence of financial support from a donor-project or NGO.

4. Registration and dissemination only of those varieties chosen by farmers.

5. Need for plant breeders rights so that new varieties from research institutes can be sold to private seed companies.

6. Information systems accessible to farmers in local languages. Available germplasm, including preferred local varieties should be properly catalogued with descriptions of their qualities and comparative advantages and disadvantages.

7. Removal of requirement for compulsory certification.

References

Bisanda, S. (2000) In-situ *Conservation of Phaseolus vulgaris and the Role of the Farmer and Natural Selection in Changing the Components of Landrace Mixtures in the Southern Highlands of Tanzania*. PhD Thesis, University of Greenwich, UK, 269 pp.

David, S. and Sperling, L. (1999) Improving technology delivery mechanisms: Lessons from bean seed systems research in eastern and central Africa. *Agriculture and Human Values 16, 381 388.*

FAO (1998) *Proceedings of a Regional Technical Meeting on Seed Policy & Programmes for Sub-Saharan Africa*, Abidjan, Côte d'Ivoire, 23 – 27 Nov, 1998, Food & Agriculture Organisation, Rome, Italy. http://www.fao.org/ag/AGP/ARPS/Abidjan/A221.htm

ICRISAT (2001) Comparative study of three community seed supply strategies in Tanzania. Patancheru, India, International Crops Research Institute for the Semi-Arid Tropics, 41 pp.

Lanteri, S. and Quagliotti, L. (1997) Problems related to seed production in the African region. *Euphytica* 173 – 183.

Maredia, M., Howard, J. and Broughton, D. (1999) Increasing Seed System Efficiency in Africa: Concepts, Strategies and Issues. MSU International Development Working Paper No 77. Michigan State University, East Lansing, Michigan, USA, 66 pp.

Miles, C. A. (2001) Existing mechanisms for smallholder seed production and dissemination in Tanzania: A case study of SUA B/C CRSP. Proceedings of the bean seed workshop, Arusha, Tanzania, January 12 – 14, 2001, 7 pp.

Muliokela, S. W. (1998) Technology transfer in rural communities of sub-Saharan Africa - seeds as a bridging tool. *Proceedings of a Regional Technical Meeting on Seed Policy & Programmes for Sub-Saharan Africa*, Abidjan, Côte d'Ivoire, 23 – 27 Nov, 1998, Food & Agriculture Organisation, Rome, Italy. http://www.fao.org/ag/AGP/ARPS/Abidjan/A221.htm

Nathaniels, N. and Mwijage, A. (2000) Seed fairs and the case of Marambo village, Nachingwea district, Tanzania. Agricultural Research & Extension Network Paper No 101.

New Agriculturalist (2004) Seeding Self-help. *New Agriculturalist on-line*, May, 2004. http://www.new-agri.co.uk/04-5/develop/dev05.html

Sperling, L., Remington, T., Haugen, J. M. and Nagoda, S. [Eds.] (2004) Addressing Seed Security in disaster Response: Linking Relief with Development. Cali, Colombia, International Centre for Tropical Agriculture, 178 pp. http://www.ciat.cgiar.org/africa/seeds.htm

Appendix 7: Working Paper A1145/4

Management and utilization of *Phaseolus* bean diversity in the Southern Highlands of Tanzania. 1. Socio-economic factors

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Abstract

A study made of management and utilization of *Phaseolus* bean diversity by farmers in the Southern Highlands Zone (SHZ) of Tanzania. The main objective of the study was to establish the socio-economic factors that are linked to bean diversity, i.e. the number of bean types that are grown by 180 farm households, in 25 selected locations in the SHZ. Based on local names and bean type, 345 distinct bean types were recognized, however, phenotypically identical beans were found to have several names within and between communities and cultures. After reclassification, 15 seed phenotypes were identified and among these, six bean types only were found to be widely grown: *Kablanketi, Kabanima, Kigoma, Njano, Masusu* and *Msafiri* types. Proximity to markets, wealth and household size have significant influence on the decision to manage and use bean diversity. Joint decision making between women and men in the household results in management and use of maximum bean diversity. The long-term effect of improved transportation and market opportunities is likely to be a reduction in bean diversity. Wealthier farmers with oxen, large land area and large families, tend to keep more bean diversity than poorer farmers

Key words: bean mixtures; common bean diversity; *Phaseolus vulgaris;* socio-economic factors; Southern Highlands Zone; Tanzania;

Introduction

The common bean *(Phaseolus vulgaris* L.) is valued as a major protein source throughout sub-Saharan Africa where about 25% of the world's beans are produced (Allen et al. 1989; Wortmann et al. 1998). Depending on the variety, the dry grain contains between 18 to 38% protein (Smartt 1977). In Tanzania, the Southern Highlands Zone (SHZ) is the major bean producer in the country, closely followed by the Northern and Lake Zones (URT 2004). The climatic conditions of the SHZ, with elevations between 1000 to 1400 metres above sea level, a mean temperature range of 16 to 24^{0}C, and an annual precipitation range of 500 to 2000mm, are conducive to bean production (Allen et al. 1989). During the 2002/2003 cropping season, the SHZ produced over 142,000 Mt of beans (31.2% of Tanzanian production) on about 200,000 hectares. This zone is home to 8.4 million people (over 80%

of Tanzania's population) who are largely engaged in agriculture and related activities. Beans are the most important food crop, being grown and eaten by almost all households (Bisanda 2000).

