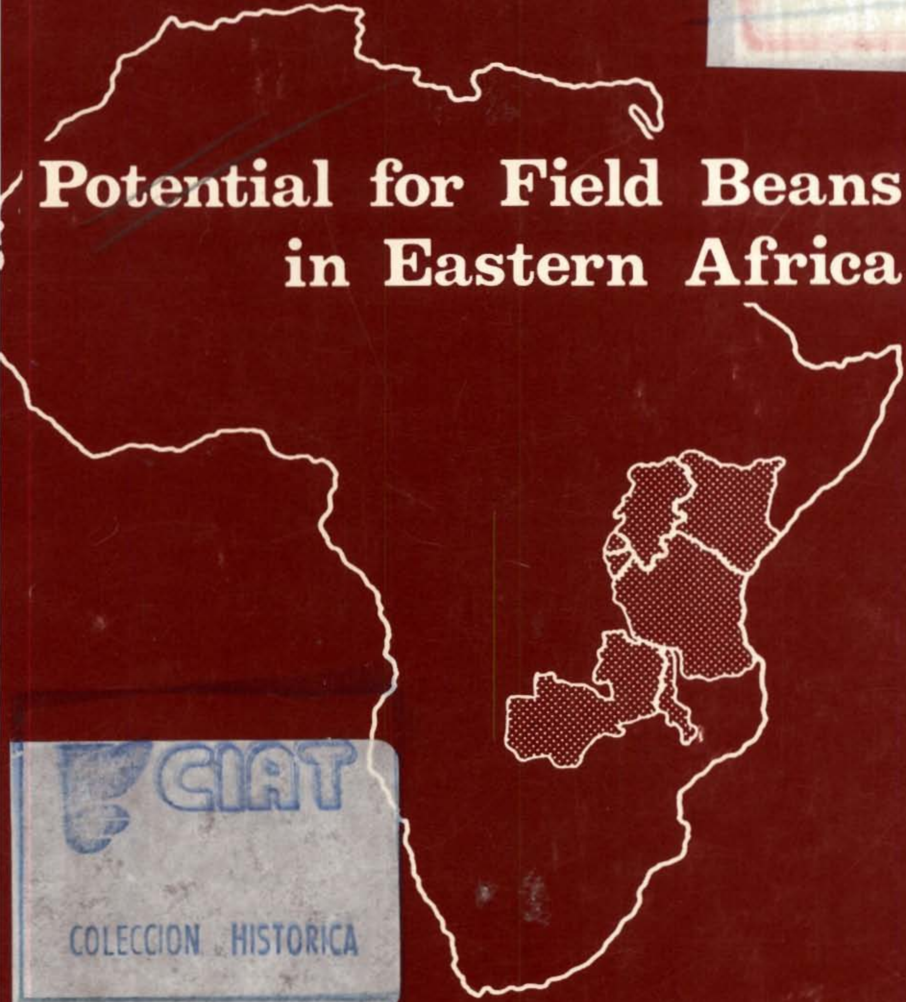
Potential for Field Beans in Eastern Africa



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held in Lilongwe, Malawi
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2403

Contents

The Proceedings of this Workshop contain the reports on the bean production situation in each of the participating countries. They are followed by a summary of panel discussions and the concluding recommendation to increase bean production in Eastern Africa. Greater collaboration at regional and international levels was considered instrumental in achieving the above objective, and in this respect it was suggested that CIAT be called upon to assist with the establishment and operation of a Regional Center for Bean Research.

Background and Objectives

Dry beans *(Phaseolus vulgaris* L.) form an important part of the diet of people in Eastern Africa. They are an important protein source for lower income families or where animal protein is not a-vailable. Production and productivity increases of dry beans are lagging behind the population increase, endangering adequate nutrition of many people.

The Consultative Group for International Agricultural Research (CGIAR) has asked CIAT to assume world responsibility for collection, preservation and improvement of bean germplasm. As most of the bean production is centered on small farms, the bean program objectives are to develop scale-neutral production technology which will overcome major production restraints. This is pursued through breeding for disease and pest resistance, improvement of the plant architecture, and less reliance on chemical fertilizers. Breeding for climbing bean varieties adapted to associate cropping with maize is also an important component of the program activities.

Up to now, over 25,000 accessions of *Phaseolus* have been collected and over half of them evaluated.

Initially the CIAT program based in Cali, Colombia, directed its efforts to Latin America, and now that lines have been developed with the potential to increase production and productivity of beans in Latin America, a workshop was programmed with the University of Malawi to study the feasibility of starting a collaborative regional program in Eastern Africa.

The workshop served as a forum for the diagnostic analysis of the constraints limiting bean *(Phaseolus vulgaris* L.) production in the Eastern Africa countries, and for discussion on the actions to be taken at the national, regional and international levels to increase bean production.

Opening Remarks and Scope of the Workshop

L.K. Mughogho

"Mr. Chairman, distinguished delegates, ladies and gentlemen:

Today is a very special occasion for my colleagues and me in the Bean Research Project in this country. It marks the first stage in the fulfillment of several years of wishes, hopes and aspirations for the improvement of bean *(Phaseolus vulgaris* L.) production in Eastern Africa.

In its place of origin in Central and South America, the bean grows in medium and higher elevations. In Eastern Africa it has adapted well to the region stretching from Ethiopia in the North to Mozambique in the South and across into Angola. Reports of yields exceeding 3000 kg/ha on experimental stations are commonplace in this region. However, their translation to consistently high yields on farmers' fields is rare; in fact, bean yields on farmers' fields rarely exceed 500 kg/ha. This wide yield gap is a challenge to all of us whose duty and interest are to promote food production and adequate nutrition in the region.

The idea of holding a workshop on beans in Eastern Africa was first mooted in 1973 after the first Latin American Bean Workshop sponsored by CIAT and held at its headquarters in Colombia in February 1973.

Although CIAT has a global mandate for bean improvement under the CGIAR system, its research activities have so far been confined to Latin America. My colleagues and I were convinced that bean production in Eastern Africa could be improved with the help of CIAT which has a large collection of germplasm essential for improvement and the machinery and experience of a regional research program. We, therefore, asked CIAT to consider the bean production situation in the region and the measures that could be taken to improve it. This took several years, and it was not until 1977/78, when Dr. O.T. Edje was at CIAT as a visiting scientist, that a proposal was drawn up to hold this workshop in Malawi as a collaborative effort between the University of Malawi, Bunda College of Agriculture, and CIAT.

The objectives of this workshop are twofold: to identify the problems and constraints to bean production in Eastern Africa; and to formulate a positive action program at national, regional and international levels for solving the problems identified.

Our governments are interested in concrete and practical, down-to-earth developmental activities whose benefits can be foreseen. Let us, therefore, come up with an action program whose focus will be on recognized priority areas that will bear fruit within a short period of time, and whose benefits will go to the small farmer.

Money for research is tight. The best we can hope for is donor finance from outside the region. But the donors too will be interested in assisting projects if they are well conceived and have a direct bearing on the needs of the small farmers.

The role of CIAT will be crucial here. It is my belief that CIAT could best help the Eastern Africa region to improve bean production by establishing a regional research program (with scientists in breeding, agronomy, pathology, entomology, and physiology) whose main objective would be to develop high yielding, agronomically stable cultivars, with good quality seeds and resistance to a range of important pests and diseases.

The key words are **positive action,** and our target group are the small farmers who grow the beans and who must benefit through increased production, improved nutrition and monetary return. The workshop is a forum for the free exchange of ideas, and every opportunity should be taken to discuss all issues fully so that rational and meaningful conclusions can be drawn.

I wish to thank CIAT, USAID, DTH and the Ford Foundation for their financial assistance without which it would not have been possible to organize this workshop. I also wish to thank the Malawi Government and the University of Malawi whose staff have done much of the ground work that has enabled us to be here today.

Last but not least, I have arranged with the immigration officials not to let you leave Malawi until you come up with concrete and practical recommendations for bean improvement in Eastern Africa."

Welcome Address

Hon. Dick Matenje
Minister of Education

"Delegates and observers from Britain, Burundi, Cameroun, Colombia, Costa Rica, Ethiopia, India, Kenya, Malawi, Mozambique, Nigeria, Rwanda, South Africa, Tanzania, Uganda, United States of America, West Germany, Zambia and Zimbabwe-Rhodesia and representatives from FAO, UNDP, AID, Dutch Government, ADMARC, Press Holdings, EPD, Ministry of Education, Ministry of Trade, Industry and Tourism, Malawi Export Promotion Council, Malawi Bureau of Standards, distinguished guests, ladies and gentlemen:

Before officially opening this important Regional Workshop on Potential for Field Beans in Eastern Africa, I wish to welcome you all to Malawi on behalf of His Excellency the Life President Ngwazi Dr. H. Kamuzu Banda, who is also the Minister of Agriculture and Natural Resources, and to thank you for your participation. On a personal note, I wish to thank His Excellency the Life President Ngwazi Dr. H. Kamuzu Banda, firstly for allowing this workshop to be hosted here and for his support to its theme. Secondly, for nominating me to deliver the opening address.

Furthermore, I would like to thank the Dutch Government, CIAT, AID, the Ford Foundation and the Malawi Government for the financial, technical and moral support which has enabled the workshop to take place here. Let me also mention that the Goverment of the United States of America, through its Agency for

International Development (AID), in addition to supporting this workshop, has offered funds under the National Rural Development Project for research and development of *Phaseolus* beans in this country.

We in Malawi wholeheartedly support regional cooperation of this nature, because discussions concerning food production problems in the countries represented here today are so important as to transcend national boundaries.

I am aware that each country represented here has its own distinctive agricultural development policy. However, it is our firm belief that we all can and should learn from each other through the exchange of ideas and experiences. This will afford delegates the opportunity to assess which of the new ideas and technologies are applicable to their countries' agricultural programmes with a view to improving production efficiency, thus achieving self-sufficiency in essential food crops, including beans.

The common bean known scientifically as *Phaseolus vulgaris* L. originated in America and was brought to Europe after Columbus had visited that continent. From Europe it spread to Africa, most probably through Portuguese influence, and reached Malawi from the East coast of Africa about three hundred years ago. The main producing areas in Africa are in the Eastern Africa highlands stretching from Ethiopia to Southern Africa and from Central Africa across to Angola.

In meeting the required protein levels in our diets, especially in the developing countries, grain legumes play a role as important as that of cereals in the supply of energy, beans being one of the most important sources of protein. In Malawi, bean production is second only to groundnuts; beans are mostly grown by the small holder farmer. The quality of bean protein is not as high as that of meat or fish. However, bean protein is very high in lysine which makes it very important in human nutrition. Therefore, a meal consisting of beans, maize in the form "nsima" and some vegetables is well balanced for both growth and maintenance of good health.

In Malawi we have what we call "likuni phala" which is a mixture of beans, groundnuts and maize in a 1:1:2 ratio which is ground together. When cooked, the mixture is used for weaning children under five.

Based on the FAO Production Yearbook, 8000 tons of beans were grown on 15,000 hectares between 1972 and 1976, with a yield level of 533 kg/ha which is very low in terms of the actual potential. There are a number of factors which limit bean production in Malawi and perhaps in other African countries. The most important ones are the lack of suitable varieties, seed availability, inadequate production technologies such as planting times, plant population and spacing, fertilization and cropping systems. In addition, diseases such as anthracnose and halo blight, in particular, which attack pods primarily; pests such as the bean fly which attacks young seedlings, bean beetles and aphids which attack the bean plant; and weeds that compete with the plant for production factors contribute to the low yields that are realized by the farmer. In view of these constraints, there is a great and urgent need to double our efforts in the following areas: (a) development of high yielding disease and pest resistant varieties; (b) production and distribution of high quality seeds; (c) improved cultural practices with emphasis on the smallholder farmer; (d) development of cropping systems such as mixed cropping for different ecological regions where the smallholder farmer can make maximum use of scarce resources such as land, fertilizer and other factors which usually limit production.

Ladies and gentlemen, looking at the present and future protein requirements in the developing countries, there is a great need to improve bean production if we are to halt malnutrition and diseases associated with it.

I would, therefore, urge you to consider seriously the ways and means of increasing bean production on the one hand, and on the other hand, other grain legumes that may also be of economic and nutritional importance in the third world countries where animal and fish protein is rather scarce.

I hope that this workshop will result in some concrete short-term and long-term recommendations for increasing bean production at both national and international levels."

Response to the Minister of Education's Opening Address

Aart van Schoonhoven

"Dear honorable Minister of Education, distinguished delegates and observers, ladies and gentlemen:

On behalf of the participants in the workshop on Potential for Field Beans in Eastern Africa and on behalf of Dr. John L. Nickel, Director General of the Centro Internacional de Agricultura Tropical, CIAT, in Colombia, who just returned to CIAT from a long technical mission to Eastern Africa and, therefore, could not attend this workshop, I wish, as head of the Bean Program at CIAT, to express our sincere gratitude to his Excellency, the Life President of the Republic of Malawi, Ngwazi, Dr. H. Kamuzu Banda, for allowing this workshop to be held and supporting its execution in this beautiful country.

I also want to thank you, your honorable Minister of Education, Sir, for your kind opening address of this conference.

From your opening address it is clear that beans form an important protein component of the human diet and that this crop is mostly produced by smallholder farmers having a large number of production constraints. In our Latin American experience we found a very similar production situation and obstacles to increased productivity and production as the ones you mentioned. In efforts to meet these constraints, we try to develop a technology which will fit the production reality of the smallholder farmer. That means we principally develop germplasm with increased resistance or tolerance to insects and diseases, in the desired grain color and type requirements, with high yields, short cooking times and tolerant to climatic and soil constraints.

Such a task is too great to be done by individual research teams. A collaborative effort is needed, therefore, between scientists of national and international programs to develop such technology. This can be done, and we have seen that lines developed in CIAT to meet our production situation performed very well in the experimental fields of Bunda College of Agriculture. CIAT has received the world mandate for research in beans from the Consultative Group of International Agricultural Research, therefore, we are very stimulated by such observations.

The objetive of this workshop is to assess the need for such a collaborative network and to develop recommendations and strategies to meet our common goal of increased bean production and productivity.

Your stimulating opening address has given a good start to this workshop, and we want to thank you for it."

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Bean Production Trends in Africa 1966 - 1979

Nohra R. Londoño*
Juliet W. Gathee*
John H. Sanders*

Africa produces approximately 1.35 million tons of beans annually, equivalent to 37% of Latin American production. Within Africa, bean production is concentrated in Eastern Africa, with 61% of the total approximately equally divided among the five producers, Uganda, Rwanda, Kenya, Burundi, and Tanzania (Table 1). The combined production of these Eastern Africa countries of 822,000 t is below that of either Brazil or Mexico but is substantially larger than that of any other Latin American country.

The data available from African sources gives very different results for the principal Eastern Africa producers. These estimates increase the total Eastern Africa bean production from the 822, 000 t in the FAO estimate in 1977-1979 to 1,399,000 t, a 69% increase (Tables 2 and 9). The apparent explanation for the divergence is the difficulty in estimating production of a basic food crop, which is principally kept for home consumption in a large number of the small farms producing beans[1]. The yield data from the Eastern Africa countries are also substantially higher than those of FAO (Tables 8 and 9). The rest of the paper used the FAO data for their longer time series.

International trade data are only available for dry legumes. In Africa beans are a much smaller proportion (27%) of dry legumes than in Latin

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[1] See country reports on bean production for their discussions on marketing.

Table 1. African bean production in the last decade, 1966-68 to 1977-79.

Country or region	1966-68 Annual Production (000 t)	(%)	1977-79 Annual Production (000 t)	(%)
Eastern Africa principal producers				
Uganda	175	17.0	175	13.0
Burundi	133	13.0	162	12.0
Kenya	133	13.0	161[a]	11.9
Rwanda	126	12.3	174	13.0
Tanzania	108	10.5	150	11.1
Other African countries				
Ethiopia	68	6.6	13	1.0
Angola	64	6.2	64	4.7
South Africa	50	4.9	75	5.5
Madagascar (Malagasy)	49	4.8	47	3.5
Cameroun	24	2.3	82	6.1
Zimbabwe (Rhodesia)	23	2.2	25	1.8
Togo	20	1.9	16	1.2
Others[b]	54	5.2	206	15.8
Africa	1027		1350	

a The Ministry of Finance and Planning data for 1978, since FAO does not report the Kenya data.
b Includes all the African countries producing less than 1% of the bean production in the continent, either at the beginning or at the end of the decade.

Source. FAO, **Production Yearbooks,** various years. Estimates for Kenya from the Kenyan Central Bureau of Statistics, **Statistical Abstract,** 1978, Nairobi, Kenya. Niger was excluded since the latest FAO documents include only dry legumes and no beans.

America (84%)[2]. Per capita consumption of dry legumes is lower in Africa than in Latin America; however, the opposite is true in some of the principal Eastern Africa producers (Table 3). The extremely high consumption of dry legumes in Rwanda, Burundi, and Uganda has been associated with the predominant calorie sources of low protein content especially root crops and plantains[3].

2 For Latin America data see J.H. Sanders and C. Alvarez P., **Evolución de la producción de fríjol en América Latina durante la última década,** Serie 06SB-1, CIAT, Cali, Colombia, Agosto 1978, pp. 6 and 8. See Tables 1 and 3 in this paper for the African data.

3 W.R. Stanton, **Grain Legumes in Africa,** Food and Agriculture Organization of the United Nations, Rome, 1966, p. 17.

Table 2. National bean production, area and yield data for the Eastern Africa producers.

Country	Year	Production (t)	Area (ha)	Yield (kg/ha)
Kenya	1974-75	476,513	763,500	624
Uganda	1975-77	305,133	393,400	776
Tanzania	1975-77	253,932	295,000	861
Rwanda	1976-78	168,407	210,365	801

Source: See the data and references in Table 9 of this paper.

Table 3. Annual production, trade and per capita consumption of dry legumes, 1975-77.

Country or region	Production	Imports	Exports	Imports minus exports	Apparent per capita consumption[a]
	(000 t)				(kg/capita)
Eastern Africa principal producers					
Uganda	350	0.038	0.001	0.037	29.3
Kenya	305	2.902	17.519	-14.617	21.0
Rwanda	217	—	0.031	- 0.031	50.6
Tanzania	203	1.899	17.299	-15.400	12.0
Burundi	171	—	—	—	44.3
Other African countries					
Nigeria	878	0.800	—	0.800	13.6
Ethiopia	682	0.020	73.287	-73.267	21.2
Morocco	362	0.120	97.436	-97.316	14.8
Egypt	352	116.723	0.751	115.972	12.3
Niger	245	—	2.716	-2.716	51.2
Zaire	148	1.100	—	1.100	5.8
Cameroun	88	0.012	0.288	-0.276	13.1
South Africa	82	6.924	7.333	-0.409	3.1
Angola	71	3.180	8.233	-5.053	10.5
Madagascar (Malagasy)	65	0.002	18.640	-18.638	5.6
Chad	57	0.006	0.063	-0.057	13.8
Zimbabwe (Rhodesia)	27	6.900	—	6.900	5.2
Togo	23	0.013	—	0.013	10.1
Benin	21	0.009	0.196	-0.187	6.5
Others[b]	736	72.047	74.795	-2.748	8.0
Africa	5083	212.695	318.588	-105.893	11.7

a Production plus imports minus exports all divided by population is the apparent per capita consumption of dry legumes. No deductions were made for use as animal feed, seed or losses.

b Countries with less than 1% of dry legume production. However, a few additional countries were included here due to their importance in either dry legume production or trade.

Source: FAO, **Production Yearbook and Trade Yearbook**, Rome, various years.

Most of the African countries are exporters of dry legumes. However, Egypt is a large importer with almost 116,000 t annually; Zimbabwe, Rhodesia imports a small quantity (7000 t). Africa was a net exporter of 106,000 t of dry legumes in 1975-77; Latin America exported 230,600 t of dry legumes but was a net exporter of only 3600 t of dry legumes in this same period.[4]

In most of Africa, bean production has been increasing faster than population growth. These production increases have been obtained principally with area expansion since yields have been stagnant or

Table 4. Growth rate[a] for population, production, area and bean yield in Africa, 1962-79.

Country or region	Population	Production	Area	Yield
Eastern Africa principal producers[b]				
Uganda	3.28	4.34	6.67	-2.33
Rwanda	2.90	4.07	3.74	0.33
Tanzania	2.62	3.52	2.65	0.87
Burundi	1.70	2.71	3.59	-0.87
Other African countries				
Zimbabwe (Rhodesia)	3.34	1.28	0.37	1.65
South Africa	3.11	3.34	-1.61	4.65
Madagascar (Malagasy)	2.78	0.50	0.10	0.40
Togo	2.77	0.80	1.39	-0.59
Cameroun	2.64	7.11	6.73	0.38
Egypt	2.35	10.69[c]	7.71[c]	2.98
Ethiopia	2.07	-8.95	-8.76	-0.19
Angola	1.74	0.63	2.70	-2.07
Africa[d]	2.74	3.61	3.75	-0.14

a Calculated from the annual data utilizing the equation LY = a ± bT, where L is the log of population, production, area or yield, T is the trend term; a and b are the parameters, where b is the geometric growth rate over time of the dependent variable.

b Kenya was not included due to the lack of prime series data at the beginning and end of the period.

c Data were not available for 1979 hence these rates were only calculated for 1962-1978.

d Includes the 12 countries above plus the following nine: Somalia, Benin, Zaire, Swaziland, Sudan, Malawi, Dahomey, Morocco, and Chad, each of which produces less than 1% of African bean production.