Throughout the Great Lakes Region, northern Malawi, and south-western Uganda, smallholder bean production is characterized by diverse landrace mixtures of distinct phenotypes and genotypes (Thurston et al. 1999). This is also the case in the SHZ of Tanzania (Teverson et al. 1994). Landraces are morphologically identifiable populations of a crop with a degree of genetic integrity, which are maintained by natural and human selection, and are adapted to local production conditions (Harlan 1975). These bean landraces are recognized by farmers by differences in seed coat characteristics, growth habits and culinary qualities (Martin and Adams 1987; Allen et al. 1989; Wortmann et al. 1998). Bean mixtures are usually consciously composed, where farmers may retain or add landraces and adjust the relative quantities of each component depending on their preferences.

In smallholder farming systems, management of food crop diversity is closely associated with the socio-economic conditions of the local people (Altieri and Merrick 1987; Shiva and Dankelman 1992; Trutmann et al. 1996). Furthermore, previous studies on beans in Tanzania have shown that growing diverse mixtures allows for flexibility in adapting to diverse local environments and production constraints (Mohamed and Teri 1989; Allen et al. 1989; Madata 1991; Teverson et al. 1994). Friis-Hansen (1999) found that cultivation of different sorghum varieties in semi-arid areas in the Usangu plains of Tanzania was associated with wealth and social status, gender and the ethnic background of the farmers. Cromwell (1999) noted that different social groups in a community may manage and use different cultivars of the same crop, each adapted to optimise performance under local farming conditions. In the Great Lakes Region, Uganda and Malawi, bean genetic diversity is largely managed by women (Sperling and Loevinsohn 1993; Ferguson and Mkandawire 1993; David and Hoogendijk, 1997). As far as we are aware, no study to date has looked at the socio-economic factors that influence bean diversity in the SHZ of Tanzania.

The main objective of this study was to establish the socio-economic factors that are linked to bean diversity, i.e. the number of bean types that are grown by farm households, in selected locations in the SHZ of Tanzania The purpose was to test the null hypothesis that bean type diversity is

independent of the socio-economic characteristics of farm households. This study was part of a wider study "On-farm genetic resource management: *Phaseolus vulgaris* bean mixtures in the Southern Highlands Zone of Tanzania" (Bisanda, 2000). Further papers on disease factors and the dynamics of bean diversity are in preparation.

Materials and methods

Sampling and collection of data

This study was conducted in two phases during 1997 to 1999. Phase 1 involved working with a small group of 23 core households in 12 villages throughout the study period (Figure 1). Villages were located in cool, warm and hot dry ecological environments where beans are produced in the SHZ. Households were purposely selected from those farmers considered to be knowledgeable in bean diversity management on the basis of gender, willingness to collaborate, and knowledge and experience in bean mixture characteristics and production. Interviews were conducted using participatory rural appraisal (PRA) techniques, e.g. semi-structured interviews with matrix and pair-wise ranking, with the core households seven times during three years, at planting and harvesting, beginning in the July 1997 cropping season. During each visit, bean mixtures were collected from participating farmers. Information was obtained on household and farm characteristics, plant growth habit, production systems, management practices, cultivar preferences (matrix ranking), marketing, utilisation, seed acquisition and handling, culinary and storage qualities, and marketing issues. Half of each bean mixture collection was deposited in the Tanzania National Gene Bank in Arusha for *ex-situ* conservation while the other half was sent to the Horticultural Research International

(HRI), University of Warwick, Wellesbourne, United Kingdom, for characterizing morphological diversity and screening for disease reaction (disease information is given in the second paper in this series).

Phase 2 was conducted between August and September 1999 by using a structured questionnaire to interview 180 households in 18 villages. The main aim was to obtain quantifiable data on farmer strategies and practices in relation to bean diversity management. A total of 18 villages, including 5 from Phase 1, were studied. During Phase 1 it was observed that accessibility to markets had an impact on the number of mixture components. All 18 villages were therefore grouped into the eco-

climatic and accessibility categories as indicated in Table 1 in order to determine access to institutional support services, e.g. markets, transport, research and extension services. From each eco-climatic area, 30 accessible and remote households were selected.

Characterizing bean diversity

Bean diversity was characterized by the number of distinct seed types based on morphological characteristics such as seed coat colour, pattern, shape and size, as perceived by the farmers who provided the seed. Seed type is one of the commonly used criteria for bean classification. During the core household and questionnaire surveys, farmers were asked to sort and classify their bean mixtures into visually distinct seed types based on colour, pattern, shape and size and to provide the local or commonly used name for each type. For ease of analysis, the number of bean types grown by households was grouped into three major categories, i.e. those who grow 1 to 5; 6 to 10 and greater than 10 types. The information collected was then used to relate bean types and frequencies to eco-climatic and accessibility characteristics. The frequency of different bean types in the mixture at each mixture collection was used as a measure of relative importance and diversity of beans in different climatic regions. This was done by multiplying the mean percentage frequency of each bean type (component) in the mixture with the total number of occasions that it was collected.

Analysis of socio-economic variables

The chi-square (χ^2) statistic was used to test socio-economic variables that appear to be associated with the number of bean types that are grown by the questionnaire survey population. An attempt was made to test a null hypothesis that bean type diversity is independent of socio-economic characteristics of farming households. Variables such as age, gender, education, family size, labour size, cattle ownership, oxen ownership, number of cattle, hire labour, land area, proximity to markets were measured. The computed value of χ^2 is:

$$\chi^2 = \sum \frac{(f_0 - f_t)^2}{f_t}$$

Where: $\sum$ = Sum of:

f_0 = Observed frequencies of socio-economic variables (age, gender, education, family size, labour size, cattle ownership, oxen ownership, number of cattle, hire labour, land area, proximity to markets).

f_t = Expected frequencies of socio-economic variables.

Results

Importance of bean mixtures to rural livelihoods

Group interviews during Phase 1 showed that bean mixtures form an important livelihood base. All households grow beans for home consumption as well as for marketing. Beans and maize were the only crops grown by all households. From the questionnaire survey involving 180 households, irrespective of eco-climatic zone or accessibility, 67 to 97% of households sold beans for cash income. Bean mixtures are largely marketed in rural markets, where they form next season's seed base and the preferred diet. Most rural bean marketing is done by women traders while men manage urban marketing. Women traders fall into two categories: those who sell their own bean mixtures locally and those who buy mixtures from other farmers, rigorously sort out homogeneous phenotypes, and sell them to urban male traders at a higher price. As urban consumers do not prefer to eat bean mixtures, they are not commonly sold in urban markets.

Bean types grown in the study area

A total of 1302 accessions were collected from the core households between July 1997 and July 1998. Using modified international seed type descriptor and CIAT bean type classifications, 345 distinct types were identified. During the farmer survey (n = 180) 1573 bean types were identified in 180 bean mixtures and 161 unique bean names were mentioned. Bean names were found, however, not to be good indicators of phenotypic diversity especially at community (village) level, because in such a culturally heterogeneous society, one bean was found to have several names within and between communities and cultures. At household level, however, bean names represent different bean types as perceived by farmers. Table 2 gives a list of some of the bean types that were found to have different names within and between

communities. Some bean types have many different names across the SHZ and up to three names within the community (also see Table 3).

Beans are named in local dialects. Female farmers were more knowledgeable than male farmers due to the long history of female farmers' involvement in bean production and as custodians of bean seed at household level. Some bean names reflect a certain culture or gender. For instance in Lyadebwe village where the local people are mainly *Wabena* tribe, female farmers put a prefix *"se"* before the actual bean name, e.g. *Semuhanga* or *Sekablanketi*. In local language this means daughter of *Muhanga* or *Kablaneti,* respectively. In contrast, male farmers put the prefix *"nya"*, thus *Nyamuhanga*, indicating that a male person provided the name.

At HRI, the 345 distinct bean types were reclassified by bean type consensus names based on morphological characteristics. Phenotypically similar seed types were grouped together using one consensus name under which other synonym names were grouped. This resulted in 15 morphologically distinct bean types (Table 4). Un-named bean types were grouped in category 16. The frequencies of individual bean types in Figures 2.1, 2.2 and 2.3 show the variation in the relative importance of different bean types grown by core households in remote and accessible areas. According to the HRI classification, highly marketable *Kablanketi* types (No. 3) are popular in all villages across eco-climatic areas throughout the study area. *Kigoma* (No. 5) and *Njano* (No. 7) (also highly marketable) are more popular and widespread in remote and than accessible areas. *Ndongauche* types are also widespread in the study area, however the red types of *Ndongauche nyekundu* (No. 12) are popular in accessible and fairly accessible areas while the white types *Ndongauche nyeupe*

(No. 13) are more popular in remote areas. Both have very low market value but tend to dominate mixture composition because of their high yielding ability.

The questionnaire survey found that rural households grow between 1 and 18 bean types. Most households (40%) grow between 6 and 10 types while 36% grow more than 10 types. The remaining 24% grow between 1 and 5 types (Table 4). Thus the majority of the farm households grow between 6 and 18 types. The most widely grown bean types are *Kablanketi, Kabanima, Kigoma, Njano, Masusu* and *Msafiri* types (Table 5). These are grown widely throughout in all climatic zones, i.e. cool wet, warm wet and hot dry areas. *Kigoma* is more popular in the warm wet areas than elsewhere while *Loto* and *Mawese* are found in

warm wet areas only. *Msafiri* and *Masusu* are more popular in the hot dry areas than in other zones. Overall *Kablanketi* and *Masusu* are the most popular bean types in the study area.

The cultural diversity of the local people promotes bean type diversity in the study area. The primary function of some beans is to provide food for home consumption. Others are grown primarily for marketing and home consumption while others are grown to meet certain ceremonial functions such as gifts at weddings and eaten during funerals. Certain beans are grown as an insurance against environmental stresses because of their perceived ability to withstand rain and drought. Beans with more functions are *Kablanketi, Njano, Kigoma, Kabanima and Kasusu* (Table 6). The sophisticated use of specific bean types in rituals and funerals was observed at Mbimba village. For instance, farmers gave specific bean types as condolence to the bereaved family. It is also a tradition of many tribes in the study area to boil a mixture of maize and beans together called *kande* for consumption during funerals.

Socio-economic factors affecting bean diversity

The null hypothesis that bean type diversity is independent of socio-economic characteristics of farming households was tested using the chi-square (χ^2) statistic (Table 7). The results showed that the gender of the household head (χ^2 = 6.371; df = 2) and proximity to markets (χ^2 = 7.140; df = 2) have a significant influence on the number of bean types grown by households.

Family size (χ^2 = 5.737, df 2), ownership of oxen (χ^2 = 4.627, df = 2) and the land area that is available to farm households (χ^2 = 7.140, df = 2) were also significantly associated with the number of bean types grown. Urban markets, in particular, favour homogeneous bean types.