Source: FAO, **Production Yearbook**, various years; FAO, **Demographic Yearbook**, various years.

[4] FAO, **Production Yearbooks**, various years.

declining in most countries. In the principal production area, Eastern Africa, production increased more rapidly than demand in the 1960-70 decade enabling falling prices or increased exports (Table 5). However, the economic disruptions of the seventies led to economic declines in almost all of the African countries. Even with the declining per capita income, high population growth and production stagnation resulted in a more rapid growth of demand than of supply with upward pressures on prices (Table 6).

Table 5. Growth rates of demand and supply for beans and components of demand growth in African countries, 1960-70.

Country	Growth rate		Income	Growth rate	
	GNP per capita	Human population	elasticity of demand[a]	Bean demand[b]	Bean supply
Eastern Africa principal producers					
Kenya	3.3	3.0	0.42	4.4	N.A.
Tanzania	2.9	3.0	0.60	4.7	4.3
Uganda	2.8	2.7	0.46	4.0	16.9
Burundi	1.0	2.0	0.21	2.2	3.5
Rwanda	-0.8	3.5	0.41	3.2	7.5
Other African countries					
Togo	5.2	2.9	0.23	4.1	8.9
South Africa	3.1	3.0	N.A.	N.A.	1.9
Ethiopia	2.8	2.0	0.51	3.4	2.4
Cameroun	2.8	2.0	0.34	2.9	-2.6
Zaire	2.4	2.6	N.A.	N.A.	N.A.
Egypt	1.6	2.5	N.A.	N.A.	15.0
Niger	1.6	2.7	0.30	3.2	N.A.
Morocco	0.9	2.8	0.30	3.1	10.7
Madagascar (Malagasy)	0.4	2.5	0.60	2.7	2.1
Benin	0.4	2.7	N.A.	N.A.	N.A.
Zimbabwe (Rhodesia)	-0.3	3.2	0.40	3.1	2.1
Nigeria	-0.3	2.5	0.51	2.3	N.A.
Chad	-1.1	1.7	0.20	1.5	N.A.
Angola	N.A.	N.A.	0.40	N.A.	2.2

a Includes pulses, nuts and seeds.

b Demand growth is the sum of population growth plus the income elasticity of demand times per capita GNP growth.

N.A.= not available.

Sources: World Bank, **1978 World Bank Atlas,** Washington, D.C., 1979
FAO, **Demographic Yearbook,** Rome, 1977, p. 158.
FAO, **Production Yearbook,** Rome, various years, vols. 25 to 32.

Table 6. Growth rates of demand and supply for beans and components of demand growth in African countries, 1970-76.

Country	Growth rate		Income elasticity of demand[a]	Growth rate	
	GNP per capita	Human population		Bean demand[b]	Bean supply
Eastern Africa principal producers					
Tanzania	-1.3	3.0	0.60	2.22	1.5
Rwanda	-1.8	3.0	0.41	0.86	1.3
Kenya	-2.9	3.8	0.42	2.58	N.A.
Burundi	-3.1	2.7	0.21	2.04	-3.4
Uganda	-6.1	3.0	0.46	0.19	-5.15
Other African countries					
South Africa	N.A.	2.57	N.A.	N.A.	4.97
Nigeria	2.2	3.2	0.51	4.32	N.A.
Egypt	0.5	2.6	N.A.	N.A.	8.25
Morocco	0.1	3.2	0.30	3.23	N.A.
Cameroun	-1.3	2.3	0.34	1.86	14.8
Zimbabwe (Rhodesia)	-1.9	3.4	0.40	2.64	0.72
Togo	-1.9	3.0	0.23	2.56	-20.66
Benin	-2.0	3.0	N.A.	N.A.	N.A.
Niger	-2.2	2.7	0.30	2.37	N.A.
Ethiopia	-2.3	2.5	0.51	1.33	-16.95
Zaire	-2.4	2.8	N.A.	N.A.	N.A.
Angola	-3.0	2.4	0.40	1.20	-0.64
Chad	-3.7	2.3	0.20	1.56	N.A.
Madagascar (Malagasy)	-4.9	2.6	0.60	-0.34	1.50

a Includes pulses, nuts and seeds.
b Demand growth is the sum of population growth plus the income elasticity of demand times per capita GNP growth.
N.A. = not available.

Sources: International Agricultural Development Service (IADS), **Agricultural Development Indicators. A Statistical Handbook**, 1980, New York; FAO, **Proyecciones para Productos Agricolas**, 1970-1980, Rome 1971, pp. 162-178; FAO, **Production Yearbook**, Rome, various years, vols. 25 to 32.

For all of Africa a yield decline was offset by a rapid area increase rate of 3.8% over the last decade. South Africa is an exception and did not depend on area expansion to offset declining yields. As in Mexico, substantial yield growth in South Africa has been obtained while the area under cultivation declined as more profitable crops displaced beans. Egypt increased bean area rapidly and achieved impressive yields by the end of the decade (Tables 7 and 8).

Table 7. Area in beans in Africa, 1966-68 to 1977-79.

Country or region	1966-68 Area		1977-79 Area	
	(000 ha)	(%)	(000 ha)	(%)
Eastern Africa principal producers				
Kenya	323	18.1	764[a]	27.6
Uganda	266	14.9	356	12.9
Tanzania	219	12.2	300	10.8
Burundi	203	11.3	259	9.4
Rwanda	155	8.7	213	7.7
Other African countries				
Angola	199	6.7	120	4.3
Ethiopia	92	5.1	18	0.6
South Africa	79	4.4	72	2.6
Madagascar (Malagasy)	62	3.5	59	2.1
Cameroun	54	3.0	133	4.8
Togo	54	3.0	60	2.2
Zimbabwe (Rhodesia)	50	2.8	50	1.8
Egypt	5	0.3	7[a]	0.3
Zaire	N.A.	N.A.	162[a]	5.8
Chad	N.A.	N.A.	97[a]	3.5
Others[b]	108	6.0	100[a]	3.6
Africa	1789		2770	

a Data were only available for 1976-78 instead of 1977-79.
N.A.= not available.
b Includes all African countries producing less than 1% of the bean production in the continent.

Source: FAO, **Production Yearbook**, various years. The Kenyan data were obtained from the Kenyan Control Bureau of Statistics, **Statistical Abstract**, 1978, Nairobi, Kenya, 1979.

In the principal bean producing countries in Eastern Africa the area increases during the last decade have been very large. Uganda increased its bean area by 90,000 ha, Rwanda by 58,000 ha, Burundi by 56,000 ha, Kenya by a staggering 441,000 ha, and Tanzania by 81,000 ha (Table 7). Absolute yields were still very low with falling mean values for all of Africa and for most of Eastern Africa, with an especially rapid decline in Kenya (Table 8).

Table 8. Bean yields in Africa, 1966-68 to 1977-79.

Country or region	Average yields 1966-68 (kg/ha)	Average yields 1977-79 (kg/ha)
Eastern Africa principal producers		
Rwanda	815	815
Uganda	667	492
Burundi	644	626
Tanzania	492	503
Kenya	412	211[a]
Other African countries		
Egypt	1400	2571[a]
Madagascar (Malagasy)	789	798
Ethiopia	743	705
South Africa	631	1040
Angola	534	533
Cameroun	468	620
Zimbabwe (Rhodesia)	463	507
Zaire	N.A.	577[a]
Others[b]	448	710[a]
Africa	574	487

a Data were not available for 1979 hence these estimates include only 1976-78.
b Includes all African countries with less than 1% of the bean production in the continent.
N.A. = not available.

Source: FAO, **Production Yearbooks**, various years. The Kenyan data source was mentioned in the previous table.

In many regions of Africa there are serious nutritional problems often involving inadequate protein intake due to a predominant starch diet of cassava and plantains[5]. In spite of an estimated per capita bean consumption of 35.5 kg/year, protein consumption is still inadequate in Rwanda[6]. Increases in pulse production for protein need to accompany

5 These deficiencies were reported for Uganda by the World Health Organization. See P.R. Rubaihayo *et al.*, "Bean Production in Uganda".

6 P. Nyabyenda *et al.*, "Bean Production in Rwanda".

production increases of calories from roots or cereals. Animal protein consumption is much lower and is less likely to compete with grain legumes in Africa than in Latin America. The production situation of beans in Africa has become very serious in the seventies with decreasing incomes and rising bean prices. Increased prices for beans and other pulses are expected to have aggravated the already serious urban malnutrition[7].

Table 9. Bean production, area and yield data for four Eastern Africa producers from the country reports and additional data sent by participants.

Country		Production (t)	Area (ha)	Yield (kg/ha)
Uganda[a]				
	1920		37,000	
	1925		56,000	
	1930		84,000	
	1935		113,000	
	1945		151,000	
	1950		185,000	
	1955		214,000	
	1960		233,000	
	1965		371,000	
	1966	114,300	383,495	298
	1967	162,600	532,494	305
	1968	206,100	371,871	554
	1969	162,200	377,541	430
	1970	186,800	376,448	496
	1971	221,800	459,000	483
	1972	236,800	309,000	766
	1973	170,000	359,000	473
	1974	196,300	408,000	481
	1975	325,800	407,000	800
	1976	337,100	434,900	775
	1977	252,500	338,300	746

a The 1920-1970 data were taken from annual reports of the Ugandan Department of Agriculture. The 1971-1977 data are from unpublished data in the annual reports of the Planning Division of the Department of Agriculture. Cited in P.R. Rubaihayo, D. Mulindwa, T. Sengooba, F. Kamugira, "Bean Production in Uganda".

7 See W.R. Stanton, *op. cit.*, p. 16, for a discussion of the deterioration of nutrition levels upon migration to African cities thereby increasing dependence upon lower quality diet especially the increased consumption of cassava.

Table 9 (continued)

Country		Production (t)	Area (ha)	Yield (kg/ha)
Rwanda[b]	1966	130,900	154,000	850
	1967	131,700	155,000	850
	1968	116,225	156,300	744
	1969	146,124	162,360	900
	1970	143,604	159,560	900
	1971	144,445	160,494	900
	1972	131,404	154,593	850
	1973	133,059	160,025	831
	1974	114,816	186,723	615
	1975	152,744	190,600	801
	1976	163,401	202,880	805
	1977	171,590	213,276	805
	1978	170,231	214,939	792
Kenya[c]	1974-75	476,513	763,500	624
Tanzania[d]	1963-64	92,656		
	1964-65	79,705		
	1965-66	102,443		
	1966-67	111,849		
	1967-68	111,527		
	1968-69	102,799		
	1969-70	122,438		
	1970-71	124,190		
	1971-72	167,938		
	1972-73	191,466		
	1973-74	189,196		
	1974-75	197,294		
	1975-76	220,719	295,000	748
	1976-77	287,145	295,000	973
	1977-78	223,397		

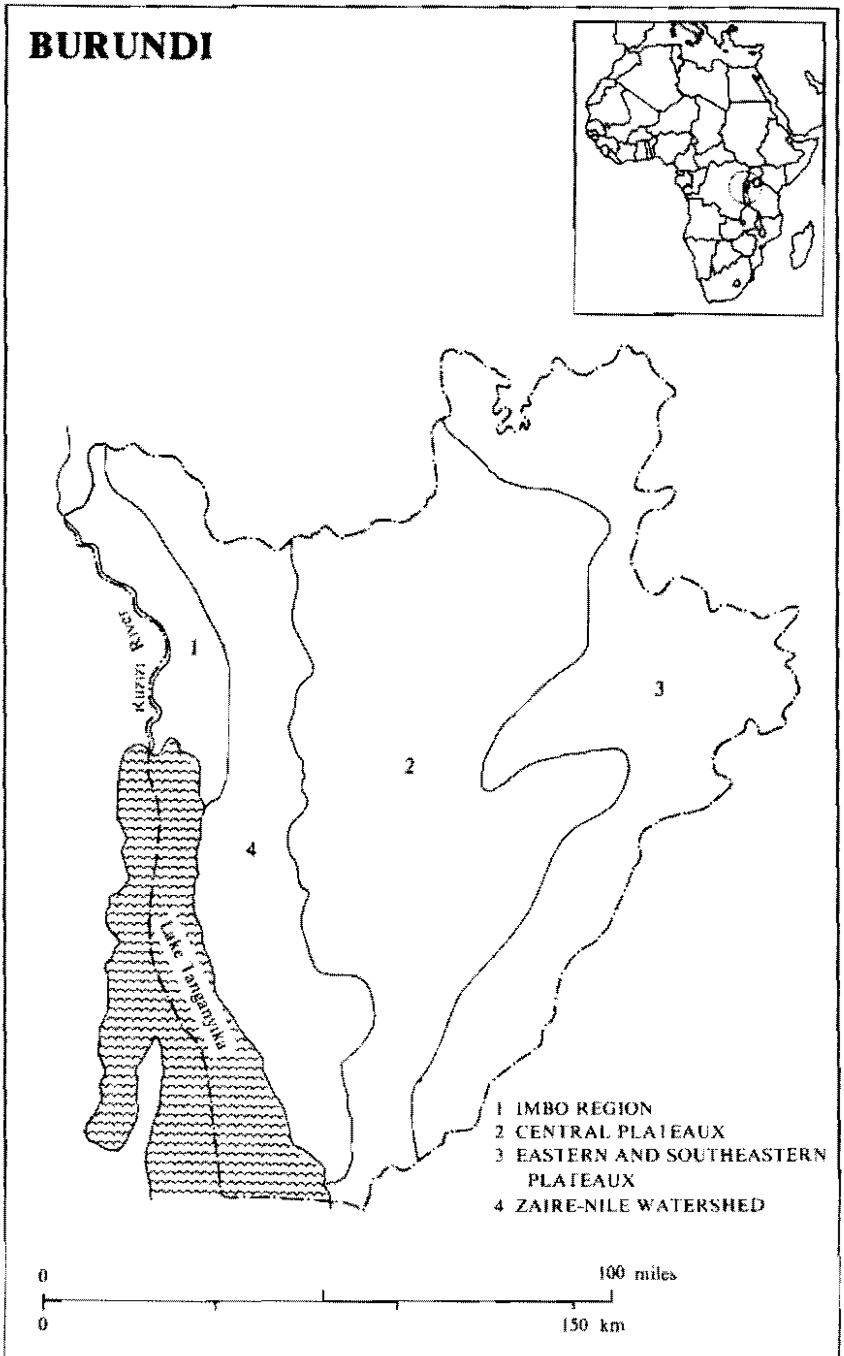
b Ministére de l'Agriculture, "**Rapports Annuels du Ministère de l'Agriculture et de l'Elevage**, Rwanda, various years. The data were provided by N. Nyabyenda.

c D.M. Thairu, "Grain Legume Production in Eastern Africa with Special Reference to Kenya", paper presented at the Symposium on Grain Legume Improvement in Eastern Africa, Nairobi, August 1979, cited in S.K. Njungunah, A.M.M. Ndegwa, H.A. van Rheenen, and D.M. Mukunya,"Bean Production in Kenya," March 1980, p. 1. The authors would like to gratefully acknowledge the help of Dr. H.A. van Rheenen, Project Manager, Grain Legume Project, National Horticulture Research Station, Scientific Research Division, Ministry of Agriculture, Thika, Kenya, in putting together these data since data in Kenya have been extremely scarce.

d The production and area data for Tanzania were taken from Statistics Section, Planning Division, Ministry of Agriculture, **Bulletin of Food Crop Production Statistics,** Dar es Salaam, Tanzania, various years and were cited in A.K. Karel, "Bean Production in Tanzania - Problems and Prospects", seminar paper, University of Dar es Salaam, Faculty of Agriculture, Department of Crop Science, Morogoro, Tanzania, 1980.

Except in South Africa and Egypt, bean production increases have depended upon area expansion. Absolute yields for most countries are very low and declining reflecting planting in association, low inputs, soil exhaustion, and shifts to more marginal agricultural areas. Low absolute yields reflect opportunities as well as problems since countries, such as Mexico and Colombia, whose national bean programs selected or produced new varieties, were able to obtain significant growth in yields over time[8].

[8] Sanders and Alvarez, *op. cit.* p. 36.



BURUNDI
Rusizi River
Lake Tanganyika
1
2
3
4
1 IMBO REGION
2 CENTRAL PLATEAUX
3 EASTERN AND SOUTHEASTERN PLATEAUX
4 ZAIRE-NILE WATERSHED
0
100 miles
0
150 km

Bean Production in Burundi

Cimpaye Dieudonné

Importance of Beans

Beans play a very important role in feeding the population of Burundi. Like cassava in Zaire, they are a basic staple food in the country. Their importance is not only quantitative but also qualitative because beans, followed by peas, are the major sources of protein.

The annual legume production in Burundi is between 55,000 and 60,000 tons of dry peas and 25,000 to 30,000 tons of groundnuts. Peas are second in importance among the legume crops planted in the country. In the Eastern plains, pigeon peas are grown between two consecutive rainy seasons, while cowpeas are not largely planted.

Beans are grown in association with crops such as maize, bananas, and pigeon peas, often at altitudes which are not always favorable; for instance, in the Zaire-Nile watershed region, pigeon peas produce twice as much as beans. The country's most productive regions are: the lakeshore plains of Lake Tanganyika on the Western part of the country; the Ruzizi Valley, and the Eastern region, at middle altitudes.

Each year about 120,000 t of dry beans are produced on approximately 240,000 ha in the lowlands (hence, the native term "dambo" crop) during three seasons: October to December, February to May, and June to September.

Factors Limiting Production

These factors are principally climatic, phytopathological and phenotypical in nature.

Climatic factors

Soils. Burundi is a mountainous country. The pedological studies of soils in Burundi show that in Mugambo Bututsi (Central Plateau) they are acidic and unsuitable for beans. At lower altitudes in the Western part of the country, they are more fertile but present drainage problems caused by the high consistency of clay. This soil texture also causes suffocation of the plant and leads to certain bacterial diseases. The tropical brown soils of Kirimiro at 1500 to 1800 masl, are poor and overworked and their mineral components have not been replaced by fertilization.

Above 1800 masl peas and maize do better than beans since beans are sensitive to low temperatures. Their recorded production under these conditions is below the unprofitable level of 500 kg/ha. However, the production of beans planted in lowlands is good provided they are protected against *Aphis fabae,* a serious pest in those regions.

Rainfall. Rains in Burundi are very variable; for example, in 1979 rains began in early October instead of their normal starting point in mid-September. Although crops have been delayed due to the weather changes, it is during the first rainy season when a good harvest of beans can be produced. Annual rainfall between 750 mm and 1800 mm is favorable for beans.

Phytopathological factors

Diseases. Major bean diseases in Burundi are those of fungal and bacterial origin, while bean common mosaic virus is not a serious viral problem. The most important disease known in Burundi is anthracnose *(Colletotrichum lindemuthianum);* other diseases are: angular leaf spot *(Isariopsis griseola)* which is especially serious in humid seasons at higher altitudes; rust *(Uromyces appendiculatus)* which is common but not widespread in high and middle altitudes; *Ascochyta phaseolorum* (Ascochyta leaf spot) exists but is not serious; *Ramularia phaseoli* (floury leaf spot) causes some degree of damage in high altitudes; web blight *(Rhizoctonia microsclerotia)* and halo blight *(Pseudomonas phaseolicola)* are of minor importance.

Insect pests. There are three types of insect pests which attack beans in Burundi: *Aphis fabae,* which causes severe damage to lowland crops in the dry season. Bean flies, which attack crops grown on poor soils such as those of the Kirimiro region in the central part of the country; their damage is considerable since young plants are severly attacked especially during dry weather. Pod borers *(Maruca testulalis)* also attack beans but their damage is seldom serious.

Phenotypical factors

Farmers prefer light-colored, low yielding beans to the black seeded, high yielding bean varieties which are not acceptable to consumers. A strong selection preference is noted for certain colors during the seed buying season in rural areas.

Research and Extension

Due to the importance of beans in Burundi, the Ministry of Agriculture and Animal Production has set short and medium term objectives to organizations which deal with research and extension work on beans.

Since 1960, when Burundi became an independent country, the government has been carrying out research on cash crops like tea, coffee, and sugarcane which attract foreign currency, while food crops have been generally neglected. However, the government has realized that in the last ten years food production has declined and prices have gone up. As an example of this problem, the price of 1 kg of beans during harvest time has gone from 8 BUF* in 1965 to 35 BUF in 1978. When beans are in short supply, prices go up to 50 or 60 BUF per kg (roughly US$ 0.60 per kg).

The Department of Agronomy in the Ministry of Agriculture and Animal Production handles bean distribution and extension work in Burundi. This deparment also offers special seed production services in 40 centres located throughout the country where farmers are taught modern agricultural methods. Unfortunately, the department is new and only very few farmers have benefited from it so far.

The Agronomic Science Institute

This Institute is in charge of agronomic and animal production research in Burundi. As such it is responsible for a five-year research program on

* 1 US$ = 77 BUF (in 1978)

beans which is in effect for 1978-1983. Basically, this program consists of the following aspects:

Permanent selection of bean varieties collected in rural areas and in local markets. Screening is very severe; only disease and pest resistant varieties go into comparative yield trials; these are done in two different ecological regions of the country.

Preliminary trials are done with materials from the national bean collection in order to obtain a more rapid rate of multiplication.

Final trials are conducted with a small number of selected varieties. Two CIAT yield trials are in process in two zones at different altitudes: 1900 masl and 1300 masl.

New varieties are added from CIAT (Colombia), Holland, Belgium and France each year. By 1983, new varieties will have been identified and distributed.

Trade

The bean market is not yet organized in Burundi. Approximately 70-75% of the total bean production is for local consumption, while the remaining fraction is bought by merchants who, in turn, resell it at high prices during periods of scarcity. Fortunately, the government has created a new committee in charge of food trade at fixed prices, but this organization is still too young to be in full operation.

Bean Production in Kenya

S.K. Njungunah
A.M.M. Ndegwa
H.A. van Rheenen
D.M. Mukunya

Importance of Beans

In Kenya beans are the most important pulse, as illustrated by Table 1, and second to maize in importance as food crop. They constitute an essential source of protein for human consumption with relatively high amounts of lysine, tryptophane and methionine.

Assuming that the average yield for a pure crop of beans is 750 kg/ha, and for a mixed crop 375 kg/ha, the total bean production was 255,000 t in 1960-61; 184,125 t in 1969-70; and it reached 476,513 t in 1974-75.

Types of Beans, their Introduction and Distribution

Introduction of beans in Kenya took place most likely in the early 17th century, when Portuguese merchants called in Eastern Africa ports (Gentry, 1969; Greenway, 1945). Over the centuries more bean seeds were imported and they spread over the country. Probably beans have been cultivated in Eastern Africa for the last 300 years although existing records date back to only the turn of the 19th century (Mukunya and Kenya, 1975).

Many different seed types occur. Van Rheenen (in press), when checking on about 1000 seed samples from Kenya, distinguished about 80 different types with different preferences from place to place. Of the ten most common seed types the Rose Cocos were widely spread and formed 36.5% of the samples collected, followed by the Canadian Wonder types with 13.1% and the Red Haricots with 9.2%. The Mwezi Moja beans were

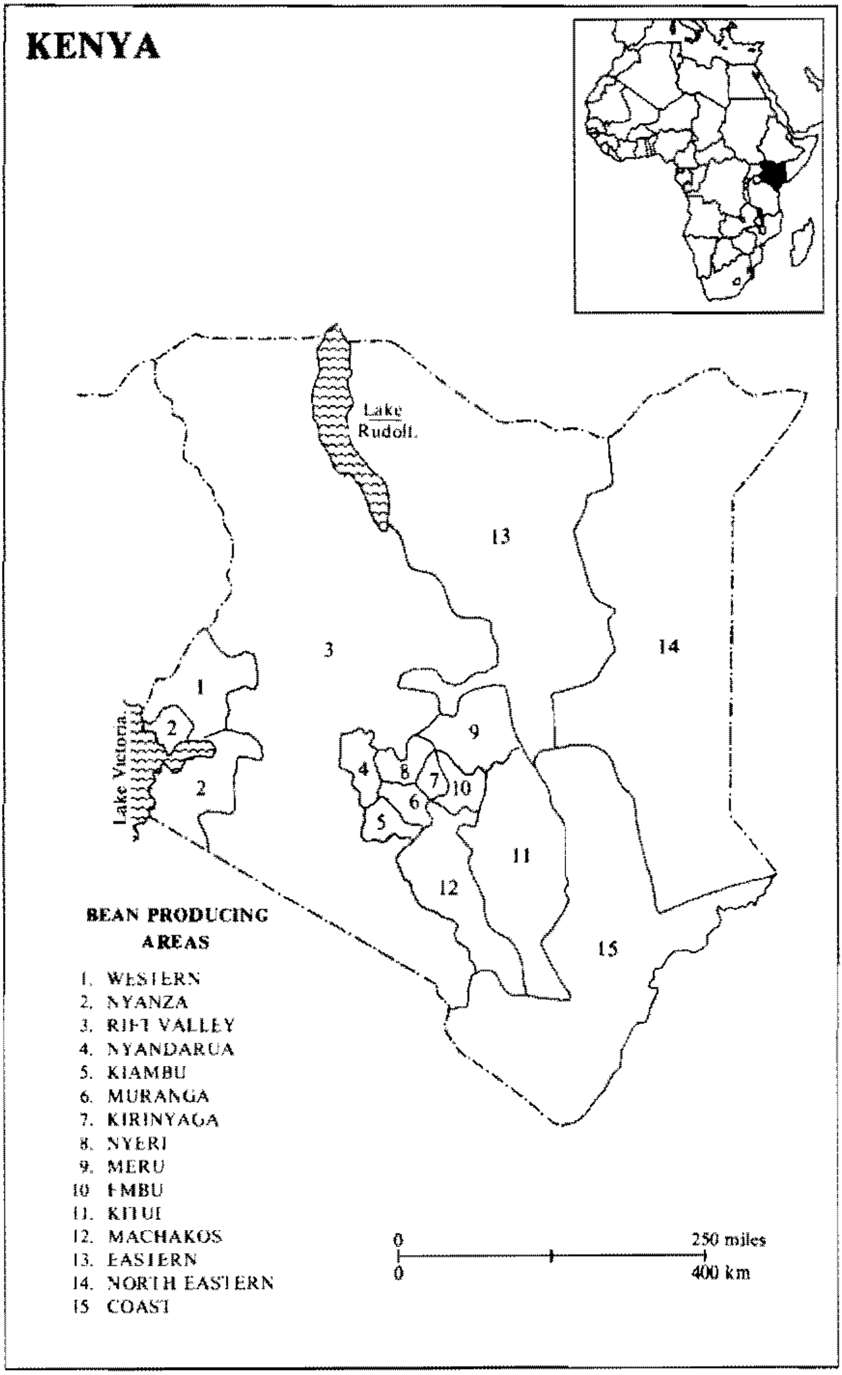

KENYA
Lake Rudolf
Lake Victoria
1
2
2
3
4
5
6
7
8
9
10
11
12
13
14
15
BEAN PRODUCING AREAS
1. WESTERN
2. NYANZA
3. RIFT VALLEY
4. NYANDARUA
5. KIAMBU
6. MURANGA
7. KIRINYAGA
8. NYERI
9. MERU
10. EMBU
11. KITUI
12. MACHAKOS
13. EASTERN
14. NORTH EASTERN
15. COAST
0
250 miles
0
400 km

Table 1. Estimated areas under grain legumes by province in the 1974-75 crop year.

Province	Area (000 ha)					
	Beans	Pigeon peas	Cowpeas	Field peas	Other	Total
Eastern	284.6	104.5	208.4	2.8	30.2	630.5
Central	232.4	4.2	7.8	13.6	0.0	258.0
Nyanza	73.6	0.0	2.9	0.0	1.7	78.2
Western	148.4	0.0	13.2	0.4	1.4	163.4
Rift Valley	7.0	0.0	0.0	0.0	0.0	7.0
Coast	17.5	6.5	38.9	9.1	4.1	67.1
Total	763.5	115.2	271.2	25.9	37.4	1204.2

Source: Thairu, 1979.

found mainly in Machakos and Kitui Districts and they formed 9.0% of the samples. The ten main seed types differ considerably from one another and the consumers' preferences show an appreciable flexibility. They are described in Table 2.

Bean Crop Environment

The National Atlas of Kenya (1970) shows that beans are common in three climatic zones of different ecological potential as follows (see map).

Equatorial climate. Humid to dry sub-humid with a moisture index not less than -10. The vegetation consists of forests and derived grasslands and bushlands. This area, which ranges in altitude from 1500 to 2500 masl, is potentially suitable for forestry and intensive agriculture, including pyrethrum, coffee and tea at the higher altitudes. The annual rainfall is generally between 1000 and 1250 mm and the annual mean maximum temperature ranges between 26 and 30°C, with mean minimum temperatures of 14 and 18°C. This ecological zone is catered for by the Kisii and Kakamega Research Stations.

Dry sub-humid to semi-arid climate. The moisture index is between -10 and -30. The land has no forest potential, carrying a variable vegetation cover (moist woodland, bushland or "savanna"), the trees are characteristically broad-leaved (e.g. *Combretum* sp.) and the larger shrubs mostly evergreen. This land is found between 1500 and 2500 masl. The agricultural potential is high, soil and topography permitting. The annual rainfall ranges from 750 to 1000 mm with an annual mean maximum temperature of 24-28°C and annual mean minimum temperatures of 10-14°C. The Embu and Thika Research Stations are within this zone.

Table 2. Description of the ten most common bean seed types in Kenya.

Name	Local language	Frequency of occurrence (%)	Description
Tonguire	Luo	10.4	Rose Coco: variegated red-brown on pink, medium-sized, oval.
Wairimu	Kikuyu	9.2	Red Haricot, small- to medium-sized, oblong.
Mwezi Moja	Swahili	9.0	Mwezi Moja, with many fine purple spots, medium- to large-sized, oblong.
Nyamariu	Kikuyu	8.7	Rose Coco, variegated red on cream, medium-sized, globular.
Lucia	Kikuyu	8.0	Rose Coco, variegated red on cream, medium-sized, globular.
Gituru Gitume	Kikuyu Kikuyu	7.0	Canadian Wonder, purple-black, medium- to large-sized, oblong.
Kathiga	Meru	7.0	Rose Coco, variegated purple on cream, medium-sized, globular.
Kabumbu	Kikuyu	6.1	Canadian Wonder, red-brown, medium- to large-sized, oblong.
Mwitemania	Kikuyu	2.4	Mwitemania, resembling pinto bean, variegated green-grey on cream, small- to medium-sized, globular.
Others	-	2.4	Rose Coco, variegated with large red flecks on cream, medium- to large-sized, oblong.

Semi-arid climate. The moisture index is between -30 and -42. The land is of marginal agricultural potential, carrying as natural vegetation dry forms of woodland and "savanna" (often an *Acacia-Themeda* spp. association) or derived semi-evergreen or deciduous bushland. It is a potentially productive rangeland within 1500-2500 masl in altitude and with an annual rainfall of 500-750 mm. The annual mean maximum temperatures are between 22 and 26°C and the annual mean minimum temperatures between 10 and 14°C. The Katumani Research Station is situated in this zone.

Most soils, where beans are grown, are sandy loams or friable clays, often red-brown in color.

Bean Cropping Systems

Extensive information on bean cropping systems in Kenya has been provided by Mukunya and Keya (1975) and by Schonherr and Mbugua (1976). A brief review follows.

Cultural practices. Land preparation is mostly done by hand with "jembes" (hoes), "pangas" (knives) and fork "jembes"; also ox-drawn ploughs are used and even tractor ploughing is done.

Planting systems. In most cases beans are interplanted with maize, although pure cropping also occurs. According to Schonherr and Mbugua (1976) 44% of the beans in the Eastern Province were grown as pure crop, while the Central Province had 17% pure crop. The *Statistical Abstracts* (1977) show evidence that the ratio of single crop to mixed crop acreage was 6% during 1974-75.

Spacing and density. Where beans grow in association with maize, 'random' planting of the beans is common, but mono-cropping of beans is often done in rows. Plant densities vary greatly, but the average is about 150,000 plants/ha (Table 3).

Table 3. Average plant densities of pure and interplanted beans during the 1975 long rains in Central and Eastern Provinces of Kenya.

Number of plants per hectare	Percentage of fields	
	Pure stand	Interplanted
Up to 50,000	-	3
50,000 to 100,000	-	12
100,000 to 150,000	10	31
150,000 to 200,000	31	25
200,000 to 250,000	19	10
250,000 to 300,000	8	9
300,000 to 350,000	8	5
350,000 to 400,000	15	2
400,000 to 450,000	6	1
450,000 to 500,000	2	1
Over 500,000	2	-

Source: Schonherr and Mbugua, 1976

Fertilizers and manure. Fertilizers were being used on nearly one fourth of the fields surveyed by Schonherr and Mbugua (1976) in Central and Eastern Province. Manure was used slightly less often. Neither fertilizers nor manure were used on half the fields in Central Province and 60% of the fields in Eastern Province.

Weed control. All weed control is by hand and most farmers weed twice. De Groot (1979) showed that neglect in weeding in Kenya may result in 40% yield loss on the average, and he recommended weeding at 20 and 40 days after emergence.

Harvesting and threshing. The most widespread method of handling the mature crop is to uproot the plants, dry them in the field or near the home, spread them on a hardened floor or mat and thresh by beating with sticks.

Place of beans in the farming system. In conventional rotation, beans usually follow an arable cereal crop, specifically during the short rains. However, beans are very often cultivated repeatedly in the same field in the small scale farming areas, where they constitute more than 95% of the grain legume production for subsistence (Mukunya and Keya, 1975).

Irrigation. It is not applied to dry food beans.

Planting. Done at the onset of rains which occur as follows: long rains: Western Kenya, February-June; other areas, March-April, June-July. Short rains: Western Kenya, August-December; other areas, October-December.

Production, Trade, Storage and Utilization

Production. Table 1 shows the bean hectareage in the various provinces. The bulk of the bean production in Kenya is from Embu, Meru, Machakos and Kitui Districts of Eastern Province, and from Muranga, Kirinyaga, Kiambu, Nyeri and Nyandarua Districts of Central Province, mostly in the medium potential areas with a bimodal rainfall of 700-900 mm per year.

Yield levels vary from two to three tons per ha, but realistic estimates give an average of 750 kg/ha for monocropping and 375 kg/ha for associated cropping of beans.

Production so far has been merely of subsistence farming; commercial production has been negligible or absent. With a rapidly growing population and rising meat prices, the demand shows a clear upward trend.

Trade. According to van Eijnatten, Muna and Hesselmark (1974) beans are marketed through two separate channels. The first one is the local outdoor market, where most beans for home consumption are sold, and the second one is through the National Cereals and Produce Board (NCPB) and through private commodity dealers. Beans are a scheduled crop, covered by the Produce Marketing Act which subjects produce to movement restrictions and price controls when purchased by NCPB. It is compulsory to sell the surplus to the NCPB but because of considerable differences in open market and NCPB prices, the latter being lower, not much of the surpluses are being sold through them. The NCPB prices used to be below 1 K.sh*/kg, but the open market price may well exceed 3 K.sh/kg. Since no overall surpluses exist in the country, export of food beans is insignificant or non-existent.

Storage practices. Farmers usually store their beans in their homesteads for a period of two to six months. "Unidentified dusts", but also Malathion 1%, Pyrethrum 0.2% and Lindane 0.1% at 115 g/90 kg seed, and ashes, are being used for protection against the bean bruchid *(Acanthoscelides obtectus);* nevertheless, severe damage is being reported.

Utilization. Mukunya and Keya (1975) give detailed information on this subject. Beans are grown mainly for the seeds. However, fresh leaves from young plants are sometimes boiled and eaten as vegetables (pot-herb) with "ugali" (maize paste with dough consistency), and green pods are used exceptionally. Freshly harvested, plump seeds are preferred for cooking because they are tender and tasty when boiled, but the fresh produce can be used only for a limited time.

Dry beans are consumed boiled alone or mixed with cereal grains especially maize, sorghum or rice, while the seed coat is left intact. After two-three hours of boiling, salt, onions or other condiments are usually added to the bean mixture, which may be served as it is or pounded into a paste. Water, meat soup or cooked vegetables may be added to the paste, or it may be fried in oil. Variations in the dishes are possible: boiled beans with or without seed coat; beans fried after boiling; pounded cooked beans with milk, water and salt added and served together with potatoes, cassava or millet.

Factors Limiting Production

Biological Factors. Main factors limiting production of beans in Kenya are diseases and pests. The following bean diseases and pests, listed according

* 1 US$ = K.sh 6.85

to their importance, is compiled from Hubbeling (1973), Mukunya and Keya (1975) with observations by the Grain Legume Team.

Finally, it has been observed that the nodulation of beans can be quantitatively very poor, which will likely have adverse effects on yield (Lie, 1980, personal communications). Strain differences occur in Kenya, and interesting work is being done in this field (Keya, personal communications), but the research results are not yet applicable at farmers' level.

Disease and its causal agent	Economic importance[1]	Source of infection
1. **Fungal diseases of major importance**		
Anthracnose *(Colletotrichum lindemuthianum)*	I	seed
Rust *(Uromyces appendiculatus)*	I	air
Angular leafspot *(Isariopsis griseola)*	I/M	air
2. **Fungal diseases of moderate and minor importance**		
Ashy stem blight *(Macrophomina phaseoli)*	M	soil, seed
Fusarium root rot *(Fusarium solani f. phaseoli)*	M	soil
Southern blight *(Sclerotium rolfsii)*	M	soil
Rhizoctonia root rot *(Rhizoctonia solani)*	M	soil
Powdery mildew *(Erysiphe polygoni)*	M	air
Ascochyta leafspot *(Ascochyta boltshauseri)*	L	soil, seed
Phoma diversispora	M	soil, seed
Scab *(Elsinoë phaseoli)*	M	air, seed
Phythium root rot *(Pythium* spp.)	L	soil
3. **Bacterial diseases of major importance**		
Halo blight *(Pseudomonas phaseolicola)*	I	seed
Common blight *(Xanthomonas phaseoli)*	I	seed
Fuscous blight *(Xanthomonas phaseoli* var. *fuscans)*	I	seed
4. **Bacterial diseases of moderate and minor importance**		
Bacterial brown spot *(Pseudomonas syringae)*	M/L	seed

[1] Abbreviations used: I = important, M = moderately important, L = less important

Disease and its causal agent	Economic importance[1]	Source of infection
5. **Virus diseases**		
Bean Common Mosaic Virus (BCMV)[2]	I	seed
6. **Insect pests**[3]		
Bean fly *(Ophiomya phaseoli)*	I	
Aphids *(Aphis fabae)*	I	
Bollworm *(Heliothis armigera)*	I	
Bean beetle *(Acanthoscelides obtectus)*	I	
Leaf-eating blue beetle *(Ootheca bennigsenni)*		
Leaf-eating green beetle *(Hallirhotius africana)*		
Blister beetles *(Coryna apicicornis, Epicanta nyassensis, Mylabris* spp.)		
Spiny bugs *(Acanthomia horrida, Acanthomia tomentosicollis)*		
Green shield bug *(Nezara viridula)*		
Helmet bugs *(Coptosoma* spp., *Brachyplata* spp.)		
Spotted borer *(Maruca testulalis)*		
Bean thrips *(Taeniothrips* spp., *Frankliniella dampfi)*		
7. **Nematode pests**		
Root knot nematodes *(Meloidogyne javanica, M. incognita)*[4]		

[2] Bean Common Mosaic Virus is a disease of major importance causing yield losses and seed multiplication problems.

[3] Of varying economic importance; unknown source of infection

[4] Ngundo, 1973.

Socio-economic aspects. These studies were recently started by farm economists, and the results are still preliminary. Nevertheless, it is expected that they will make important contributions to production improvement, especially where mixed cropping *vs* pure cropping, sowing systems, plant densities, weed control methods, and frequencies of weeding are compared.

Labor constraints are considered a serious problem for bean production. Marketing, although showing organizational shortcomings, is not a limiting factor, neither is transport, nor acceptance by consumers as long as the seed characteristics do not deviate too much from the traditional types.

Institutional aspects. Research activities have been concentrating on agronomy, pathology, breeding, entomology and microbiology at the following institutions: National Horticultural Research Station, Thika; Kenya Agricultural Research Institute, Muguga, Nairobi; Nairobi University, Faculty of Agriculture.

Although research has been limited in scope, it has made a useful contribution to bean development in Kenya. Extension and training normally come after research, and although a start has been made in those fields over the past two years, further developments are needed to increase the rate of adoption of new technology in bean production.

The National Cereals and Produce Board does not play a significant role in bean production, and marketing organizations and policies have no appreciable effect on it.

Description of Country Bean Program

The Kenyan bean development program is at present mainly coordinated at the Thika National Horticultural Research Station and implemented at the following stations: Dry Land Research Station, Katumani; Embu Agricultural Research Station, Embu; Nyanza Agricultural Research Station, Kisii; Western Agricultural Research Station, Kakamega.

In addition, the Faculty of Agriculture, Nairobi University, and the Kenya Agricultural Research Institute, Muguga, Nairobi, have both been actively involved in bean research and some aspects of bean production. Also useful support and collaboration have been given by the Biometric Section of the Ministry of Agriculture, Nairobi, on experimental designs and data analysis; by the National Agricultural Laboratories, Nairobi, on field and laboratory identification of pests and diseases and on seed and soil analysis; by the Research Institute for Plant Protection, IPO, Wageningen, the Netherlands, in testing bean material for anthracnose resistance, and in BCMV strain testing; and by the Laboratory of Microbiology, Agricultural University, Wageningen, the Netherlands, in testing soil samples on *Rhizobium* activity.

The Grain Legume Project, National Horticultural Research Station, Thika, carries out a multidisciplinary program with the following scientists: six agronomists, five of them at the MS and one at the BS level;

two breeding scientists, one of them a Ph.D. and one a BS; two pathologists at the MS level.

The supporting staff consists of one technical officer (Egerton graduate), four technical assistants, one laboratory attendant, field staff and clerical staff.

The project is funded by the Kenyan Government, while expatriate personnel, the purchase of vehicles and part of the equipment, are paid for by the Dutch Government.

Research is conducted in the following areas: Agronomy: mixed cropping: crop ratios, weed control, fertilizer responses, time of planting effects, planting methods; pure cropping: weed control, fertilizer responses, time of planting effects. Breeding: germplasm collection, variety testing, breeding for disease resistance, production of breeders' seed. Pathology: disease surveys and studies, chemical disease control, screening for disease resistance. Extension activities are the responsibility of the Ministry of Agriculture Extension Services.