Sixty-five percent of female-headed and 37% of male-headed households kept between 6 and 10 bean types (Table 8). Thirty eight percent of the male-headed and 15% of female-headed households keep more than 10 bean types. More households with larger families (more than six members) (41%) kept more than 10 different bean types compared with households with smaller families (29%). Smaller households (less than five members) (50%) grew between 6 and 10 bean types compared to larger households (32%). In areas close to markets, more households (32%) kept between 1 and 5 bean types, mainly those which have high market value, than households in remote areas (15%). In contrast, more households in remote areas

(38%) kept more than 10 bean types than their counterparts in accessible areas (33%). In general, the number of bean types grown in accessible areas was equally distributed among the three groupings (1 to 5, 6 to 10 and more than 10). Ownership of large land area was used as an indicator of wealth. More of the rich households (45%) kept more than 10 bean types than the poor households (29%). The majority of the poor and middle wealth category households kept between 6 and 10 bean types.

Discussion

Extensive collection and characterization of bean landraces throughout three contrasting eco-climatic areas and involving 180 households from 25 different villages in the SHZ of Tanzania clearly showed that farmers manage and use a notable amount of *Phaseolus* bean diversity. The questionnaire survey found that rural households grew between 1 and 18 bean types, with most households growing between 6 and 18 types. This complements previous surveys in Rwanda and Malawi where households grew a mean of 11 and 13 visually different bean types per mixture, respectively (Thurston et al. 1999). From 1302 bean accessions collected in the SHZ of Tanzania, 345 distinct bean types were recognized based on local name and seed phenotype. A comparable survey in Rwanda found 550 local varieties (Sperling et al. 1994) while a survey in south west Uganda noted 135 local varieties

(Thurston et al. 1999). In this study, however, bean names, were found not to be good indicators of phenotypic diversity at community (village) level. Phenotypically identical beans were found to have several names within and between communities and cultures. Some bean types had many different names across the SHZ and up to three names within one community. After reclassification of bean types based on more extensive morphological characteristics, 15 phenotypically similar seed types could be grouped together using the most commonly used name (Table 4). Among these, six bean types only were found to be widely grown. These were *Kablanketi, Kabanima, Kigoma, Njano, Masusu* and *Msafiri* types (Table 5) which are grown widely throughout all climatic zones, i.e. cool wet, warm wet and hot dry areas. With one exception, these bean types are believed to be local landraces. The exception is *Kabanima* which was widely-distributed throughout East and southern Africa from a bean improvement programme in Uganda in the early 1970's (Colin Leakey, personal communication). It is interesting to note that throughout its diffusion through the SHZ, it has retained its original name.

The results suggest that socio-economic factors, both within the community and at household level, are important factors determining the number of bean types grown. There is no single factor that alone influences farmer decisions to maintain few or many bean types. Any factor that seems to be positively correlated with the number of bean types grown by farm households has to be compared with other factors, even those which seem to be statistically less significant. Individual farmers have their own motivations to maintain diversity guided by household circumstances. For instance some households maintain diversity in order to enhance food security and to spread production risks. Others take the risks of keeping low diversity in order to concentrate on marketable beans in order to generate cash income. At the same time, the majority of farmers surveyed sell surplus beans for cash income irrespective of market access or eco-climatic area.

The influence of proximity to market opportunities on the number of bean types grown by households is particularly clear from the findings of this study. Where villages have easy access to markets there is a tendency of most households to grow few bean types, mainly those with high market value. However, in remote villages where the market has had little influence, farmers grow many bean types, as shown in Table 8. In remote areas, by not being sure whether bean buyers will be available or not, stability rather than profit maximisation appears to be the motive behind production.

The long-term effect of high market opportunities appears to be two-fold. Firstly, it can reduce bean diversity as a result of specialisation in marketable beans where farmers continue to grow bean mixtures with a narrow range of diversity i.e. fewer types (David and Hoogendijk 1997; Wortmann et al*.* 1998). Secondly, it can encourage farmers to abandon diverse bean mixtures entirely in favour of genetically uniform cultivars in order to maximise profits (Altieri and Merrick 1987). Studies on the effect of proximity to the markets in Uganda (David, 1994, David and Hoogendijk 1997) and Malawi (Ferguson and Mkandawire 1993) revealed that farmers who are less restricted by market forces grow more bean types but smaller quantities of each, representing greater cultivar diversity. However, where there are strong market influences, farmers often grow large quantities of beans with low diversity and very often the market orientation is accompanied with cultivar erosion.

The hypothesis that rich farmers manage low diversity (Friis-Hansen, 1999) by growing few crop varieties with high market value is not valid in this study. During our surveys, rich farmers were identified as those with cattle, oxen and large land area. Results showed that farmers with a large land area and those with oxen managed a larger numbers of bean types than their poorer counterparts (Table 8). These findings suggest that rich farmers can take the risk of experimenting with many varieties without the fear of crop loss because they can afford to plant a larger land area. Rich farmers with oxen, unlike the poor, can afford to plough their land in advance of the growing season and plant large quantities of beans with a high genetic diversity at the on-set of the rainy season. In contrast, poor farmers have to wait and rent oxen when the rich farmers have finished ploughing thus often plant late. Poor households often have to select a few early maturing varieties, as also found by Friis-Hansen (1999) in semi arid areas of Usangu in Tanzania and Cromwell (1999) in communal areas of Zimbabwe. In a similar study in Uganda, David and Hoogendijk (1997) found no association between the number of bean varieties cultivated and household wealth.

Our study also showed that households with large families grow more bean types than those with smaller families (Table 8). Large families tended to be wealthier households, often polygamists with many wives and children, cultivating a large land area and therefore needing a large labour force to perform operations such as sowing, weeding and harvesting. This translates into many mouths to feed and encourages such households to grow many bean types in order to enhance food security. In a similar study in Uganda, David and Hoogendijk (1997) found no association between the number of bean varieties cultivated and farm size.