Seed Production and Distribution

Three bean varieties have been released by the National Horticultural Research Station of the Ministry of Agriculture, Kenya. They are: GLP-2 (Roko), GLP-24 and GLP-1004. Seed of these varieties produced by breeders is inspected and certified by the National Seed Quality Control Services (NSQCS), Nakuru. Similarly, breeders' seeds are multiplied by Hortiseed, Nairobi, a subsidiary of the Kenya Seed Company Ltd. They are inspected, certified and labeled as super elite, elite, first generation, second generation, and third generation seeds by the NSQCS, Nakuru. Packing and distribution are done through a well established network of agencies.

Achievements

Knowledge of bean production problems has increased over the years as can be seen from the literature listed. Achievements in the agronomic work, apart from results published in journals, are crystallized in "guidelines" for bean production. Those of the breeding work are: release of varieties, seed production by breeders, successful breeding for resistance to anthracnose, BCMV, angular leafspot and halo blight, and miscellaneous investigations related to bean improvement through breeding and selection. Achievements in pathology are: the description of the disease situation in the country, the successful control of diseases by chemical means, identification of disease resistances, and support to the breeding program in respect to disease screening.

Future Plans

During the coming years the bean improvement program will concentrate on the following areas:

Agronomy: Competition problems in mixed cropping; optimal bean-maize ratios for different ecological zones; optimal relative planting times; weed control; definition of parameters for fertilizer recommendations; relation of nodulation-fertilizer requirements; long-term rotation-fertilizer trials.
Breeding-selection: Production of improved varieties; breeding for disease resistance; seed production by breeders; improvement of crop mixtures.
Crop protection: Screening for disease and pest resistance; monitoring disease and pest situations; chemical control of pests and diseases; identification of disease strains and races; support to the breeding program with screening for disease resistance.
Farm economy: Evaluation of different cropping systems.

Summary

Beans are one of the most important food crops in Kenya, second only to maize, and covering the largest acreage of all grain legumes. Beans were introduced in the country in the early 17th century, and different types have been imported since and have spread over the country.

Beans grow in different climatic zones ranging from equatorial to dry sub-humid and semi-arid climates. The bulk of bean production comes from the Eastern and Central provinces.

In most cases beans are interplanted with maize; the average plant density is about 150,000 plants/ha of pure and interplanted beans. Average yields are 750 kg/ha for monocropping and 375 kg/ha for associated croppings.

Production is mostly of subsistence farming, and the demand shows an upward trend due to rising meat prices and growing population.

Marketing for consumption is mainly done at the local outdoor markets, and surpluses are to be sold through the NCPB. No surpluses really exist

for an export market. Storage is done mostly at the farms for periods of two to six months, with severe bruchid damage reported.

Beans are mostly consumed as boiled dry seeds, alone or mixed with cereal grains and with condiments added. There are many varieties of dishes prepared with beans.

The main biological factors limiting production are fungal, bacterial and virus diseases, and pests (insects and nematodes). Labor constraints are a serious problem in bean production; marketing is not a limiting factor, nor transportation or acceptance by consumers.

Research concentrates on agronomy, breeding and pathology, and it is done at five experimental stations, with the coordination of the Thika National Horticultural Research Station. The results so far are the release of three bean varieties, seed production by breeders and the Hortiseed Co., breeding for resistance to anthracnose, BCMV, angular leafspot and halo blight, disease control by chemical means, identification of disease resistances, description of the bean situation in the country and agronomy guidelines for bean production.

Future plans are to concentrate on the same areas of research and evaluate different bean cropping systems.

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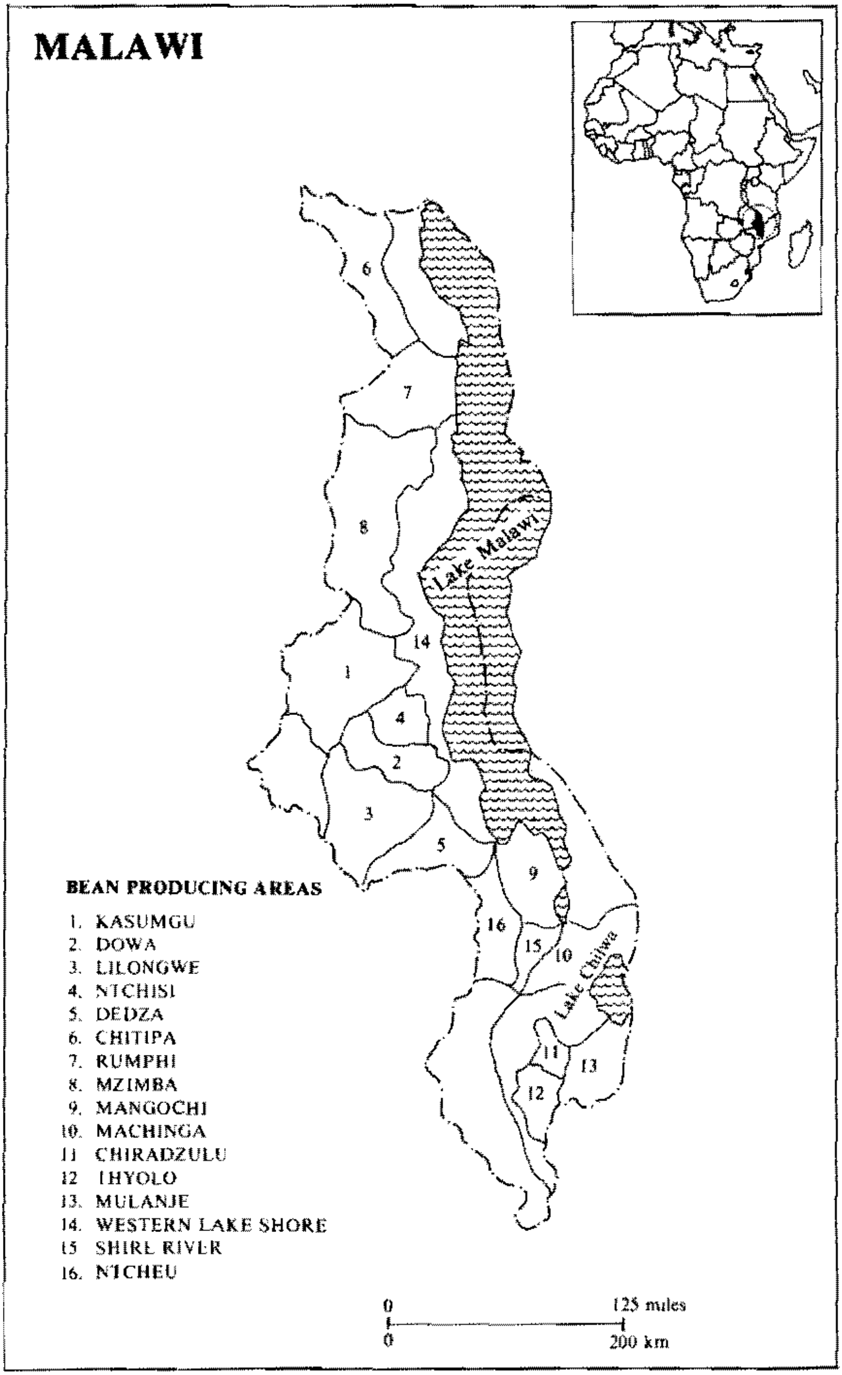
MALAWI
Lake Malawi
Lake Chilwa
BEAN PRODUCING AREAS
1. KASUMGU
2. DOWA
3. LILONGWE
4. NTCHISI
5. DEDZA
6. CHITIPA
7. RUMPHI
8. MZIMBA
9. MANGOCHI
10. MACHINGA
11 CHIRADZULU
12 THYOLO
13. MULANJE
14. WESTERN LAKE SHORE
15 SHIRE RIVER
16. NTCHEU
0 125 miles
0 200 km

Bean Production in Malawi

O.T. Edje
L.K. Mughogho
Y.P. Rao
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Importance of Beans

The common bean *Phaseolus vulgaris* L. is one of the most important grain legume crops grown in Malawi, being second only to groundnuts in total production (Table 1). It should be noted that groundnuts are a cash crop while beans are essentially a food crop and only surplus is sold for cash. Therefore, the figures for beans purchased by the Agricultural Development and Marketing Corporation (ADMARC) represent a small percentage of the total production.

The types of bean grown in Malawi are used as dry beans, although green-shelled seeds and immature pods are also cooked and eaten. Green tender leaves are sometimes plucked before pods set and eaten as green vegetables. As food, beans provide a cheap source of protein for the majority of the people who are far from the lakeshore areas where fish is the

Table 1. Grain legume purchases by ADMARC in two seasons.

Crop	Grain purchase (t)	
	1977-78	1978-79
Groundnuts	11,509	22,045
Beans	3,005	1,215
Guar beans	709	351
Dolichos beans	30	137
Ground beans	18	9
Soya beans	5	10

main source of protein. Also the dry seeds are relatively easier to store at the small farm than beef, poultry or fish.

Tables 2 and 3 show that beans contain a high percentage of protein as compared with maize, rice and cassava. Green pods and green-shelled seeds are also a good source of vitamins A and C. The quality of bean protein is not as high as that of meat or fish because it is low in the sulphur-containing amino-acids, methionine and cystein (Table 3) which are essential in human nutrition. However, bean protein is high in lysine which is relatively deficient in maize, rice, and cassava, so when consumed with these staples, as is the custom in Malawi, the mixture does provide a more balanced diet.

Table 2. Nutritive value of different parts of a bean plant (per 100 g).

Bean part eaten	Nutritional content					
	Energy (cal)	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (I.U.)	Vitamin C (mg)
Green immature pods	34	2	50	1.4	200	20
Green-shelled seeds	104	7	40	2.0	150	25
Mature dry seeds	339	22	110	8.0	10	0

Source: Kenya Department of Agriculture, Horticultural Handbook, Vol. 1.

In addition to the protein supply, beans are also a good source of energy (Platt, 1962) providing comparable values of calories as maize flour ("ufa"), milled rice or cassava flour, but about 1 ½ and about 4 ½ times more energy than bread and potatoes *(Solanum tuberosum)*, respectively (Table 4).

In addition to providing the subsistence needs of the grower, beans are also sold for cash. There is a big demand in urban areas, teaching institutions, and others where large numbers of people are fed communally. There is also a good export market for beans. The present shortage is reflected in the high market prices throughout the country.

Types of Beans, their Introduction and Distribution

Types. The genus *Phaseolus* consists of 30-50 species of annuals and perennials. The most important species in Malawi is *Phaseolus vulgaris* L.,

Table 3. Comparison of protein and amino acid content of beans and other foods (per 100 g).

Food	Moisture (g)	Protein (g)	Lysine (mg)	Sulphur-containing amino acids: Methionine (mg)	Cystein (mg)	Total (mg)	Trytophan (mg)	Total essential amino acids (mg)	Total amino-acids (mg)
Beans	11.0	22.1	1,593	234	188	422	223	8,457	20,043
Groundnuts	5.2	25.6	1,036	338	366	704	305	9,502	27,610
Maize	12.0	9.5	254	182	147	329	67	3,820	9,262
Rice	13.0	6.7	255	150	108	259	95	2,695	6,785
Cassava	13.1	1.6	67	22	23	45	19	404	1,884
Beef	61.0	17.7	1,573	478	226	704	198	7,875	17,163
Chicken	66.0	20.0	1,570	502	161	764	205	8,380	18,206
Fish	10.1	75.0	5,808	2,052	924	2 976	720	30,360	70,308

Source: Litzenberger S.C. 1973. *The improvement of food legumes as a contribution to improved human nutrition. In:* Papers presented at the International Symposium on the Potential of Field Beans and Other Food Legumes in Latin America, Cali, Colombia. Centro Internacional de Agricultura Tropical, CIAT, 1975.

Table 4. Energy and other food values of some common foods in Malawi (per 100 g).

Food	Energy (cal)	Protein (g)	Fat (g)	Carbo-hydrates (g)	Ca (mg)	Fe (mg)
Beans	339	24.0	1.7	57	11.0	8.0
Maize (ufa, 60% extraction)	354	8.0	1.5	77	9.0	2.0
Rice (highly milled)	352	7.0	0.5	80	5.0	1.0
Sorghum (flour)	353	10.0	2.5	73	20.0	4.0
Bread or scone	249	7.1	0.7	53	11.0	1.1
Cassava root flour	342	1.5	-	84	55.0	2.0
Potato (European)	75	2.0	-	17	10.0	0.7

Source: Platt B.S. 1962 *Tables of representative values of foods commonly used in tropical countries.* H.R.C., London.

the field bean, which is also known as beans, haricot bean, salad bean, runner bean, pole bean, snap bean, string bean, sugar bean, dry bean, ration bean, bush bean, seed bean, mixed beans or, more commonly, as "nyemba". ADMARC also has various names for beans depending on shape, seed coat color and use.

On the basis of growth habit, beans are classified as: (a) dwarf, bush or determinate, (b) semi-climbing, and (c) climbing indeterminate, or pole.

In the Malawi bean collection about 25% of the lines are dwarf. These cultivars have short and erect stems with about ten nodes, with the main stem and branches terminated by an inflorescence. Maturity is about 90-100 days.

In semi-climbing cultivars, vegetative growth is more prolonged and the main stem is much longer than the branches. Although the main stem and the branches continue their vegetative growth, they become thinner and thinner at their apical ends, and pods are clustered at the lower nodes. Such cultivars are weak climbers and can be grown without support.

The climbing cultivars are the most common types in Malawi accounting for over 70% of the Malawi bean collection. These types have a long main stem, few branches and show strong vegetative growth with long and weak internodes and have the ability to twine around other plants or supports. Because of the long internodes these types need support in order to reach their full growth and yield potential. Most of the beans grown in Malawi are of this type and are adapted to intercropping with maize which provides the necessary support; over the years farmers have tended to select cultivars with climbing habit.

In accordance with their use beans are divided into three groups: (a) dry bean, (b) seed bean, and (c) canning bean. Dry beans are the most common type. These are large-to medium-sized kidney, round, oval or oblong shaped beans which range in color from red to white with variations of speckled colors. They are usually harvested when the pods are fully dry; the dry seeds are cooked. The pods are like parchment and dehisce on both seams when dry.

The second type, seed bean, also known as snap or French bean, refers to seeds sent to Malawi by overseas firms to be grown on contract. A limited definition would only include those types whose pods are eaten green, i.e., the snap or French beans. These may be used for canning or produced for home use. The pods are indehiscent and stringless with tender thick pod walls with comparatively small seeds. At the moment most of bean seed production is for the export market.

The canning beans are white and roundish and are grown for their dry seed which is used for canning. Because of the stringent seed quality requirements, especially for color, production under irrigation is preferred to rainfed cropping. ADMARC's canning factory, Mulanje Peak, cans beans in tomato sauce.

Introduction and distribution. Beans originated in Central and South America where, together with maize, they are the most ancient of cultivated crops (Kaplan, 1965). In the 16th century the Spaniards and the Portuguese took beans to Europe and from there to Africa and various parts of the world (Purseglove, 1968). Beans probably reached Malawi from the Eastern coast of Africa about 300 years ago through the influence of traders and merchants (Mughogho, Edje and Ayonoadu, 1972). In recent years a number of cultivars have been introduced from Europe, North America and neighboring countries. Beans grown in Malawi are mixtures or blends of different types with respect to growth habit, seed coat color and shape although the kidney-shaped, medium-to-large-sized seed with red-seed coat color is preferred.

Although most of the beans grown in Malawi are mixtures or blends, ADMARC requires growers to sort out their seeds according to their classification before the seeds are sold. ADMARC, however, buys mixed beans grouped on the basis of color and shape. Their price is lower than that of pure groups. Apart from "meeting internal requirements (mixed beans), are difficult to dispose of at a profitable price" (Anon, 1979).

Bean Production Environment

There are three main agricultural regions in Malawi with different climate, soil series and crops (Agnew and Stubss, 1972). The first is the Rift Valley floor extending from the lower Shire Valley, with an altitude of 37 masl at the Southern frontier, northwards to Lake Malawi and then along the lowlands of the Western lakeshore to about 762 masl. Crops grown here are cassava, millet, rice, cotton and tea. Hardly any beans are grown. Because of its low altitude this area is more suited to cowpeas.

The second region is the plateau between 732 and 1372 masl. Its agricultural potential is high in well drained ferruginous soils. Beans are grown here except in areas with poor drainage.

The third region is the hilly zone between 1372 and 1539 masl. Beans are grown where the slopes are moderate and the soils are deeply weathered.

Generally most beans are grown between 1000 and 2000 masl, on well drained soil and rainfall between 800 and 1500 mm. In areas with prolonged rainfall such as Thyolo two crops can be planted, one during November/December, and the second crop in February/March. Major bean producing areas are the upland areas of Kasumgu, Dowa, Lilongwe, Ntchisi, Dedza, Chitipa North, Rumphi East and West, Southwest Mzimba, Mangochi, Machinga, Chiradzulu, Thyolo and Mulanje (see map, pag. 54).

Bean Production Systems

Mixed cropping is the most common bean cropping system in Malawi, especially for the small farmer who produces the bulk of the crop. This cropping system, of long standing tradition, is characterized by intensive land use with the growing of two or more crops in association. It is not primitive or haphazard, as once thought; rather, the agronomic management and decision making involved are more complex than for monoculture.

According to the national sample survey of agriculture (Anon., 1970), 94% of the total cultivated area was under mixed crops while only 6% was grown as pure stand (Table 5).

While the relative plant densities in crop mixtures was not well explained in the survey, the figures in Table 5 do indicate that pulses are hardly planted as a pure stand.

Table 5. Percentage of cultivated hectareage grown as pure and mixed stand.

Crops	Pure stand (%)	Mixed stand (%)
Maize	6.4	93.6
Groundnuts	9.7	90.3
Pulses	1.0	99.0
Cassava	11.0	89.0
Millet and sorghum	2.9	97.1
Potato (European and sweet)	5.1	94.9
Mean	6.0	94.0

Mixed cropping systems. Beans are generally grown in association with other crops, notably maize, the latter following a groundnut or a tobacco crop.

Ridge intercropping. Almost all crops in Malawi are grown on ridges. It is the system whereby farmers grow maize and beans on the same ridge. There is substantial intercrop competition during most of the growth cycle of one or both crops because both may be planted at the same time on the same hill or the beans are planted during the early vegetative stage of the associated crop. The position of the bean plant with respect to the maize or sorghum plant varies between districts and the growth habit of the crop. But generally, the climbing beans are planted on the same hill as the maize with the latter providing support.

In Lilongwe plain and areas of similar rainfall, ridge intercropping is common because delay in planting of the bean crop will cause substantial reduction in seed yield primarily because of inadequate moisture and shading from the associated crop. According to Johnson (1973), the rainfall which "begins" in Lilongwe district about November 25 and "ends" about March 19 is fairly low, only 930 mm, has a net length of 118 days, 72% wet pentads and 80% reliability index. Areas with similar rainfall characteristics should interplant maize with beans when maize is knee high (Edje, Mughogho and Rao, 1975, Table 6).

Sometimes farmers interplant groundnuts with beans using beans to fill missing stands of groundnuts especially when the supply of groundnut seeds is late.

Table 6. Yield and seed value of maize-bean mixture planted in rows at Bunda College.

Treatment No.	Treatment[1]	Yield (kg/ha)			Value of produce[2] (k)
		Maize	Beans	Total	
1	Pure maize	10,348	-	10,348	398.40
2	Pure bush bean	-	1,673	1,673	184.03
3	Pure climbing bean	-	2,620	2,620	288.20
4	Maize and bush bean	9,974	760	10,734	467.60
5	Maize and climbing bean	10,005	493	10,498	439.42
6	Pure bush bean	-	878	878	96.58
7	Pure climbing bean	-	1,965	1,965	216.15
8	Maize and bush bean	10,725	220	10,945	437.11
9	Maize and climbing bean	10,428	108	10,536	413.36
	Mean	10,296	1,090	6,689	326.77
	S.E. ±	179	57	338	

[1] Beans in treatments 2-5 were planted shortly after maize emergence while those in treatments 6-8 were planted when maize was 45-50 cm high.

[2] 1 k = 100 t = US$0.82; value of bean seed was 11 t/kg while maize was 4 t/kg.

Relay cropping. It is the growing of two or more crops on the same piece of land during one growing season. The second crop is planted when the first one has reached its physiological maturity or reproductive stage but before it is ready for harvest (Andrews and Kassam, 1975).

This cropping system is common in Thyolo, Mulanje, and Chiradzulu. Areas with an average net season's length of 140 days and over, season's reliability index of over 75% and about 80% wet pentads, and also locations like Karonga which have bimodal rainfall, are suited to the relay cropping system where there is adequate, residual soil moisture for reasonable yields. Spurling, 1972 (Table 7) reported that it was possible to obtain a reasonable bean yield from both relay and double cropping of maize and beans at Bvumbwe because it has 1230 mm of rainfall, about 100 mm falling between May and October as very light rains.

Table 7. Yield of maize and beans as intercrop, relay and double cropping at Bvumbwe[1].

Treatments	Yield (kg/ha) and season		
	Maize	Beans	
	November	November	March
Maize in November intercropped with beans in March	4407	-	373
Maize in November interplanted with beans in November, relay planted with beans in Mareh	4238	355	389
Bean monoculture in November, replanted with beans in March	-	1033	747

[1] Other mixed cropping systems include strip cropping and polyculture.

Double cropping. This system is becoming a feature in tobacco estates where beans form an important food component for their large labor force. Where tobacco is dry-planted early, the harvesting of the first planted crop can be completed about the middle of February in the Central region and earlier in the Southern region. The tobacco stems are uprooted and beans planted on the ridges. If the beans are planted early, reasonable yields can be obtained with the residual moisture and fertilizer.