The widespread view that the gender of the decision-maker on bean production influences diversity was not supported by this study i.e. there was no indication that where men or women were decision makers, more or less bean types are grown (Table 7). This is similar to the findings of Cromwell and van Oosterhout (1997) in Zimbabwe but contrary to the findings of Sperling and Loevinsohn (1993), in Rwanda, where high bean diversity was associated with female decision-makers. In fact, in this study, more bean types were grown where joint decisions between men and women were made than where only one person made the decisions. One explanation for this may be that where the husband and wife are interested in different bean types, the joint decision results in all bean types being grown. In contrast, if

only one person makes the decision, he/she may influence the household to grow only those bean types he/she is interested in.

The view that because of their deep involvement in managing crop plant diversity, female farmers tend to manage higher levels of biodiversity than male farmers (Friis-Hansen, 1999; Cromwell, 1999) is also not supported by this study. In this study, even where women are the overall decision-makers for bean production in male-headed households, there was no association between gender and increased bean diversity (Tables 7 and 8).

Conclusions

Proximity to markets, wealth and household size have significant influence on the decision to manage and use bean diversity.
Joint decision making between women and men in the household results in management and use of maximum bean diversity (especially in male headed households, Table 8).

The long-term effect of improved transportation and market opportunities is likely to be a reduction in bean diversity.
Wealthier farmers with oxen, large land area and large families, tend to keep more bean diversity than poorer farmers (Table 8).

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References

Allen D.J., Dessert M., Trutmann P. and Voss J. 1989. Common beans in Africa and their constraints. In: Shwartz H.F. and Pastor-Corrales M.A. (eds), Bean Production Problems in the Tropics. CIAT, Cali, Colombia, pp. 9-31.

Altieri M.A. and Merrick L.C. 1987. In situ conservation of crop genetic resources through maintenance of traditional farming systems. Economic Botany 41: 86-96.

Berlin B., Breedlove D.E. and Raven P.H. 1974. Principles of Tzeltal Plant Classification: an Introduction to the Botanical Ethnography of a Mayan Speaking Community in Highland Chiapas. Academic Press, New York, pp. 660.

Bisanda S.Z. 2000. On-farm genetic resource management: Phaseolus vulgaris bean mixtures in the southern highlands of Tanzania. PhD thesis, University of Greenwich, U.K.

Cromwell E. 1999. Agriculture, biodiversity and livelihoods: issues and entry points. Final Report, Overseas Development Institute, London, pp 60.

Cromwell E. and van Oosterhuit S. 1997. On-farm conservation of crop diversity: policy and institutional lessons from Zimbabwe. [publ?], pp 20.

David S. 1994. Seed first: developing farmer seed enterprises in Uganda for the production and distribution of bean varieties. Rockefeller Foundation Social Sciences Fellows' Workshop. ILCA, Addis Ababa, Ethiopia, 14-18 November 1994.

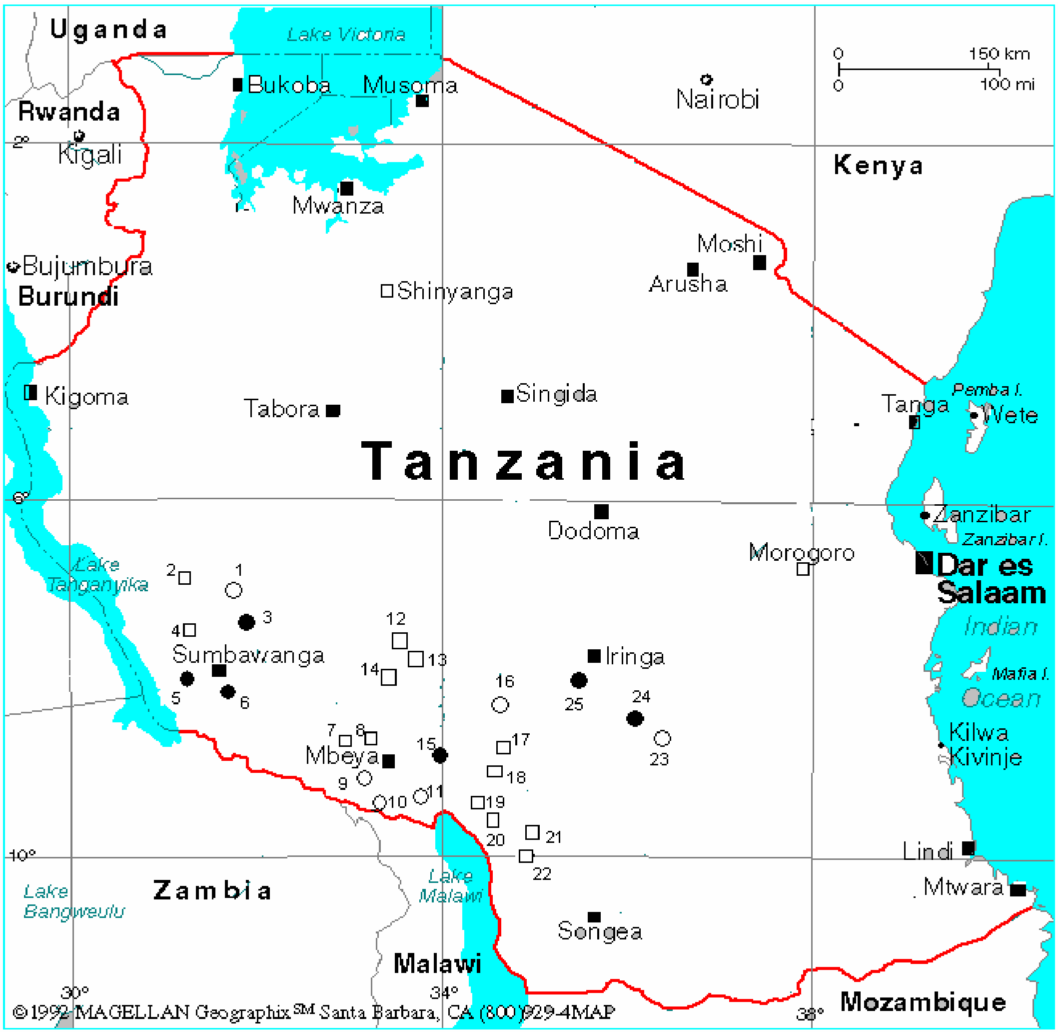
David S. and Hoogendijk M. 1997. Bean production systems in Mbale district, Uganda, with emphasis on varietal diversity and the adoption of new climbing varieties. Network on Bean Research in Africa, Occasional Publications Series, No.20. CIAT, Kampala, Uganda, pp 31.

Ferguson A. and Mkandawire R. 1993. Common beans and farmer managed diversity: regional variations in Malawi. Culture and Agriculture No. 45-46.
Friis-Hansen E. 1999. Socio-economic dynamics of farmers' management of local plant genetic resources: a framework for analysis with examples from a Tanzanian case study. CDR Working Paper 99(3): pp53. Harlan J.R. 1975. Our vanishing genetic resources. Science, 188: 618-621.
Madata C.S. 1991. Evaluation of bean varieties in farmers' fields in the southern highlands. In: Mabagalla R.B. and Mollel N. (eds), Bean Research vol.6. Proceedings of the Tenth Bean Research Workshop, Sokoine University of Agriculture, Morogoro, Tanzania, September 16-18, 1991.
Martin G.B. and Adams M.W. 1987. Landraces of Phaseolus vulgaris (Fabaceae) in Northern Malawi. I. Regional variation. Economic Botany 41: 190-203.
Mohamed R. and Teri J. 1989. Mgeta farmers and bean diseases. ILEIA Newsletter 4(3): 18-19.
Shiva V. and Dankelman I. 1992. Women and biological diversity: lessons from the Indian Himalaya. In: Cooper D., Vellvé R. and Hobbelink H. (eds), Growing Diversity: Genetic Resources and Local Food Security. IT Publications, London, pp. 44-52.

Smartt J. 1977. Tropical Pulses. Tropical Agriculture Series. Longman, London.
Sperling L., Scheideggar U. and Buruchara R. 1994. Enhancing small farm seed systems: principles derived from bean research in the Great Lakes Region. Network on Bean Research in Africa. Occasional Publications series, No. 15, CIAT, pp. 13.
Sperling L. and Loevinsohn M.E. 1993. The dynamics of adoption: distribution and mortality of bean varieties among small farmers in Rwanda. Agricultural Systems 41: 441-453.
Teverson D.M., Taylor J.D. and Lenné J.M. 1994. Functional diversity for disease resistance in Phaseolus vulgaris bean mixtures in Tanzania. Aspects of Applied Biology, 39: 163-172.
Thurston H.D., Salick J., Smith M.E., Trutmann P., Pham J.-L. and McDowell R. 1999. Traditional management of agrobiodiversity. In: Wood D. and Lenné J.M. (eds), Agrobiodiversity: Characterization, Utilization and Management. CABI, Wallingford, pp. 211-243.
Trutmann P., Voss J. and Fairhead J. 1996. Local knowledge and farmer perceptions of bean diseases in the Central African Highlands. Tropical Pest Management 39: 334-342.
United Republic of Tanzania, 2004. National Crop Production Statistics 2002/2003. Ministry of Agriculture, Dar-es-Salaam, Tanzania.

Wortmann C.S., Kirkby R.A., Eledu C.A. and Allen D.J. 1998. Atlas of Common Bean (Phaseolus vulgaris L) Production in Africa. CIAT, Cali, Colombia, pp 133.

igure 1. Locations of study sites in the Southern Highlands Zone of Tanzania



Key:

● Core villages covered during Phase 1 only
○ Core villages covered during Phase 1 and 2
□ Villages covered during Phase 2 only

1. Kasu; 2. Katani; 3. Kantawa; 4. Kipande; 5. Matanga; 6. Mpui; 7. Insani; 8. Itaka;
9. Mbimba; 10. Mbebe; 11. Masebe; 12. Lupa; 13. Mamba; 14. Upendo; 15. Iyawaya;
16. Lyadebwe; 17. Ilembula; 18. Kanamalenga; 19. Mlondwe; 20. Ng'onde;
21. Magoda; 22. Njoomlole; 23. Lulanzi; 24. Kilolo; 25. Rungemba.