Occasionally farmers may plant one or two ridges of maize between several ridges of an otherwise pure stand of beans.

Farmers sometimes plant a mixture (polyculture) of maize, beans and pumpkin or maize, beans, cowpeas, groundnuts and cassava with the more complex combinations—sometimes containing about half a dozen or more crops—nearest the household. The tally is often higher if non-annual crops present are counted. The sight often shocks the extra-tropical observer who regards it as a mixed-up rather than a mixed cropping system.

The main objective of crop production is greater output per unit of land; many experiments have shown that one means of increasing crop yields is by mixed cropping rather than monoculture as shown in Table 8. Edje, Mughogho and Rao (1979) conducted mixed cropping trials of maize and beans over a three-year period. The advantages of mixed cropping are well illustrated in this experiment. By cropping maize and beans in association (mixed crop), the farmer obtained a combined maize and bean yield of 11,540 kg/ha (10,975 + 565). If, however, the farmer had grown one half hectare to a pure stand of maize and the other half hectare to beans, he should have obtained 6671 kg/ha (½ of 10523 + ½ of 2818), which is a 42% increase in seed yield over pure stand (Tables 6 and 8).

By similar calculation the mixed cropping produced 46.4% more gross revenue than the pure stand. It should be noted here that the bean yield was a bonus crop because no additional fertilizer was applied when sown under maize; nor was additional land used since both crops were planted on the same ridge. The land equivalent ratio was 1.24 indicating that 1.24 hectare of pure stand of both crops was needed to produce the same yield from one hectare of mixed stand. Using conversion tables (Platt, 1966), since 100 g of ufa with 60% starch extraction contain 354 calories, while 100 g of beans contain 339 calories, and since 100 g of the edible portion of maize andbeans contain 8.0 and 24.0 g of protein, respectively, the energy and protein yields in Table 8 can be obtained from the two cropping systems.

Using FAO estimates of 2.5 Kcal and 65 g protein as the daily requirement of a 65 kg active man, the maize and the bean mixture should provide enough energy for 44.7 men and enough protein to feed 42.7 men per year. However, if the farmer had practiced pure cropping and planted a half hectare to each crop, he should have produced enough energy and protein to feed only 27.9 and 32.0 men, respectively.

Table 8. Yield, revenue, energy and protein yield of maize and beans in pure and mixed stand at Bunda College (1977-78).

Cropping systems	Yield (kg/ha)			Value (k)	Energy (Kcal/ha)			Protein (kg/ha)		
	Maize	Beans	Total		Maize	Beans	Total	Maize	Beans	Total
Maize (pure)	10523	-	10523	636.64	372.51	-	372.51	8.42	-	8.42
Beans (pure)	-	2818	2810	371.90	-	95.53	95.53	-	6.76	6.76
Maize and beans	10975	565	11540	730.56	388.48	19.15	407.63	8.70	1.36	10.16

Time of planting. It varies from area to area depending on the rainfall and the cropping system used. Actual dates of planting are misleading especially with the recent fluctuation of climate in Malawi. As a rule, the time of planting should be such that the crop will mature and be ready for harvest in dry weather at the end of rains. Where beans are interplanted with maize the actual time of planting beans is determined by the maize which is planted at the beginning of the rains.

In the Central region, mid-December is the optimum date of planting. In parts of the Southern region where there is prolonged rainfall and in parts of the Northern region with bimodal rainfall, it is possible to grow two bean crops in one season. In the South, for example, the first crop is planted at the onset of rains, about mid-November, and the second in February/March. The first crop is usually low in quality because it matures and is harvested during the rainy season. Rains are late in the North and beans are planted there about mid-January. With relay cropping, as is the case in Thyolo, the seeds are planted when the maize is physiologically mature and the crop is harvested in dry weather.

Plant population and spacing. Plant population and spacing depend on the cropping system. In mixed cropping, the plant density ranges from 20,000 to 60,000 plants/ha with two to four bean plants/hill on the same hill as maize or between maize hills. Where beans are planted in pure stand the plant population ranges from 50,000 to 80,000 plants/ha and seeds are generally planted on ridges 91 cm apart and in hills with four to five seeds/hill.

The reason for the low density of beans is not well known but it is attributed to lack of adequate seed supply. Generally farmers do not have enough seed to cover a prepared piece of land but nonetheless plant it with the available seed so as to have the psychological satisfaction of having planted a "large" hectareage.

The low density and the hill planting pattern that are so common in Malawi prompted Edje (1978, personal communication) to compare several bean cultivars at the Centro Internacional de Agricultura Tropical (CIAT) at Cali, Colombia. He found that there were no appreciable differences between several Type II and III cultivars (according to CIAT's growth habit classification system) when they were grown in plant densities of 8 and 24 plants/m^2 both in hill and "row" planting. The Types II and III are semi-climbers that do not need support because their internodes are short enough to withstand some lodging. Several bean lines are being screened for response to low density and hill planting.

Earlier experiments, on the size of ridge for planting beans in pure stand (Edje, Ayonoadu and Mughogho, 1972) in which 30, 45 and 60 cm ridges were compared, showed that highest seed yields were obtained at the narrowest ridge size. However, farmers prefer larger ridges (91 cm apart) since small ones are difficult to make and maintain without repeated re-ridging.

Fertilizer. Farmers do not apply fertilizers to beans probably because it is a subsistence crop which is grown in association with other crops such as maize, the latter sometimes fertilized with nitrogen and phosphorus. Another reason could be the age-long belief that all legumes fix nitrogen, and since it is the most limiting nutrient in soils there is no need for a supplemental one. However, Edje, Mughogho and Ayonoadu (1975a) showed that although beans are a legume crop they respond to liberal doses of nitrogen.

Weed control. Weeding is by hand, the number of times depending upon the associated crop. Where farmers plant pure stand, which is rarely the case, two or three weedings are enough. Edje and Mughogho (1974) in their investigation on the effects of various cultural practices on bean yield showed that weed control, plant population and spacing, and time of planting had more effect on yield than improved varieties and the use of fertilizers. They also showed that weeding within the first 20-30 days had more effect on seed yield than any subsequent weeding.

Harvesting and threshing. Beans are uprooted and dried in the compound with the pods on the plants, or the pods can be stripped and allowed to dry on the floor, on used fertilizer bags, or mats before threshing, either by trampling on them or by beating with sticks. Once the pods are dry, threshing is not difficult as the pods dehisce easily. However, mechanical seed damage is increased when pods are "flogged" with sticks.

Irrigation. Beans are not irrigated. They are grown as a rainfed crop. However, because of the need to diversify crop production and to serve as a short seasoned "winter" crop between two rice crops, efforts were made a few years ago in the then British Irrigated Rice Project, now Dwangwa Sugar Project, to encourage smallholders to grow beans after the rice crop. Recently, efforts have been renewed at the Chinese Agricultural Mission at Domasi and Likangala on growing beans on residual moisture following rice harvest. Preliminary results look promising but water management is still a problem.

Production, Trade, Storage and Utilization

Production and trade. No data are collected on the area planted to beans and the total production as is the case with most crops grown by small farmers. Even on estates where the area planted to beans is increasing, production data are not available. However, between 1910 and 1930 some data were published on bean production on large farms in the Southern region (Table 9). By examining the records of bean purchases by ADMARC, and reports by the Ministry of Agriculture and Natural Resources, which makes annual estimates for the Food and Agriculture Organization of the United Nations, FAO (1977, FAO Production Yearbook), the production, area and bean yield in Malawi from 1972 to 1976 were: 8000 t on 15,000 ha with a yield of 533 kg/ha. This very low yield per unit area has not improved since 1927 in spite of advances in agricultural technology.

The main factors limiting bean yields and hence total production are (a) lack of suitable varieties, (b) lack of specific production technology for beans, (c) diseases, and (d) pests.

Table 9. Production of beans in Malawi, 1912-27

Year	Area (ha)	Production (t)	Yield (kg/ha)
1912	110.16	-	-
1913	265.68	77.13	290.31
1916	27.54	-	-
1917	130.01	-	-
1920	282.49	56.60	200.36
1923	640.91	167.06	260.66
1925	558.50	285.55	511.28
1927	648.41	302.21	466.08

Source: Nyasaland (Malawi) Department of Agriculture, Annual Reports.

The internal bean market is dominated by ADMARC which is responsible for the purchase of crops grown on customary land, the land on which all smallholder farmers live. The total amount of beans sold to ADMARC represents the surplus to subsistence needs. Beans are also sold at local markets throughout the country where prices tend to be higher than those offered by ADMARC. Table 10 gives the amounts of beans bought by ADMARC in each region. It can be seen that the Central region produces over 70% of the bean crop, the main producing areas being the upland areas of Kasungu, Dowa, Lilongwe, Ntchisi, Dedza and Ntcheu. In the Northern region, the main producing areas are Chitipa North, Rumphi East and West and Southwest Mzimba. In the South beans are important in Mangochi, Machinga, Chiradzulu, Thyolo and Mulanje districts. Beans are a relatively unimportant crop in the lakeshore and low altitude areas of the lower Shire Valley where cowpeas appear to do better.

Although the export market for beans is good, the big internal demand which is increasing every year, and the low levels of production, prevent Malawi from becoming a major bean exporting country in Africa. Table 11 shows the fluctuating bean exports between 1973 and 1977. It is important to note that no beans were exported in 1978.

Table 10. Regional ADMARC purchases of *Phaseolus vulgaris* beans.

Region	Beans purchased (t)					
	1974	1975	1976	1977	Total	%
North	591.23	143.33	328.02	297.38	1364.96	9.18
Center	1008.70	1594.52	5581.06	2446.06	10,630.34	71.50
South	203.40	469.30	1961.01	238.57	2872.28	19.32
Total	1803.33	2207.15	7870.09	2982.01	**14,867.58**	100.00

Source: ADMARC Crop Purchase Statistics.

Table 11. Beans exported by ADMARC (tons).

Year	Total	Destination	Amount per destination
1973	371.14	Zimbabwe (Rhodesia)	371.14
1974	844.82	Zimbabwe (Rhodesia)	844.82
1975	412.89	Zimbabwe (Rhodesia)	358.44
		United Kingdom	54.45
1976	794.92	United Kingdom	640.66
		South Africa	154.26
1977	6899.14	Israel	2495.46
		Portugal	1923.77
		Iran	1814.77
		Zambia	274.95
		Spain	272.23
		United Kingdom	90.74
		Italy	27.22

Source: ADMARC Sales Statistics.

Storage. Beans are stored on the farm in containers such as clay pots, sacks, used fertilizer bags, etc. The seed may be stored with tobacco leaves or tobacco dust, with the nicotine from tobacco presumably acting as insecticide and the dust filling up intergranary space. Farmers also store beans with wood ash.

Until about five years ago some farmers, especially in the Lilongwe Agricultural Development Program, stored beans with lindane, but this was prohibited because of contamination with cured leaves. Lindane is being replaced by actellic.

Utilization. The beans most commonly eaten in Malawi are the dry bean and the red or tan, large seeded (40-50 g/100 seeds); kidney shaped seed, which after cooking looks like small chunks of meat, is preferred.

There are several ways of preparing bean dishes in Malawi. The most common one in homes, boarding schools, colleges, farming estates and most institutions where a large number of people are fed communally, is to soak the seeds in water for a few hours discarding the water afterwards. The purpose of soaking is to accelerate cooking, and secondarily to reduce flatulence (generation of gas in the digestive system). Salt, pepper, cooking oil, tomato and other ingredients may be added according to taste to the bean mixture and cooked. This "ndiwo" is served with ufa. The seedcoat is sometimes removed after soaking, and the beans are boiled till soft. They are mashed with a special stick or laddle to form "chipere". Beans are also boiled together with maize from which the pericarp has been removed to produce a popular Karonga dish called "ngata". In Karonga and Chitipa, beans are cooked with bananas to produce a dish known as "mbaraga". This dish may form one of the main meals of the day. Beans may also be cooked in the pods, "makata", and eaten with no accompanying porridge. Bean flour is also a constituent of "likuni phala" which is used for weaning children and for children under five.

In the Southern and Central regions, the green immature pods, "ziteba", are commonly eaten as relish. The young and tender leaves are boiled, and groundnut flour may be added to taste ("khwanva"). Any 'surplus' leaves are dried and stored for future use as "mfutso". In areas where bean production is low or at the time of the year when the supply is low, beans, cowpeas *(Vigna unguiculata)* and pigeon peas *(Cajanus cajan)* can be cooked together either for the bean flavor and/or to stretch their supply.

The effect of plucking bean leaves for relish has been studied for both dwarf and climbing beans. The results in Table 12 show that seed yields are reduced by leaf removal with reduction being higher in the dwarf beans. A study of yield and value of harvested seed and plucked leaves at different defoliation treatments and N levels is reported in Tables 13 and 14.

Table 12. Yield of bean seeds and fresh and dry leaves at two or three leaf plucking frequencies.

Bean growth habit	Plucked beans				
	No. of pluckings	Leaf yield (kg/ha) Fresh	Dry	Seed yield (kg/ha)	Yield reduction (%)
Bush	None	-	-	1104	-
	One	1128	208	863	21.8
	Two	2052	369	633	42.7
	Mean	1590	289	868	32.3
Climbing	None	-	-	1587	-
	One	868	136	1394	12.2
	Two	1468	228	1306	17.7
	Three	2515	441	1055	33.5
	Mean	1617	268	1335	21.1

Source: Edje, O.T., Mughogho, L.K. and Ayonoadu, V.W.V., 1972. Malawi Journal of Science.

Table 13. Yield (kg/ha) of seeds and of fresh and dry weight of leaves of a determinate bean at three N levels and four defoliation treatments.

N levels	Defoliation frequencies after days from planting									
	None	21			21 and 28			21, 28 and 35		
	Seed	Seed	Leaves		Seed	Leaves		Seed	Leaves	
(kg/ha)			fresh	dry		fresh	dry		fresh	dry
0	799	734	2066	185	296	2600	296	158	3021	341
60	945	827	2251	215	490	2888	341	376	3273	467
120	1121	1081	2296	200	653	3414	363	516	4621	481
Mean	955	881	2204	200	480	2967	333	350	3638	430

S.E.: N level, ± 60; defoliation, ± 58; N x defoliation, ± 100.

Source: Edje, O.T. and Mughogho, L.K., 1974, Research Bulletin of Bunda College of Agriculture.

Table 14. Value (K)[1] of seeds and fresh leaves of a determinate bean variety at three N levels and four defoliation treatments.

N levels	Defoliation frequencies after days from planting									
	None	21			21 and 28			21, 28 and 35		
(kg/ha)	Seed	Seed	Leaves	Total	Seed	Leaves	Total	Seed	Leaves	Total
0	87.89	80.74	32.23	112.97	32.56	40.60	73.12	17.30	47.15	64.51
60	103.95	90.97	35.12	126.89	53.90	45.05	98.95	41.36	66.66	108.02
120	123.31	118.91	35.82	154.73	71.85	53.26	125.09	56.76	72.09	120.85
Mean	105.05	96.87	34.39	131.26	52.77	46.29	99.05	38.47	61.97	100.46

[1] 1 kg of bean fresh leaves = 1.56 t = 0.016K

Source: Edje, O.T. and Mughogho, L.K., 1974, Research Bulletin of Bunda College of Agriculture.

Factors Limiting Production

The main constraints to bean production in Malawi are the lack of suitable varieties, inadequate production technology, diseases and pests. Another equally important constraint is the uneven supply of seeds throughout the year because of unimodal rainfall. A possibility of increasing bean supply is to plant them on irrigation schemes using the residual moisture after the rice harvest; most irrigation schemes are idle during winter and can be put into bean production.

Biological and crop husbandry practices. Varieties used in Malawi are a mixture or blend of different growth habit, seed coat color and shape types. These types have been grown for several years without selection except for superficial mass selection. Although they have adapted well to the areas where they are grown, the lack of selection limits their potential for increased production.

In the 1940's Canadian Wonder was introduced into Malawi through the Agricultural Research Station at Bvumbwe near Limbe. Because of seed production and distribution problems, this cultivar was confined to research stations and demonstration centers which made its adoption difficult for the smallholder for whom it was intended.

The National Seed Company of Malawi, formed two years ago, now handles bean seed multiplication and distribution. Previously research stations were charged with those tasks which were rather strenuous since they had neither the facility nor the staff to cope with them.

Time of planting is one factor limiting bean production. This problem is compounded by the fact that beans are hardly grown as a pure crop but in association with other crops, notably maize. Farmers can fill up vacant stands in groundnut fields with beans because they mature earlier. Since beans are a short seasonal crop, farmers plant them late, sometimes much later than expected, especially when there is pressure to weed groundnuts and maize. Resulting yields are generally low because of inadequate moisture. Also, plants are vulnerable to diseases and pests.

Extensive experiments on the time of planting in the Central region show that beans should be planted about mid-December. A two-week delay caused 50% yield reduction. However, farmers do not seem to do so because, in recent years, there has been considerable variation in rainfall distribution causing yield losses either from inadequate moisture or too much rainfall at the time of harvest.

Where beans are interplanted with maize, the actual time of planting of the beans is determined by the maize which is planted at the beginning of the rains. In parts of the Southern region where there is prolonged rainfall and in parts of the North with bimodal rainfall, it is possible to grow two crops of beans in one season. In the South, for example, the first crop is planted at the onset of the rains and the second one in February/March.

Plant population. As stated earlier, one of the main constraints to increased bean production is lack of seed supply. This may explain why bean plant populations are low, ranging from 30,000 to 80,000 plants/ha planted at 4-5 seeds/hill on the 91 cm traditional ridges. At this low plant population and with other poor cultural practices, such as late planting, no fertilizer application, and poor weed control, it is not surprising that bean yields are generally low.

In Malawi several experiments have been conducted on the effects of plant population and spacing on bean yields. The optimum plant population for the highest yields have not been difficult to ascertain because seed yield is an interaction of several complex factors such as cultivar, fertility and moisture of the soil. Beans also exhibit considerable plasticity and are, therefore, able to compensate for spacing differences over a wide range of populations. For example, Edje, Mughogho and Ayonoadu (1975b) investigating the effect of three plant populations (111,000, 222,000 and 444,000 plants/ha), different cultivars and fertilizer levels, reported that plant population yields pooled over cultivars and fertilizers were 1244, 1477 and 1601 kg/ha for low (111,000), medium (222,000) and high (444,000) plant populations, respectively.

Doubling the plant population from 111,000 to 222,000 plants/ha increased seed yield by 16.8% as compared to 7.7% when plant population was redoubled from 222,000 to 444,000 plants/ha. Similar results have been reported by Edje, Ayonoadu and Mughogho (1974). It should be noted, however, that from the farmers' point of view, the interest is not in the highest yield but in the highest net returns.

Another constraint is the distance between ridges. In Malawi most crops, including beans, are planted on 91 cm ridges which are generally too wide apart. Edje *et al* (1972, 1973) reported that the yield of determinate bean cultivars planted on ridges 30, 40 and 60 cm apart were 1738, 1321 and 1145 kg/ha respectively, while indeterminate bean cultivars planted on ridges 45, 60 and 90 cm apart yielded 1340, 1209 and 1107 kg/ha, respectively. Despite these findings farmers still plant on 91 cm ridges to avoid making ridges of different sizes from one year to another. Results of many trials over a number of years show that satisfactory bean yields can be obtained from plant populations of 20-22 plants/m^2 and 10-15 plants/m^2 for bush and climbing cultivars, respectively. The way these plant populations are arranged in the field depends upon whether planting is on the flat or on ridges. On the flat any planting pattern would be satisfactory, but on ridges, higher yields of bush beans are obtained from small ridges 30 cm apart planted to a single row. Small ridges are, however, difficult to make and maintain with hand tools. Small ridges also fail to provide good drainage when rainfall is high. It is for these reasons that the standard 91 cm ridges are being recommended as a compromise, and to plant two rows per ridge in pure stand.

Cropping system. Currently most beans are grown by the smallholder in association with a variety of crops. While this system is adequate to meet subsistence demand at the farm level, it is inadequate to meet the national demand that is spiralling. One means of increasing production would be to expand production in large estates where the genetic potentials of high yielding varieties can be exploited, when developed, and when seeds become available for large scale production. In the absence of the above, the smallholder, with his limited resources of land, fertilizer and other production factors cannot increase yield significantly in his present mixed cropping system, where beans are regarded as a bonus or subsidiary crop.

Weed control. In beans it is as important as it is in other crops. Results (Ayonoadu, *et al.*, 1972, Edje and Banerjee, 1979, unpublished) have shown that bean fields should be kept weed-free until pod setting in order to obtain high yield. As would be expected, hand hoe weeding is the most popular method for obvious reasons, and it has proven to be superior to the use of herbicides.

However, when beans are grown in estates the use of herbicides may be preferred because of the importance of timely weeding which may not be accomplished with competing demands for labor.

Fertilizers (organic and/or inorganic). These are applied to maize and tobacco but not to beans. Two-year experiments under irrigation at Dwanga (Table 15) showed that there was a linear response of beans up to 200 kg/ha of N with a correlation coefficient of 0.922** between N levels and yield.

Results of NPK factorials have shown highly significant responses to N and P, but rather negative responses to K, even at 5 kg/ha, have been reported.

In view of the high costs of fertilizers, especially nitrogen, the authors are investigating in collaboration with Dr. P. Davies at Chitedze Agricultural Research Station, seed inoculation of beans with different strains of *Rhizobium phaseoli*.