Table 1. Classification of study villages by ecological conditions and accessibility

Eco-climatic areas	Accessible villages	Remote villages
Cool Wet	Masebe, Magoda, Njoomlole	Lulanzi, Ng'onde, Mlondwe
Warm Wet	Mbebe, Itaka, Insani	Kasu, Kipande, Katani
Hot Dry	Kanamalenga, Lyadebwe, Ilembula	Upendo, Lupa, Mamba

Table 2. Popular bean types (by consensus see Table 3) with different names within and between communities

Popular name	Names in Iringa region	Names in Mbeya region	Names in Rukwa region
Kablanketi	*Kagunira, Soya, Nyamuhanga, Semuhanga*	*Kablanketi*	*Chimula, Kablanketi*
Kigoma	*Njano ndogo*	*Kigoma, Njano mviringo,*	*Kigoma*
Njano	*Njano, Seyelo*	*Njano, Ndondo, Namayelo, Yelo*	*Njano*
Ndongauche nyekundu	*Semdung'u, Msafiri*	*Msafiri*	*Msafiri*
Lusaka	-	*Maini, Namaini*	*Lusaka*
Nyamuhanga		-	-
Kasukanywele	*Msukanywele*	*Kasukanywele, Mwasipenjele Ngitikila*	*Ngoli, Nangoli Hosana, Kasukanywele,*

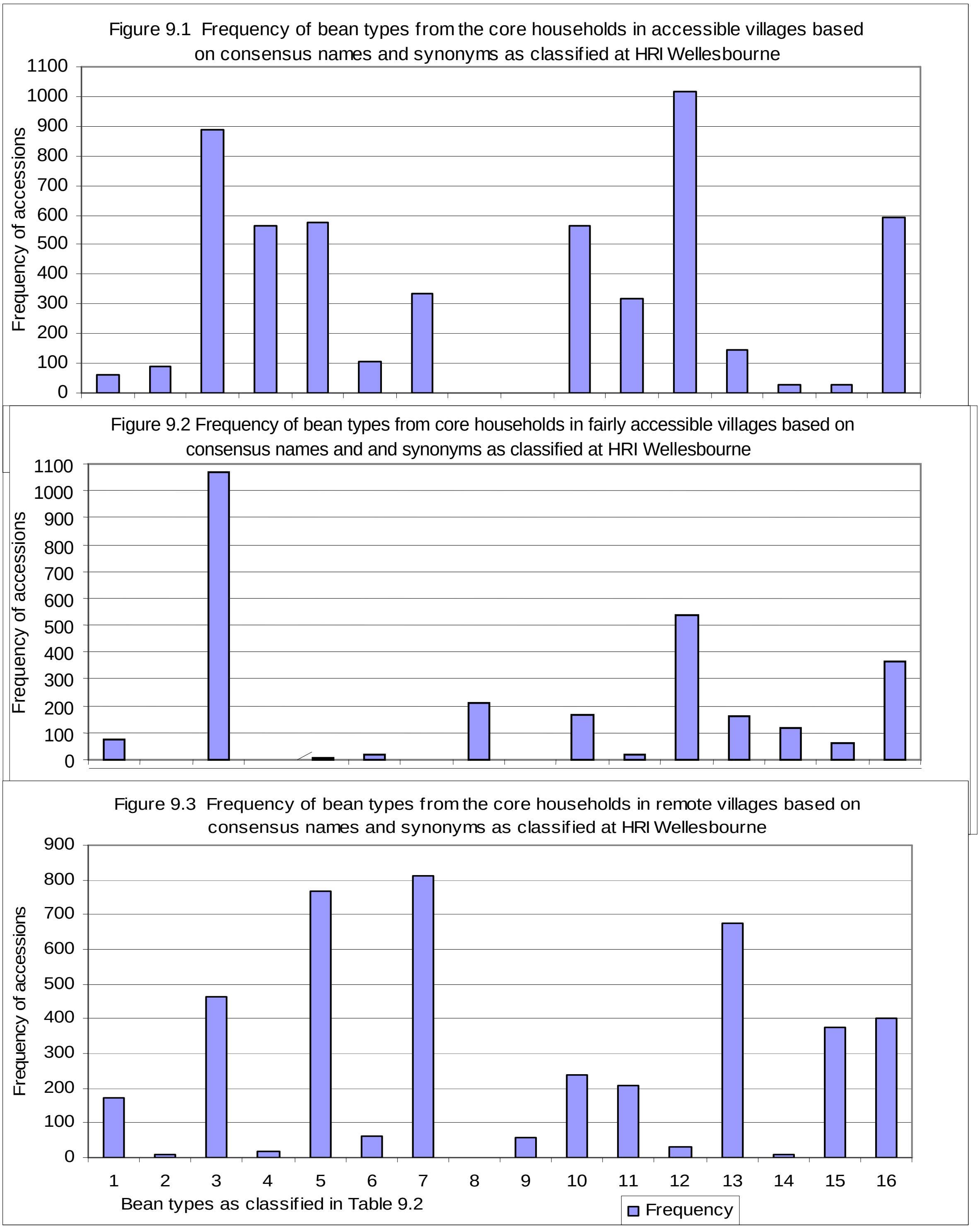


Figure 2. Frequency of bean types in accessible, fairly accessible and remote villages in the study area.

Table 3. Classes of recognisable bean types classified by consensus name and synonyms[1] used by farmers in the study area.

HRI Class No.	Consensus name	Number of synonyms in use	Primary colour[3]	Secondary colour[4]	10 seed weight (gm)
1	*Kabanima* (L/M)[2]	*3*	*10*	*12*	*2.73 -5.30*
2	*Nambalala* (M)	*2*	*11; 12*	*8; 10*	*2.99 - 4.30*
3	*Kablanketi* (L/M)	*15*	*8; 10*	*0*	*2.96 - 5.05*
4	*Kasukanywele* (L)	*11*	*12*	*6; 9*	*2.83 - 5.57*
5	*Kigoma* (M)	-	*4*	*0*	*2.60 - 3.93*
6	*Lusaka* (M)	*5*	*4*	*0*	*2.92 - 3.58*
7	*Njano* (L/M)	*7*	*4*	*0*	*3.15 - 3.94*
8	*Maselege* (S/M)	*7*	*5; 12*	*6; 9*	*3.17 – 5.04*
9	*Loto* (M)	-	*5; 12*	*6; 9*	*2.44 - 3.99*
10	*Masusu* (S/M)	*6*	*6*	*0*	*1.95 - 5.03*
11	*Mwasipenjele* (L)	*5*	*12*	*0; 10*	*3.53 - 4.60*
12	*Ndongauche nyekundu* (S/M)	*12*	*10*	*0*	*2.07 - 3.90*
13	*Ndongauche nyeupe* (S/M)	*12*	*1*	*0*	*1.95 - 3.69*
14	*Ndongauche nyeusi* (S)	*4*	*9*	*0*	*1.93 - 2.91*
15	*Mpotampungo* (M)	*1*	*5; 12*	*0*	*2.20 - 4.12*