Table 15. Yield and other characteristics of climbing beans at six N levels under irrigation.

N levels (kg/ha)	Yield (g/plant)	Yield (kg/ha)	LAI	LAR	Crude protein (%)	Crude protein yield (kg/ha)
0	2150	12.8	1.19	1.30	18.4	382
40	2704	16.5	1.91	1.35	19.8	518
80	3048	18.3	3.31	1.43	20.4	567
120	3147	19.8	3.34	1.65	22.1	637
160	3366	22.5	3.08	1.40	22.5	678
200	3779	21.6	2.72	1.50	24.8	762

Source: Edje, O.T., Mughogho, L.K. and Ayonoadu, V.W.V. 1974. Research Bulletin of Bunda College of Agriculture.

Diseases. They are the most important single factor limiting bean yields in Malawi. Although a total of 23 diseases have been reported (Peregrine and Siddigi,1972), our investigations have revealed that the most important diseases are: anthracnose, caused by the fungus *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scribner; halo blight, caused by the bacterium *Pseudomonas phaseolicola* (Burk.) Dows; angular leaf spot, caused by the fungus *Phaeoisariopsis griseola* Sacc.; Southern blight, caused by the fungus *Sclerotium rolfsii* Sacc.; and rust, caused by the fungus *Uromyces appendiculatus* (Pers.) Unger.

In general, it is the first two seed-borne diseases which are common wherever beans are grown. When the collection of local land-races was planted at Bunda in the 1969-70 season, about 7% of them showed symptoms of seed-borne anthracnose. As shown in Table 16, anthracnose occurred in beans received from all districts.

Table 16. Incidence of anthracnose in local beans.

District	Total samples	Samples with anthracnose (%)
Chitipa	311	6.4
Karonga	119	5.9
Rmphi	183	2.7
Mzimba	545	9.5
Dedza	234	6.8
Dowa	135	5.2
Lilongwe	150	10.7
Ntcheu	15	6.7
Ntchisi	2	50.0
Chikwaw	80	8.8
Thyolo	164	4.3
Mangochi	190	10.5
Mulanje	129	6.2
Nsanje	512	3.7
Total/Mean	2769	9.8

Anthracnose is one of the most widespread and destructive diseases of beans. Severe infections may result in total loss of the crop. Most bean varieties are susceptible to this disease. It may appear in the field about four to six weeks after seedling emergence. Symptoms may appear on leaves, stems and pods. They first appear on the underside of leaves as brown to dark brown dead areas on the vein.

The most striking symptoms, however, appear on pods. Minute brown to purplish streaks surrounded by raised margins are the initial symptoms on the pods. These spots later develop the characteristic large, dark, more or less circular spots with sunken centers and raised margins. In any weather the centers of the spots are filled with pink or flesh-colored slimy spore masses. Seeds in such pods may develop slightly depressed dark lesions similar to those of the pods. The disease is favored by high relative humidities and temperatures between 17 and 23°C. At temperatures below 13°C or above 27°C or in dry conditions, there is little infection. The disease becomes severe under cool and wet conditions.

Control measures include the use of disease-free seeds, resistant cultivars, or spray with Daconil 75% WP at 3.5 g/liter or Zineb 70% WP at 3.7 g/liter at bi-weekly intervals.

Halo blight is the most common and most destructive type of bacterial blight in Malawi, the other two being the common and fuscous blights.

Halo blight is among the diseases that appear first in the field and it attacks all plant parts above ground. The most striking symptoms are spotting on leaves and pods. Others are lesions on the stem and branches, stunting, wilting and death of the plant. Infection is first initiated on the underside of the leaf where it appears as a small, dark green, watersoaked, translucent (semi-transparent) spot which soon develops into distinct circular spots with brown dead centers surrounded by a wide greenish yellow zone called "halo". This is more conspicuous on the upper side than on the under side of the leaf. On pods, circular, dark green, watersoaked spots, which often run into each other, are produced. These spots look greasy and produce a creamy and slimy bacterial ooze which dries up on the surface of the spots as flakes. Seeds in such pods are also invaded and develop reddish cankers.

Control measures include the use of disease-free seeds, especially seeds produced under flood irrigation during the dry season, or to spray with copper oxychloride at 4.5 g/liter at fortnightly intervals.

Angular leaf spot appears in the crop at about the middle of the growing season. Once established, it spreads rapidly and becomes severe towards the end of the season causing spots on leaves and pods. The spots on the leaves are angular, greyish-brown, often so numerous that they impart to the leaf a checkerboard appearance. Infected pods develop more or less circular spots of varying size with black borders and reddish brown centers. From these infected centers the fungus may grow into the pods and infect the seeds.

Control measures include the use of disease-free seeds, resistant cultivars, crop rotation, Daconil 75% WP at 3.5 g/liter, or Zineb 70% WP at 3.7 g/liter, both at fornightly intervals.

Pests. A number of pests attack beans in Malawi inflicting varying degrees of damage and causing considerable yield reduction. The most important ones in the field are various types of beetles, beanfly, American bollworm, aphids, cutworms, and nematodes. In storage the most serious one is bean weevil.

There are two kinds of beetles that attack beans, those that feed on leaves and those that feed on flowers. The leaf eaters, *Ootheca* spp., are the most abundant and are more destructive than the flower or pollen beetles, *Mylabris* spp. and *Coryna* spp. Control measures include spraying with lebaycid or dipterex.

The beanfly or bean maggot *(Melanogromyza phaseoli)* causes considerable loss of stand in plants up to flowering stage. The insect lays its eggs on leaves, the larvae invade the vascular bundle of the infected plant at ground level where they pupate. Infected plants turn yellow and die at the seedling stage. Tolerant plants produce aerial roots above the pupated section, but such plants have reduced vigor and may lodge easily.

Control measures are to plant early, use resistant varieties, or spray plants with dipterex.

The bean aphid *Aphis fabae* can be destructive of bean especially in dry weather. Damage is caused by the aphid withdrawing sap from the plant and from injury as they feed. Severely infected plants are less vigorous and stunted and their shoots may be deformed or distorted. Besides the direct damage to plants, the bean aphid serves as a vector of the bean common mosaic and bean yellow mosaic virus diseases. The only effective control measure is the use of insecticides which farmers cannot afford.

The American bollworm, *Heliothis armigera,* is an important bean pest. It is also a major pest of cotton. Damage is done to beans by the young larvae which first attack the flowers and then partially or wholly destroy the pods. The main effect of larval damage on pods is their feeding on the developing seeds.

The bean weevil is the most destructive pest of stored beans. Weeviled beans are not only unfit for human consumption but are also unsuitable for planting. Infection begins in the field and continues in storage if unchecked. Control measures include insecticidal sprays in the field, but the use of actellic or other suitable insecticides is more effective.

Socio-economic factors. Research on socio-economic aspects of bean production is recent and results are preliminary. However, it is common knowledge that the farmer is a price conscious individual. For example, the hectareage grown to different crops varies with the price offered by ADMARC. In other words, an increase in bean prices will increase production, as it did with dark-fired tobacco about three years ago, and is currently doing with groundnut production, especially when prices are announced by ADMARC at the onset of the crop season.

Labor is not a problem at the current rate and level of production. However, it could become a problem, except for those estates where most field operations are mechanized. Marketing channels are not a constraint to bean production since ADMARC has several "bush markets" where farmers can sell the surplus produce. In fact the demand for beans is so high that disposal is not a problem. As stated earlier, consumer preference is for red or tan, kidney shaped, large seeded beans which are easy to cook. The preference is sometimes so narrow that it may become a constraint to bean production. For instance, small seeded high yielding cultivars with black seed coats and resistant to diseases and pests are objectionable to farmers.

Institutional factors. One of the main factors limiting bean production in Malawi is the lack of research and extension workers. For example, the Malawi bean collection with its broad genetic base has been hardly used for purposes of breeding for resistance to diseases and pests and for developing agronomic characteristics through hybridization. Pest control is virtually untouched because of lack of staff. Also lacking is a well trained support staff to assist with field trials. For instance, since the inception of the bean project (referred to in the following chapter) the most educated support staff has only two years of secondary school; not even a single person is found with a certificate in agriculture from Colby College of Agriculture or a diplomate from Bunda College. This means that almost all the field work has fallen on the senior staff, thus limiting the volume of research that they can do to increase bean production. The lack of a vehicle for field visits to experiments and to learn about problems on the spot has also been a constraint on research efforts.

Another constraint is the lack of training facilities. Many districts have general purpose extension staff down to the village level. They are usually diplomates, called technical officers, with three years of training at Bunda College, or technical assistants with certificates from Colby College of Agriculture. At the present level of production, and with the large number of other crops such as maize, groundnuts, tobacco, etc, the authors do not advocate recruitment of extension staff to work solely on beans. Rather, an alternative would be to organize in-service training periodically on production technology, first for extension staff and later to include farmers.

Description of Country Bean Program

In spite of their importance as a food crop, no significant work was done to improve bean production in Malawi prior to 1969. The little research that was done concentrated on one variety called Canadian Wonder introduced at various times since the 1940's. In 1960, a time-of-planting trial conducted at Chitedze, Thuchila, Chitala and Mbawa gave yields ranging from 660 kg/ha in the early January plantings to 15-20 kg/ha or nil for late plantings. Using the same variety but grown at Bvumbwe, Spurling (1973) obtained yields from 1000 kg/ha to nearly 2000 kg/ha depending upon the plant population and spacing used and disease control measures applied.

This work by Spurling pointed to the great potential of research for increasing bean production in Malawi. To this end a National Bean Research Project was established at Bunda College of Agriculture to coordinate all research on beans. Its main objectives are to produce high yielding varieties with stable and durable resistance to diseases and pests and acceptable to both growers and consumers. Also to develop technology for bean production on irrigation schemes as a short seasonal rotational crop. Emphasis is placed on the development of cultivars that fit in with the cropping systems of the small farmers and the large estates. Shape, size and color of the seeds are the main considerations for consumers' acceptance.

Collection of bean germplasm. The logical starting point for the improvement program is to evaluate local land races of beans for desirable characteristics such as high yield and disease resistance. To this end an extensive collection of bean samples was made by agricultural extension staff from villages in all districts except Nkhotakota, Kasungu, Mchinji, Machinga and Zomba.

Each sample was given an accession number plus other useful information such as place of collection, seed coat color and shape. Most samples were not uniform in those characteristics, and accessions were separated on such basis and given sub-accession numbers. Thereafter, seeds of each accession or sub-accession number were planted singly and further selected at harvest according to growth habit and other characteristics. From the total samples received, 11,255 accessions were finally assembled for evaluation.

Data on Tables 17 and 18 show clearly that the majority of beans grown in Malawi are climbing in growth habit and have plain seed coat colors. While this color preference is difficult to explain, the traditional practice of mix-cropping maize and climbing beans explains their predominance over bush types which are better grown as a sole crop.

The total collection of beans assembled at Bunda College is probably the largest collection of African land races. It is invaluable not only as a source of genetic variability for breeding purposes but also for studies of genetic diversity resulting from the adaptation of the introduced beans to different habitats in which they have been grown for several hundred years. The germplasm collection is maintained in a cooled seedstore at about 5°C temperature and is periodically renewed by growing under furrow irrigation during the dry season to filter out seed-borne diseases.

Table 17. Growth habit and seed coat color of local beans in Malawi.

Bean growth habit	Accessions		Seed coat color	
	Total	%	Plain (%)	Speckled (%)
Climbing	8486	75.4	70.4	29.6
Bush	2769	24.6	88.1	11.9
Total	11,255	100.0	74.8	25.2

Table 18. Growth habit and seed coat color of local beans by district in Malawi.

District	Bean growth habit					
	Climbing			Bush		
	Total accessions	Seed coat color		Total accessions	Seed coat color	
		Plain (%)	Speckled (%)		Plain (%)	Speckled (%)
Chitipa	463	52.5	47.5	311	91.3	8.7
Karonga	80	97.5	2.5	119	95.8	4.2
Rumphi	669	77.3	22.7	183	82.5	17.5
Nkhata Bay	94	76.6	23.4	0	0.	0
Mzimba	4296	82.8	17.2	545	94.1	5.9
Dedza	815	40.4	59.6	234	98.3	1.7
Dowa	387	40.6	59.4	135	66.7	33.3
Lilongwe	286	44.1	55.9	150	97.3	2.7
Ntcheu	3	100.0	0	15	100.0	0
Ntchisi	140	44.3	55.7	2	50.0	50.0
Chikwawa	70	100.0	0	80	100.0	0
Thyolo	182	68.1	31.9	164	99.4	0.6
Mangochi	395	39.5	60.5	190	24.2	75.8
Blantyre	27	100.0	0	0	0	0
Mulanje	121	97.5	2.5	129	100.0	0
Nsanje	458	74.2	25.8	512	93.4	6.6
Total/Mean	8486	71.0	29.0	2769	74.5	13.0

In addition to the local collection of beans, the germplasm includes varieties and breeding lines from the United States of America, Latin America, United Kingdom, the Netherlands, France, Kenya, Tanzania, Uganda, Ethiopia and Zambia. Most of these introduced cultivars have special traits such as high yield or resistance to certain diseases and are being evaluated together with the local land races, but their main use will be as source of desirable traits in the hybridization program.

Agronomic investigations. When the project began in 1969 there was no information on the potential yield of both local and introduced bean cultivars, neither on the agronomic or crop husbandry practices for maximizing bean yields. As both kinds of information were essential for the rest of the research program, agronomic investigations have so far formed a major part of the bean improvement program.

Table 19 gives data on the evaluation of 557 bush and 1501 climbing lines from the germplasm collection. The climbing lines were grown without support, hence, yields obtained were lower than they would have been had supports been provided.

Although only 18% of the germplasm was evaluated, the data show that among bush and climbing cultivars there are many lines with a yield potential above 1500 kg/ha. These high yielding cultivars were used in further experiments.

Experiments on the time of planting beans have been done only in the Central region at Chitedze and Bunda which are ecologically similar. Results in Table 20 show that mid-December plantings at these two locations give the best yields.

Table 19. Yield of 557 bush and 1501 climbing bean lines evaluated at Bunda.

Bean growth habit	Yield groups (kg/ha)	Lines per group	
		Amount	%
Bush	Over 2500	3	0.5
	2001 - 2500	11	2.0
	1501 - 2000	60	10.8
	1001 - 1500	131	23.5
	501 - 1000	219	39.9
	Below 501	133	23.3
Total		557	100.0
Climbing	Over 2500	13	0.9
	2001 - 2500	29	1.9
	1501 - 2000	76	5.1
	1001 - 1500	143	9.5
	501 - 1000	378	25.2
	Below 501	862	57.4
Total		1501	100.0

Table 20. Time of planting effect on seed yield at two locations in the Central region.

Planting date	Yield (kg/ha)		
	Sites		
	Bunda College	Chitedze	Mean
1-12-71	991	1581	1286
15-12-71	1274	1842	1558
29-12-71	964	776	870
12- 1-72	421	630	526
26- 1-72	282	411	347
Mean	786	1048	

During the dry season beans can be successfully grown under irrigation. Trials on the time of planting have shown that at lower elevations (below 366 m) of the lakeshore plain and the Shire Valley, temperatures are higher than in the upland areas and good yields are obtained from May plantings. In upland or medium and higher altitude areas, where temperatures are lower and frost may occasionally occur, the best time for planting is when soil temperatures are above 10° C, and this is generally in August. Plantings later than August will mature during the next rainy season in November and will produce low quality seed.

One of the earlier experiments was on plant population and spacing for bush and pole beans on different ridge sizes such as ridges 30, 45, 60 and 91 cm apart; and in different planting patterns such as one or two rows per ridge, square, rectangular or staggered planting. The results showed generally that beans exhibit considerable plasticity and are able to compensate for spacing differences over a wide range of populations. Results of many trials over a number of years show that satisfactory bean yields can be obtained from plant populations of 20-22 plants/m^2 and 10-15 plants/m^2 for bush and climbing cultivars, respectively. The way these plant populations are arranged in the field depends upon whether planting is on flat or on ridges. On the flat any planting pattern is satisfactory, but on ridges higher yields of bush beans are obtained from small ridges 30 cm apart planted to a single row. The standard 91 cm ridge is recommended, planting two rows per ridge.

Nitrogen, phosphorus, potassium and sulphur are some of the major nutrients investigated. The results of NPKS factorial trials involving 2-3 levels of each element showed a highly significant response to N and P at several sites, occasional positive response to sulphur but rather frequent negative response to K even at the rate of 5 kg/ha. In view of this, the compound fertilizer 20-8.7-0 (N-P-K) at the rate of 200 kg/ha, depending upon soil test results, is recommended for bean production.

Several experiments have shown no significant differences in yields obtained from using sulphate of ammonia, calcium ammonium nitrate, nitrate of sodium or urea as sources of nitrogen.

Trials using sulphate of ammonia under irrigation showed that beans, although a legume crop, respond to a liberal application of nitrogen. Yields of two season's experiments for 0, 40, 80, 120, 160, and 200 kg/ha of nitrogen were 2150, 2704, 3048, 3147, 3347, and 3779 kg/ha respectively. The experiments and the control received 33 kg/ha of P.

Nitrogen can be applied to beans either all at planting or split into two, some at planting and the remainder at flowering. Experiments to test split application did not show significant results, thus single application of nitrogen at planting is recommended.

Experiments on the inoculation of bean seed with strains of *Rhizobium phaseoli*, in an attempt to increase nodulation and hence yield without nitrogen application, have so far given no useful results.

Production systems. It is a common practice in Malawi to pluck or remove young bean leaves before plants set pods for use as a green vegetable or as a dry vegetable that can be stored. The effect of this practice on seed yield has been determined on both bush and climbing beans. Table 13 (p. 70) shows that seed yield was reduced by leaf removal and that these reductions were higher in the bush than in the climbing cultivars.

In another experiment (Tables 13 and 14, p. 70) using high nitrogen levels to increase the foliage, plucking leaves once, twice or three times during the season reduced seed yields by 7.7, 49.7 and 63.3%, respectively. No advantage was obtained by the application of levels of nitrogen higher than 60 kg/ha. The most important result from this experiment was that, although leaf removal reduced seed yield, the combined yield of seeds and leaves in monetary value was higher when compared with the value of seeds alone.

The traditional method of growing climbing beans is to interplant them with maize. In pure culture, yields are not maximized and seed quality is poor unless support for the stems is provided. Experiments were, therefore, conducted to find out both the best method and the height of support for growing climbing beans as a pure crop. Yield from plots where bean plants were left prostrate on the ground along the ridge were compared with yield from plots with the vertical and the horizontal support systems. In the vertical system, split bamboos or thin stems of woody plants were spaced 30 cm apart along the ridge and provided support for two plants. In the horizontal method of support, horizontal stakes were tied at intervals of 50 cm to vertical stakes spaced one meter apart to form a trellis of four tiers. All the plants on each ridge were trained on the same trellis. In both cases support heights were 1.2-2.0 m.

Yields for the unsupported, vertically supported, and horizontally supported were 1178, 2069 and 2061 kg/ha, respectively. Seed quality of unsupported plots was also low because of microbial growth on pods resting on the soil. The effect of trellis height on yield was also investigated and results show that the optimum height for staking beans is between 2 and 3 m (Table 21).

Table 21. Yield and other agronomic parameters of beans at four trellis heights.

Trellis height (m above ground)	Yield (kg/ha)	Pods/m²	DM (g/m²)	LAI
0	1158	148.9	283.4	1.74
1	2409	104.8	305.4	1.80
2	2782	127.6	365.0	3.28
3	2944	137.1	352.8	2.47
Mean	2323	129.6	326.7	2.32

In order to obtain information on crop rotation, an experiment was carried out to find the effect of planting maize on plots previously grown to beans, soya beans and groundnut. The yield of maize following maize was generally lower than when the previous crop was a legume (Table 22). It appears that beans have a beneficial effect on the following maize crop in rotation.

Table 22. Effects of previous crop and N fertilizer on yield of maize at Bunda College.

N fertilizer (kg/ha)	Yield after previous crop (kg/ha)			
	Groundnut	*Phaseolus* beans	Soybean	Maize
0	7233	7600	7317	5733
40	9517	8733	9583	7967
Mean	8375	8167	8450	6850
S.E.		±497		

The following aspects of intercropping are being studied: time of undersowing maize with beans, competition between different maize and bean cultivars, fertilizer requirements for maize-bean associations, fertilizer and planting densities in maize-bean associations, planting patterns in maize and bean association, cassava and bean associations, bean and groundnut associations, relay cropping of maize and beans, tobacco-bean association, polyculture of maize, beans and pumpkins.

As shown earlier in Tables 6 and 8, p. 62, 64, the yields obtained from growing beans in association explain why farmers grow mixed crops despite repeated attempts by research workers to the contrary.

Plant pathology. Three approaches have been attempted to control bean diseases: chemical control, disease resistance and disease-free seed.

The following ten chemicals have been screened for their efficacy under conditions of natural infection in the field: Bavistin, copper oxychloride, Daconil, Dithane M-45, Du-Ter, Koccide, lime sulphur, Maneb-M22, Plantvax and Zineb. All of them proved effective in controlling the major diseases depending upon dosage rates and frequency of application. Unfortunately with the present prices it is not economical to use chemicals and they are not recommended.