[1] As classified at HRI Wellesbourne

[2]Seed size: S = small; M = medium; L = large; S/M = some of the bean types in that class are small others are medium

Jill needs to add footnotes for 3 and 4

Table 4. Numbers of bean types grown by farmers in the study area (n= 180).

Eco-climatic area	Bean types (no.)	Remote villages (%)	Accessible villages (%)
Cool Wet	1 to 5	23	33
	6 to 10	47	44
	Above 10	30	23
Warm Wet	1 to 5	3	27
	6 to 10	23	30
	Above 10	74	44
Hot dry	1 to 5	27	33
	6 to 10	53	44
	Above 10	20	23

Table 5. Most frequently grown bean types and the percentage of farmers growing them (n= 180).

Bean name	Climatic zone			Overall % of farmers growing bean type
	Cool Wet	Warm Wet	Hot Dry	
Kablanketi	20	18	19	57
Masusu	13	14	28	55
Njano	7	22	11	40
Msafiri (Madung'u)	11	8	19	38
Kigoma	4	28	2	26
Kabanima[2]	6	16	2	24
Mwasipenjele	4	14	6	23
Kablanketi nyeusi	6	11	5	22
Kablanketi ndefu	13	3	2	18
Nyamuhanga	7	0	10	17
Kalalasi	0	15	0	16
Mashabala	1	3	11	16
Mtitu	7	0	9	16
Loto	0	13	0	13
Kambani	1	3	7	12
Mawese	0	12	0	12
Chipukupuku (Dolea)	0	7	4	11
Kasukanywele	3	2	6	11

[1] Percentage does not add up to 100 because of multiple responses to some bean types of households. Sample size for each zone was 60 households

[2] Unlike all other types, Kabanima is a bred variety originally from Uganda

Table 6. Functional diversity of bean mixtures as perceived by core household farmers

Bean functions	**Bean types**
Resistance to "rain" (disease) damage	*Masusu, Kabanima, Loto, Mwasipenjele, Njano, Ndongauche nyeusi, Ndongauche nyeupe, Ndongauche njano, Ndongauche nyekundu*
Source of income	*Kigoma, Kablanketi, Masusu, Kabanima, Lusaka, Mwasipenjele, Ndongauche nyekundu*
Cooks well and palatable	*Kigoma, Kablanketi, Masusu, Mwasipenjele, Kasukanywele, Njano, Ndongauche nyekundu*
Matures early to "off-set possible hunger"	*Kablanketi, Kasukanywele, Kabanima, Loto, Lusaka, Masusu, Ndongauche nyeupe, Njano, Kigoma, Ndongauche nyekundu*
Resist drought stress	*Maselege, Njano, Kigoma, Masusu, Kablanketi, Mwandogasya, Kambani, Ndongauche nyeupe, Ndongauche nyeusi, Ndongauche nyekundu*
Consumed during funerals	*Lusaka, Mwasipenjele, Njano*
Given as gifts in weddings/ceremonies	*Maselege, Ndongauche nyekundu, Ndongauche nyeupe,*
Used in traditional religious ceremonies	*Inzelu kubwa, Namasanku*
Suitable for intercropping	*Lusaka, Kabanima, Kigoma, Ndongauche nyekundu*

Table 7. Socio-economic factors affecting bean diversity: Chi-Square results

Socio-economic variables	**Chi-square value**	**df**
Age of household head	2.198	2
Amount of land under cultivation	7.916[1]	4
Cattle ownership	0.298	2
Education of decision maker	1.845	2
Education of household head	0.442	2
Family size	5.737[1]	2
Gender of decision maker	1.696	6
Gender of household head	6.371[2]	2
Hiring labour	1.047	2
Labour size	1.354	4
Number of cattle owned	3.261	2
Ownership of oxen	4.627[2]	2
Proximity to crop markets	7.140[2]	2

[1] Significant at p= 0.10 level. [2]Significant at p= 0.05 level; df= degrees of freedom.

Table 8. Socio-economic variables, percent of households and the corresponding number of bean types they grow (n= 180).

	Number of bean types grown			**Sample size**
Socio-economic variables	1 to 5	6 to 10	Above 10	
Male headed households	25	37	38	160
Don't own a pair of oxen	23	45	31	119
Large households[1]	27	32	41	102
Remote villages[2]	15	47	38	90
Accessible villages	32	35	33	90
Small households	21	50	29	78
Medium cultivated land area	19	50	31	70
Large land area	26	29	45	65
Own a pair of oxen	26	29	42	61
Small cultivated land area[3]	31	40	29	45
Female headed	20	65	15	20

[1] 1 to 5 is a small family and above five is a large family

[2] Remote and accessible markets relates to accessibility to markets

[3] 0.4 to 2 = small; 2.1 to 4 = medium and above 4ha large land area