The ultimate solution to disease problems is to grow resistant varieties. To this end, the germplasm has been screened for durable resistance to the main diseases listed above but with initial emphasis on anthracnose and halo blight. All the screening has been carried out under field conditions where the cultivars have been exposed to natural infection or to infection from seed-borne or soil-borne inoculum. From such tests resistance to some of the diseases has been located in a number of cultivars within the local land races and in introduced germplasm. Resistance to anthracnose and halo blight has been found mostly in the local land race of climbing beans; the bush ones have shown high susceptibility to these two diseases.

Resistant cultivars will be released as varieties if found agronomically suitable, but since all of them are not resistant to all the major diseases, they will be used as parents in the hybridization program.

In the absence of agronomically suitable varieties resistant to anthracnose and halo blight, the production of disease-free seed for growers is the alternative for successful bean production.

It has been proved possible to produce seeds relatively free from heavy seed-borne disease inoculum under flood or furrow irrigation during the dry season. As Table 23 shows such seeds produce a better crop than seeds from a rain fed crop.

Table 23. Yield (kg/ha) of six seed lots, three unfiltered and three filtered, with two fungicide treatments at Bunda College.

Treatment	Seed lots[1]					
	A		B		C	
	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
Control	1021	1245	924	1182	620	999
Copper oxychloride	1804	2303	1048	1928	868	1869
Mean	1413	1774	986	1555	744	1434
S.E. (seedlot x fungicide) = ± 138						

[1]A = apparently healthy: no visible infection; B = apparently infected: slight decoloration of seed; C = heavily infected: seeds heavily discolored and shrivelled.

Bean physiology. Physiological studies include growth analysis, shading experiments, sink source relationship, defoliation and apical and lateral bud removal. Most agronomy experiments have included considerable amount of physiological data. Cultivars have been evaluated and compared on the following characteristics: days to flowering, days to physiological maturity, maximum leaf area index, leaf area duration, pod number/m^2, seeds/pod, dry matter accumulation and distribution, morphological and physiological yield determinants in beans, and other important primary and secondary yield components.

Varietal improvement. In view of the importance of diseases in limiting bean yield, the breeding program has concentrated on the production of disease-resistant varieties. Parents in the compound or multiple crosses are exotic cultivars with resistance to one or more of the major diseases and a local cultivar which is resistant to rust and has acceptable characteristics with respect to seed shape and color. Table 24 gives details of the parents involved in the crosses.

The lines obtained after completion of Phase IV are multiplied for screening and selection.

Early and advanced generation trials have given acceptable yield levels, some of them above 3000 kg/ha. Selection and assessment of these lines for resistance to the major diseases is continuing.

Table 24. Parents used in the compound crosses of beans in the disease resistance breeding program.

Accession No.	Cultivar and source	Disease reaction
245/1	Local	Resistant to rust (A)
1219	Great Northern Nebraska No. 127	Tolerant to common bacterial blight and to halo blight races 1 and 2 (B)
1127	Cornell 49-242 ex Uganda	Resistant to races of anthracnose (C)
1209	Confinel ex Uganda	Resistant to races of anthracnose (C)
1245	2/5/4 ex Uganda	Homozygous for Are gene (C)
1250	2/2/3 ex Uganda	Homozygous for Are gene (C)
1253	10/3/8/3 ex Uganda (early maturing)	Homozygous for Are gene (C)
1261	K25 ex Uganda	Resistant to races of anthracnose (C)
1216	HBR 73 ex Wisconsin	Resistant to halo blight races 1 and 2 (D)
1218	Redkote ex Cornell	Resistant to halo blight and bean common mosaic (D)
1131	Perry Marrow ex Uganda	Resistant to alpha and beta races of anthracnose, tolerant to halo blight (E)
1134	Perry Marrow ex U.S.A.	idem
1236	Perry Marrow ex Michigan State	idem

The breeding plan involves making the following crosses:

Phase I	A x B	A x C	A x D	A x E
Phase II	AB..........x..........AC		AD..........x..........AE	
Phase III	ABC.........................x.........................ADE			
Phase IV	ABCDE			

As an interim measure to meet the demand for better bean cultivars, some varieties, all selected from the Malawi land races, have been provisionally released for use by growers. Table 25 gives some of their characteristics. The National Seed Company of Malawi is responsible for their multiplication, and seed is available for sale at ADMARC markets throughout the country.

Table 25. Characteristics of some bean lines on provisional release in Malawi.

Accession No.	Growth habit	Type	Seed coat color	Yield (kg/ha)	Pods/ plant	Seeds/ pod	Seed size (g/100 seeds)	Days to full bloom
253/1	Bush	Dry	Coffee brown	1179	6.4	3.6	49.1	35
296	"	"	White	1377	6.9	3.5	41.7	36
373	"	"	Yellow	2084	8.1	3.4	31.5	37
600/1	"	"	Red	1256	7.0	3.6	49.3	36
1196	"	Canning	White	2070	25.5	5.5	16.1	36
97/1	Climbing	Dry	Red	2739	34.0	4.4	51.9	40
186	"	"	Coffee brown	1709	23.2	4.0	40.1	41
499/5	"	"	Black	3075	57.0	6.2	20.7	52
1200	"	Canning	White	2801	49.0	6.0	18.2	42

Seed Production and Distribution

Prior to 1976 much of Malawi's seed requirements were imported from neighboring countries. Without direct road or rail routes, and with spiralling transport costs, this situation could not continue. A Seed Technology Unit (STU) at Chitedze Research Station, five miles from Lilongwe, was established with the prime view of initiating a national seed production program, and providing the necessary field inspection services and an official seed testing station of international level. This, together with staff training, was accomplished during 1976-1978. Then it became apparent that, with the dramatic increase in demand for improved seed of all crops by all sectors of the Malawian community, some organization to take over the specialized commercial aspects of the seed industry, i.e., seed production, processing and packaging and parent seed maintenance and storage, was required.

This resulted in the establishment of the National Seed Company of Malawi Limited (NSCM), a private company whose major shareholders are ADMARC and The Commonwealth Development Corporation (CDC). In the initial stages of development, CDC has been given the responsibility for management, to set the operation in motion, and to train Malawian staff at all levels. An investment of approximately 2.44 million k* financed solely by ADMARC and CDC, is involved, the main assets being a specialized seed farm on the outskirts of Lilongwe, and a large complex, nearing completion, on the heavy industrial estate at Kanengo,

* 1 k=US$0.82

which houses the administration head quarters, seed processing factory, and long-term storage facilities.

The seed industry in Malawi comprises the following aspects: a) plant breeding and development of new cultivars, cultivar testing and introduction; b) seed production: seed quality control at the field and at the laboratory; general aspects of production; c) seed distribution and storage.

Bean seed production, while still in its relative infancy, is based on a certification scheme carried out by the NSCM under the control of STU at Chitedze.

The following seed nomenclature is used: a) Breeders seed, as the name implies, is produced by a plant breeder or another research worker responsible for the crop. At present this is carried out bythe crop production department of the Bunda College of Agriculture; then it goes to the NSCM for further multiplication or storage; b) Basic seed is multiplied from the breeders seed by the NSCM, usually on its own seed estate, under the direct supervision of the STU. At least one year's reserve of all basic seed stock should be kept at all times. In theory, in order to maintain sufficient uniformity of cultivars and to prevent their deterioration, new breeders seed should be used whenever a basic seed bulk is required. However, in the case of beans, control by the STU, the NSCM and Bunda staff is considered sufficient and permits recirculation of basic seed, which has been done over the past two years; c) Certified seed is usually produced from basic seed, but again, in the early stages of multiplication a certain amount of recirculation is carried out. It is only this year that certified seed is offered to the commercial sector of the two new varieties: 97/1 (a red seeded climbing bean) and 253/1 (a brown seeded dwarf bean); d) Approved seed is either produced from certified seed or from known stocks of uncertified seed. Seed lots of this standard do not carry a government certificate but require to be tested for purity and germination prior to sale. In the initial stages fairly large tonnages of this grade are needed for sale until sufficient seed of certifiable standard can be multiplied.

Seed bean crops registered with the STU require fairly exhaustive field and laboratory inspections before final certification. The purpose of a field inspection is to confirm the details of the application, including the correct location of the field; to identify the variety being grown; to detect admixture with other varieties; to assess weed contamination; to check isolation requirements; to ensure that all the certification standards for the species being inspected are being met; to detect disease incidence; to advise on the operation of the certification schemes in general.

Inspectors visit registered seed crops at any reasonable time, with or without a request from the grower or the NSCM. The standards in operation in the field are as follows: parent seed: basic or certified; minimum inspections: two, one post harvest though considerably more inspections are usually carried out; isolation: 50 meters; previous cropping: no beans during the previous 24 months; field inspection: no more than 0.1% undesirable plants at vegetative maturity (varietal purity inspection).

Once the seed field has passed all inspections, and after harvest, the seed is sampled by government inspectors and taken to the official seed testing station at Chitedze for laboratory testing.

Here the bean seed is subjected to the following tests: a) Purity or percentage of pure seed in a seed lot. Obviously, the higher the pure seed percentage, the higher the seed quality. The minimum purity percentage is 99%. It must be stressed that this is physical purity in comparison to a varietal purity, which is also carried out in the laboratory, the standart being 99.9%, the same as for field inspection; b) Germination is the percentage of seeds in the pure seed fraction from the purity tests, which produce seedlings with all the structures necessary to ensure healthy plant development under test conditions. The seedlings in a germination test are divided into five categories: normal seed, abnormal seed, hard seed (legumes only), fresh seed, and dead seed. Standards for certified bean seed in Malawi require a minimum germination of 80%; c) In addition to the above tests required by the certification scheme, further tests are carried out for moisture content (10% maximum is allowed for beans); disease content (maximum allowance of visibly diseased seed is 0.5% by weight); further growing: it may well be carried out if indicated by the germination test; and post control plots to confirm varietal purity.

General agronomic practices demanded by NSCM for seed certification are:

Rotation: no beans or runner beans should have been grown during the previous two years on the site where the seed crop is to be planted to avoid build-up of pests or diseases.

The NSCM advises 300 kg compound mixture (3:2:1) plus 200 kg ammonium nitrate per hectare as a top dressing, depending on season.

To allow for mechanical cultivation and ease of inspection, seed crops at the NSCM farm are planted at 75 cm interrow and 7.5 cm intrarow, seeds being planted mechanically on the flat. With this planting pattern, a plant population of about 150,000 plants/ha is obtained.

Bean seed is normally treated with prentasan, the usual seed dressing used by the NSCM, at the rate of 100 g/ 100 kg seed; in addition, to prevent beanfly infestation, a further treatment of dieldrin is applied to the seed prior to planting.

To avoid excessive disease infestation normally associated with the heavy rain period, planting is done fairly late in the season, usually at the end of January or even in early February. This has given good results over the last few years and has helped keep chemical spray costs down to a minimum. With the crops maturing during the dry season it is possible to obtain the highest percentage of clean, uninfected seed. Ideally, the NSCM would prefer to have their basic seed crops grown in the dry season under irrigation, and it hopes to have access to such a facility in the not-too-distant future.

Self-pollination is the rule, but pollination by insects is not uncommon in bean crops in Malawi. To avoid it at the NSCM estate, a measure of isolation of 50 m between varieties is required for certified seed.

Weekly copper sprays are given in the initial stages to control halo blight, and bi-weekly sprays of daconil later to control anthracnose. Physical roguing of infected plants is also done. As mentioned previously, beanfly control is done by a dieldrin seed dressing, and usually a spray of dieldrin is also applied between one and two weeks after emergence. Bean aphid, if prevalent, can be controlled by dimethoate.

Rouging to remove 'off-types' from the crop is done at all stages, in particular at the vegetative growth stage prior to flowering, at the flowering and full pod stages.

Harvest commences when the seed crop has been defoliated and the pods are dry. At the NSCM harvest is done in the morning when pods and plants are supple; with the present acreage it is hoped to install a small threshing machine. The seed is then packed in clean, new sacks, labelled with variety and grower's registration number, then sent to the NSCM factory for final processing.

Seed processing is carried out by the NSCM in the new factory complex at Kanengo, where in the last few months a modern seed processing plant was installed.

Seed is packed into two different sizes: 50 kg for the estate sector and 10 kg for the smallholder farmer. All seed packs are labelled, both inside and outside, with details of type, variety, certificate number (where applicable) and date of test.

It is essential that seed produced in the certification schemes be distributed and made available where applicable to all areas of the country. All NSCM seed, once processed, is collected by ADMARC and distributed via their market network to the smallholder. The estate sector generally collects directly from the NSCM. For the first time this season, tested, treated seed was made available to the rural community on time, and it is hoped that increased commercial crop production will result.

Proper seed storage at the breeders, basic and certified seed stages is vital. Poor storage conditions or the storage of out-of-condition seed can cause a rapid decline in germination. The two most important factors causing it are high humidity and high temperatures, which should be avoided at all costs.

Also associated with poor storage conditions is an increase in fungal development, causing quality deterioration, especially to seed of high moisture content. It is NSCM policy in their own store, and it is recommended to ADMARC, to fumigate with phostoxin regularly to carry over stocks and to store seed in as dry and cool a place as possible.

Seed production depends upon maintenance of breeders and basic seed stocks; in this respect Malawi is fortunate in having several environmentally controlled seed stores. At the NSCM the carryover basic seed material is stored in a moisture-proof room at 50°F temperature and a relative humidity between 45 and 50%. Certified and approved seed storage in Malawi is done by ADMARC. The majority of bulks are issued the same year they are produced, and the problem arises only with carryover stocks. As a safety margin a 15-20% reserve in bean seed should be aimed at. NSCM has started, with the cooperation of senior ADMARC personnel, a series of lecture courses for depot managers, and it is hoped that this will improve storage practices.

Future Plans

In order to increase bean production in Malawi the following research activities are proposed for the Bean Research Project:

- Germplasm evaluation, cataloguing and maintenance of the existing germplasm, isolation of resistant donors, production of varieties through selection.

– Breeding for resistance to major diseases such as anthracnose and halo blight and high yield of commercially acceptable varieties.

– Screening cultivars for response to low densities and varying planting patterns, e.g., hill vs. row planting; mixed cropping (including the incidence of pests and diseases in mixtures); mixed cropping for bean cultivars that respond to mixed cropping with maize; maize and bean association at varying bean densities and different planting patterns; response of maize and bean association at different fertilizer levels; relay cropping in areas with prolonged rainfall such as Thyolo or locations with bimodal rainfall, such as Karonga; polyculture of maize beans and pumpkins; double or sequential cropping with emphasis on tobacco after the dry planted crop has been harvested.

– Plant nutrition through nitrogen fixation.

– Water rate studies; interaction between plant density, fertilizer and moisture; screening for response to excess moisture to obtain information on the planting of beans on residual moisture after rice; screening for drought resistance.

– Screening for response to high temperatures with the view to expanding bean production along the lakeshore and the Shire Valley.

– Production of disease-free seeds under irrigation through the disease filtration method; chemical pest control; seed storage; evaluation of herbicides for mixed cropping.

– Economics of bean production: input costs, field operations, labor and returns from bean production on rainfed and irrigated crops.

Summary

Beans are an important grain legume crop in Malawi because they are high in protein content. When eaten with maize, rice and cassava, as is the custom in the country, the mixture provides a balanced diet. Beans serve as a cheap source of protein for the people from the lakeshore areas where fish is the main protein source.

Beans were introduced into Malawi about 300 years ago by Spanish and Portuguese traders and merchants. The beans grown in Malawi are mixtures or blends of growth habit and other agronomic characteristics, with the climbing beans acounting for about 70%. The cropping system is mixed cropping with maize providing support for the associated crop.

The main producing areas are: Kasungu, Dowa, Lilongwe, Ntchisi, Dedza and Ntcheu in the Central region; Chitipa North, Rumphi East and West and Southwest Mzimba in the Northern region, and Mangochi, Machinga, Chiradzulu, Thyolo and Mulanje districts in the Southern region.

There is a great demand for beans in Malawi. However, production has lagged behind demand because of several constraints. These include the lack of suitable varieties, the lack of adequate production and distribution of improved seeds, production technology not available to the farmer at the village level where it is mostly needed, and diseases and pests that cause considerable yield reduction.

In order to increase production, a Bean Improvement Program was initiated in 1969 with the following objectives: to produce high yielding, disease-resistant bean cultivars acceptable to the consumer; to investigate bean production under irrigation as a winter rotation crop in irrigation schemes; and to develop package practices for economic bean production.

In order to achieve the above, germplasm materials were collected and evaluated, and production system trials as well as crop protection experiments were conducted throughout Malawi. Some varieties which are now on provisional release are being multiplied by the NSCM.

Future objectives and strategies include varietal development, production systems with emphasis on mixed cropping, growing of beans under irrigation on residual moisture, screening for stress, and the production of clean seeds under flood irrigation.

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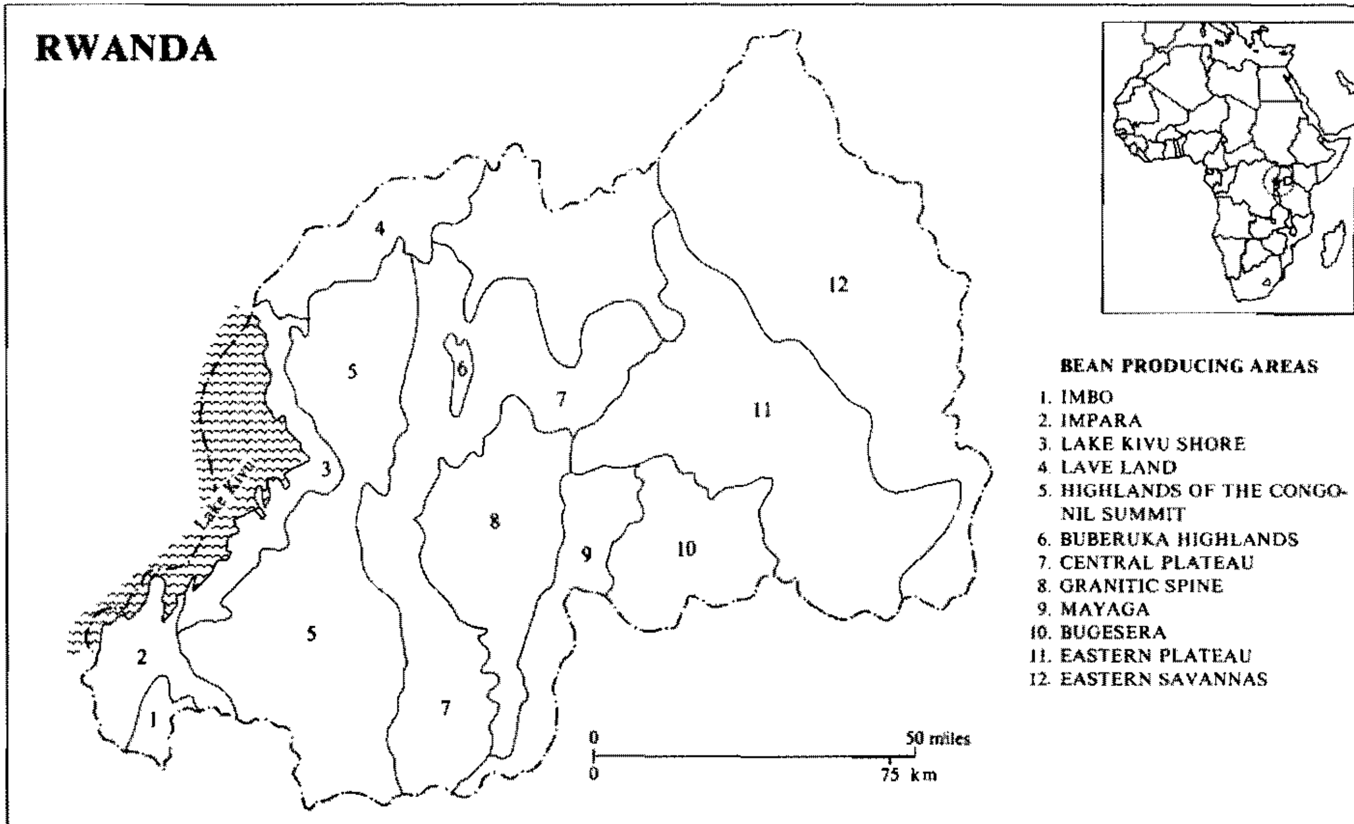
RWANDA
Lake Kivu
1
2
3
4
5
5
6
7
7
8
9
10
11
12
BEAN PRODUCING AREAS
1. IMBO
2. IMPARA
3. LAKE KIVU SHORE
4. LAVE LAND
5. HIGHLANDS OF THE CONGO-NIL SUMMIT
6. BUBERUKA HIGHLANDS
7. CENTRAL PLATEAU
8. GRANITIC SPINE
9. MAYAGA
10. BUGESERA
11. EASTERN PLATEAU
12. EASTERN SAVANNAS
0
50 miles
0
75 km

Bean Production in Rwanda

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C. Sekanabanga
L. Nyangurundi

Importance of Beans

Bean production in Rwanda is important in human nutrition because of its high protein content that partially replaces animal proteins. The latter is not always available in sufficient quantity to the low-income sector of the population.

In addition to their protein value, beans are considered to be one of the main staple foods in Rwanda. Approximately 160,000 ha are planted each year, which are in large part cultivated during the first growing season.

Despite the ample range of climates found at different altitudes, different bean varieties are adapted to regions of low and medium (1000-1800 masl) and high altitudes (1800-2300 masl). Among them are the non-selected local varieties (climbing and semi-climbing), usually a mixture of genotypes, and the selected, introduced varieties (bush, semi-climbing and climbing).

Variety selection is done by a Seed Selection Project (SSS), which is also in charge of multiplying and releasing germplasm selected by the Institut des Sciences Agronomiques du Rwanda (ISAR).

The Rwanda government established a semi-official service, known as the Office des Produits Vivrieres et Animaux (OPROVIA) which purchases production to prevent price fluctuations. Storage services are rendered by the Grenier National du Rwanda (GRENARWA projects), which are in charge of building silos and warehouses with capacities from 90-2000 tons for storage of cereals and legumes, mainly beans and sorghum.

Bean Types

In Rwanda there are three types of beans: bush, semi-climbing and climbing. They include local and introduced varieties, and selections from local varieties.

Local varieties. Genotypes are usually planted in mixtures because of differences in resistance to diseases, especially anthracnose, and to climatic conditions (excessive rainfall, drought, etc.), thus permiting a production equilibrium when one of these conditions is present. Semi-climbing varieties are the most widely cultivated since they do not need trellises and require less labor. Climbing varieties are cultivated mostly in high rainfall areas at intermediate to high altitudes.

Most beans are produced during the first growing season under traditional cultivation systems, normally associated with maize.

Introduced varieties. These come from foreign research stations and have been subjected to comparative adaptation trials. The most important ones are listed in Table 1.

Selections were made from local genotypic mixtures; the principal ones are also listed in Table 1.

Production Areas

Altitude. Different varieties are used in low, intermediate and high altitude regions.

Temperature and rainfall. Average temperatures vary from 16 to 24°C (average 18°C) according to altitude. Average annual rainfall is 1200 mm with a maximum of 2000 mm at the summit of Zaire-Nile and a minimum of 800 mm in the Southeastern plains (Akagera Park).

Being a tropical or subtropical crop, beans can be cultivated up to a maximum altitude of 2000 m where low average temperatures and especially the low minimum night temperature prolongs the vegetative cycle.

Average annual rainfall (800-1000 mm) for the low altitude regions (less than 1500 masl) is frequently badly distributed making bean production risky. Bush varieties with short vegetative cycles (e.g., Var. 1/2, 78 days, Table 1) are the best adapted to these conditions.

Table 1. Selected, local and introduced bean varieties of Rwanda.

Climbing varieties	Origin	Semi-climbing varieties	Origin	Bush varieties	Origin
Cajamarca	Perú	Inyumba	Rwanda	Bataaf	Holland
Wulma	Zaire	Nyirakabuye	Rwanda	Emma	Rwanda
C_8	Zaire	Jamapa incremento	Nicaragua	Mélange Jaune 1	Rwanda
C_{10}	Zaire	Masterpiece	Kenya	Saxa	Holland
Gisenyi 1	Rwanda	Kicaro	Rwanda	Var. 11	Uganda
Gisenyi 6	Rwanda	Everbearing	Kenya	Munyu	Rwanda
Urunyumba 1	Rwanda	Rwerere 7	Rwanda	Frejol Tostado	Ecuador
Urunyumba 3	Rwanda	Rutagayisambu	Rwanda	Actoran	Nicaragua
Urunyumba 12	Rwanda	Richmond wonder	Kenya	Sabre plano	Denmark
Rwerere 14	Rwanda	Var. 5	Uganda	Var. 1/2	Uganda
Sabre á rames	Belgium	Bayitungirubwiza	Rwanda	Mutiki	Rwanda
Var. 54	Rwanda	Kalikabageni	Rwanda	Caru 3	Rwanda
Bayo 158	Mexico	Bayo 7	Mexico	Nain beau port	Australia
Var. 18	Uganda	Angola	Angola	Namus	Denmark
Amarillo ouro	Angola			Baron	Rwanda

Table 2. Summary of agricultural regions.

S.N.	Region	Altitude (masl)	Rainfall (mm)	Soils	Main products	Agricultural value
1.	Imbo	970-1100-1400	1050-1200-1600	Alluvial soils	**Plantain, cassava,** beans, peanuts, sweet potatoes, **cotton, rice,** sugar cane, citrus fruits	Excellent
2.	Impara	1400-1700-1900	1300-1400-2000	Heavy red soils derived from basalts	Plantains, beans, maize, sorghum, sweet potatoes, cassava, peanuts, **coffee, tea,** Peruvian bark	Good
3.	Shore of Lake Kivu	1460-1600-1900	1150-1200-1300	Clay loam surface soils	Plantain, beans maize, sorghum, sweet potatoes, cassava, peanuts, **coffee**	Bugoyi and Kanage, excellent; the others, good
4	Lave lands	1600-2200-2500	1300-1500-1600	Volcanic soils	Plantain, beans maize, sweet potatoes, sorghum, peas, potatoes, **wallwort, tobacco**	Excellent
5.	Summit	1900-2100-2500	1300-1600-2000	Humic, acid soils	**Peas,** maize, potatoes, *Eleusine* sp., buckwheat, **summer wheat, tea, sunflower, lumber**	Fair
6.	Buberuka	1900-2000-2300	1100-1200-1300	Lateritic soils	Plantain, beans, sorghum, sweet potatoes, maize, potatoes, **peas, summer wheat,** barley	Good
7.	Central plateau	1500-1700-1900	1100-1200-1300	Different humic soils	**Beans,** sorghum, maize, **sweet potatoes,** plantain, taro, yams, coffee, soybeans	Good
8.	Granitique spine	1400-1600-1700	1050-1100-1200	Light gravelly soils	Plantain **beans,** sorghum, maize **sweet potatoes,** yams, taro, peanuts, cassava, coffee, livestock	Fair
9.	Mayaga	1350-1450-1500	1000-1050-1200	Clay soils derived from slates	**Coffee, beans, sorghum,** maize, plantain sweet potatoes, cassava, peanuts soybeans (rice)	Very good
10.	Bugesera	1300-1400-1500	850- 900-1000	Clay, highly altered soils	Beans, sorghum, maize, plantain, sweet potatoes, **cassava,** peanuts, livestock	Poor
11	Eastern plateau	1400-1500-1800	900- 950-1000	Lateritic soils	Beans, sorghum, maize, **plantain,** sweet potatoes cassava, **peanuts,** coffee	Fair in the North, good in the South
12.	Eastern savanna	1250-1400-1600	800- 850- 900	Old soils of variable texture	Cassava, peanuts, beans, sorghum, maize, sweet potatoes, livestock	Very poor

The intermediate altitude region (1500-1900 masl) is located on both sides of the Zaire-Nile summit. Rainfall varies from 1000-1250 mm and daily average temperature from 19 to 20° C. This is the most important and most productive region of the country, and bean production there is very good.

Agricultural regions. There are 12 agricultural regions where beans are cultivated in Rwanda. Given the different soil conditions, production and yields are also variable. Table 2 summarizes agricultural conditions of the 12 agricultural regions of the country (see map p. 98).

Bean Production Systems

Soil preparation is limited to a first tillage with a hoe or a hoefork and a second tillage before seeding. Sowing is done manually mostly by broadcasting.

In addition, the farmer performs a second cultivation and up to two weedings, if needed. Cattle and sheep manure is only used as fertilizer near the farming facilities since transportation is scarce and the amount of manure limited because cattle confinement is not practiced on a permanent basis. In certain areas, climbing beans are supported with trellises or *Pennisetum* sp. particularly in high rainfall areas at intermediate to high altitudes.

Progressive farmers, cooperative groups, and those in charge of field demonstrations plant seed manually in rows spaced 30 x 20 cm, 40 x 20, 40 x 10 or 60 x 15 cm for climbing beans at a rate of two seeds per hole. At the present time ISAR is recommending sowing beans in continuous rows.

Small farmers do not use chemical fertilizers, herbicides and phytosanitary products due to their high cost, which makes their application nonprofitable at current bean prices.

Crop rotation. It is done in the following sequence: tuber, crops and cereals. In high altitude regions where potatoes are the main crop, farmers grow peas or climbing or bush beans in association with maize after potatoes. Maize or wheat are the cereals cultivated after the legume. The above rotation is not always kept. In low and intermediate altitude regions where sweet potatoes and cassava are grown, beans are sown after sweet potatoes, but when sown after cassava the field is left to fallow as this crop is believed to exhaust the soil. Cassava is harvested after 24 months and sweet potatoes progressively from the fifth month on. When following a tuber crop, beans are cultivated in association with maize.

It is common to improve the land by planting *Stizolobium* sp. (mucun or velvet bean) in low and intermediate altitude regions and *Vicia* sp. (vesoe) at high altitudes. However, this type of soil improvement is limited to less populated regions. Agricultural projects and research centers assess the agricultural value of the land before resorting to land improvement schemes.

Crop associations. As stated before, a mixture of varieties is planted by the small farmers of Rwanda to maintain a balanced and increased food production. ISAR is attempting to improve associated cropping systems.

Some common crop associations with two, three or more crops are:

Low and intermediate altitudes:

- Bush or climbing beans with maize or sweet potatoes
- Beans and soybeans, peas or sorghum
- Soybeans with maize or sweet potatoes
- Beans with tubers: cassava, taro and potatoes

High altitude:

- Maize, sorghum and bush, semi-climbing or climbing beans
- Potatoes, maize, sorghum or sweet potatoes
- Potatoes, beans (or peas) and maize
- Climbing beans and sunflowers

The last association is interesting because the sunflower grows more rapidly than maize, whose development is retarded by beans.

Irrigation. It normally exceeds the economic threshold for food crops including beans. However, irrigation trials with beans were carried out by ISAR on lake colluvia and dry valley colluvia during 1971-1974 on 4633 ha in the Bugesera region.

Average precipitation in this region ranges from 800 to 1000 mm; and there is a three to four months dry season. Rainfall is distributed irregularly during the rainy seasons; dry periods of 5-20 days or longer are frequent. Consequently, irrigation trials were done to permit planting.

Sprinkling irrigation is the most suitable system for the region. The light-textured, pendent, rapidly percolating soils are not suited for other irrigation methods.

ISAR estimates that 160 mm irrigation level would increase production by 1700 kg/ha for the best climbing varieties and by 700 kg/ha for bush beans, indicating that high yields can be obtained with and without irrigation in these high quality colluvial soils (Table 3).

Table 3. Average yield of three bean varieties with and without irrigation in the Bugesera region, Rwanda, 1971-74.

Treatment	Yield (kg/ha)		
	Wulma	Amarillo 156	Var.1/2
With irrigation	1259	3312	2296
Without irrigation	1042	1563	1399

As to the critical period for irrigation of beans, a moderate lack of water before flowering will not affect yields. During flowering and pod setting, a long period without water reduces yields. A five-day water stress period diminishes plant development but does not affect yields. A stress longer than five days during maturation diminishes seed weight.

During flowering, the plant uses 55-65% of the available water; this amount rises to 70-80% when maturity approaches. On the other hand, an excessive amount of water during flowering is harmful.

According to ISAR, irrigation costs in 1976 were 130 Fr*/mm water/ha. At present, it would cost 160 Fr/mm water/ha. Beans were sold at 20 Fr/kg in 1976 and 25 Fr/kg in 1979.

Production, Marketing, Storage and Utilization

Production regions and yields. All regions in Rwanda produce beans. Some regions are less productive than others, but they are counterbalanced by the more productive ones. The highly productive are Imbo, Impara, the shores of Lake Kivu, the Central plateau, and part of the Eastern plateau.

* 1US$ = 91 Rwanda francs (1978)

Production increases are directly related to increments in the area harvested (Table 4) whereas productivity is almost stagnant. Acreage increases result from the incorporation of previously untilled land.

Table 4. Bean production, yield and cultivated area in Rwanda from 1974 - 1978.

Year	Area (ha)	Yield (kg/ha)	Production (t)	Growth rate (%)
1974	186,723	610	114,816	
1975	190,600	800	152,744	33.0
1976	202,880	800	163,401	7.0
1977	213,276	800	171,590	5.0
1978	214,939	790	170,231	0.7
Total and averages	1,008,418	760	772,782	11.0

Table 5 shows the actual low yields as compared to the average of 1470 kg/ha obtained by ISAR. Low yields could be increased considerably by improving cultural practices and planting climbing varieties. Progressive replacement of bush beans by climbing beans would constitute an appreciable improvement and could increase production by 30-50%.

Table 5. Population, bean production, yield and cultivated area per county in Rwanda in 1978.

County	Area (ha)	Yield (kg/ha)	Production (t)	Population*
Kigali	26,986	800	21,589	698,063
Gitarama	21,949	700	15,364	602,752
Butare	25,416	720	18,300	601,165
Gikongoro	18,501	720	13,321	369,891
Cyangugu	19,700	880	17,478	331,300
Kibuye	15,111	800	12,089	337,729
Gisenyi	20,763	820	17,026	468,786
Ruhengeri	23,296	800	18,642	528,649
Byumba	22,675	800	18,140	519,968
Kibungo	20,542	890	18,282	360,934
Total and averages	214,939	721	170,231	4,819,237

* General population and housing census for 1978.

Production increments as a result of the utilization of improved varieties are estimated to amount to an average of 25-50%. Apart from the cultivation of improved varieties, application of improved, adequate cultural practices, such as tillage, optimum planting densities and distances between plants, should increase yields.

Demand tendencies and projections. With a production of 170,231,000 kg in 1978, per capita bean consumption was estimated at 35.5 kg/yr, or approximately 100 g/day. Protein consumption in Rwanda is still insufficient although other legumes such as peas, soybeans and peanuts partially substitute this deficiency.

Bean prices collapse after harvest. Seasonal deficiencies in protein supply occur from two to three months after harvest when the bean supply is below demand, and the average daily consumption per capita becomes very low.

Bean production for direct or subsistence consumption. Farm families receive an income from bean growing totalling Fr $935,323,000. This figure divided by the 974,117 families gives an income of Fr$960/family/year. The annual family income for all legume crops is Fr$13,518 and the average gross earnings Fr$37,974. These figures were estimated taking into account total legume production and an average price of Fr$23,600/t. Taking prices at harvest, the gross income becomes Fr$31,698 (for a legume average price of Fr$18,500/t).

Average bean area harvested in 1978 was 214,939 ha corresponding to 0.22 ha or 2200 m^2 per family per year.

Marketing channels and organization. Since bean production in Rwanda is far from meeting domestic demand, only domestic trade will be discussed in this section (Tables 6 and 7).

Middlemen buy bean surpluses in the most productive regions and transport them to the less productive ones. There they sell them to the semi-official service OPROVIA, which is in charge of marketing beans. Finally, OPROVIA distributes the commodity among its branch offices.

Alternatively, middlemen can sell the beans to a storage project called GRENARWA, financed by USAID. When beans are scarce on the local market, middlemen repurchase them from these two services and sell them to the people at a price fixed by the Department of Commerce.

Table 6. Percentage of bean production marketed in Rwanda and average prices per county, 1978.

County	Production marketed (%)	Average price (Fr)
Kigali	30	20 - 30
Gitarama	30	20 - 30
Butare	30	19 - 31
Gikongoro	40	21 - 30
Cyangugu	35	15 - 24
Kibuye	20	21 - 33
Gisenyi	22	19 - 29
Ruhengeri	20	18 - 26
Byumba	30	15 - 26.5
Kibungo	40	16 - 27
Rwanda average	29.7	Low price = 18.4 Medium price = 23.5 High price = 28.6

Table 7. Bean production consumed and marketed in Rwanda and bean prices in 1978.

Production					Average price (Fr/t)
Consumed		Marketed		Total price	
(t)	(%)	(t)	(%)	(000 Fr)	
119,673	71.3	50,558	29.7	935,323	18,500

A third way of marketing beans is used by some middlemen who store bean surpluses to sell directly to consumers. They charge a relatively high price in comparison to the one set by OPROVIA. To counteract this, a project to finance the construction of silos at the municipal level was created. There farmers will be able to buy beans against the purchase price at harvest time plus storage expenses. This price is much lower than that charged by middlemen.

Storage systems. There are two storage projects in Rwanda: GRENARWA and the SILO project financed by the Catholic Relief Services. Both are building warehouses for storing grains (Table 8).

GRENARWA, initially known as the Storage and Trading Project for Food Commodities (Projet d'Entreposage et de Commercialisation des

Denrées Alimentaires, PECDA) is a project sponsored jointly by the U.S. and Rwanda governments. The Swiss government and the World Food Program also contributed.

Table 8. Existent warehouses in Rwanda and their capacity.

Warehouse	Optimum capacity (t)	Maximum capacity (t)
Kicukiro (Kigali)	250	325
Kibungo	250	325
Byumba	250	325
Kora (Gisenyi)	500	700
Nyanza (Butare)	3500	4000
Cyangugu	250	325
Kibuye	150	200
Ruhengeri	2000	2500
Total	7150	8700

GRENARWA will be progressively integrated with OPROVIA, and the joint services GRENARWA/OPROVIA will play the role of a national storage and trading agency for staple foods, especially beans and sorghum.

GRENARWA's goals are to encourage production by stabilizing the prices of staple foods. To achieve this goal, it buys the coming harvest during the production season at a guaranteed price in order to protect the farmer from a price fall (sometimes as high as 50%). In the same way, GRENARWA sells the stored products at reasonable prices during scarcity periods to prevent prices from rising too steeply (Table 9). A second objective is to diminish the storage losses common with traditional systems, and to balance availability of foodstuffs by transferring surpluses where they are lacking.

Table 9. Beans purchased and sold (t) from 1976 and bean market projection up to 1981.

Market operation	1976	1977	1978	1979	1980	1981
Purchase	1163	2876	719	2500	4000	7500
Sale	28	1486	1959	3000	4000	7500

Another objective is the development of nonspeculative marketing systems whereby middlemen are prevented from intervening in the process.

GRENARWA started to work at the municipal level, making beans available to farmers at a price much lower than that charged by traders. In 1978 this project was carried out in municipalities of Gitarama, Butare and Gikongoro counties.

In the near future GRENARWA will try to increase its storage capacity to 10,000 t in order to assure a stock rotation of at least 6000 t/yr.

The Catholic Relief Services (CRS) SILO project, which started in 1975, is supported by USAID, CRS/Australia, CRS/New York and UNICEF. Its objectives, similar to GENARWA's, are to build silos to preserve seeds and foodstuffs. Each silo is operated by a manager and several workers. The farmer has his product weighed; impurities and moisture content are controlled. He receives the equivalent in cash (estimated at a fixed price) and a depositary bond. According to the degree of infestation, the crops are treated before entering the silo.

The farmer who needs his product may withdraw it at any time, simply by presenting his depositary bond, or do it gradually according to his needs and resources (Table 10). In order to withdraw foodstuffs he has to pay the amount he received when he deposited them plus Fr3/kg.

The staples stored are beans, sorghum and soybeans; in the near future, the service will be extended to peas, peanuts and wheat.

Once in a silo cell (capacity 14.8 t) foodstuffs can remain there for several months. In Rwanda there are 16 silos at the municipal agricultural cooperative levels, with total capacity of 1417 t. Once all the municipalities have silos at their disposal, the storing capacity will be 12,664 t.

Table 10. Amounts (t) of food grains stored by SILO from 1976 to 1978.

Year	Stored	Withdrawn
1976	180,177	89,101
1977	192,425	216,125
1978	380,541	387,492
Total	753,143	692,718

In GRENARWA and SILO projects beans are protected from storage insects with malathion. Phosphotoxin tablets are placed among the bean sacks when an insect attack is detected. Beans are received and stored at a moisture level of 12-14%.

Use of different parts of the plant. Beans are consumed in Rwanda in five forms: tender green pods; tender seeds (pods are harvested two weeks before they dry); dry seeds; beans without integument; and bean leaves as vegetable. The third form is the most common. As for acceptability, almost everyone in Rwanda loves and consumes beans.

In all five forms beans are simply cooked and seasoned with butter or with palm, peanut, cotton or soybean oils. Beans are prepared alone or with cereals, tubers, plantains, etc.

The quantities consumed vary from one region to another, depending on the tonnage harvested and the time of the year. The quantity consumed per family is 2.5 kg of dry beans/day after harvesting and 1 kg or even less during scarcity periods and in less productive regions. However, this seasonal deficit is partially offset by other legumes such as peas, soybeans and peanuts.

Factors Limiting Production

Biological, socio-economic and institutional factors limit bean production.

Biological factors

Selected varieties are used only by a limited percentage of the population. Farmers mostly grow local mixtures.

Climbing varieties are more productive, but lack of physical support (trellises) in certain regions prevents area increase.

Diseases and pests. Bean anthracnose, caused by *Colletotrichum lindemuthianum*, which can reduce yields seriously; root rot, *Rhizoctonia solani*, causing damping off; bean rust (*Uromyces phaseoli*); Southern blight, *Sclerotium rolfsii;* angular leaf spot(*Isariopsis griseola*), a common fungus, although its damage is limited; and *Ascochyta* sp.

The following are the most important insects:

Bean fly, which attacks seedlings causing yellowing and withering of the first two leaves; frequently the seedling dies. *Aphids* are frequent during sunny periods, and cause severe losses. Weevils cause losses in untreated stored beans.

Nodulation. The inoculation of beans with *Rhizobium* specific strains such as 9.6, 9.35.1 (Gembloux, Belgium), A47 (Holland), and Mexico CC511 (Australia) did not give significant results.

The degeneration of strains, the difficulty of strain maintenance in agar-agar and the execution of trials in soils that had been planted to beans for a prolonged period explain the inconsistent results obtained with bean inoculations in Rwanda.

On the other hand, soybeans and peas reacted very favorably to inoculation with regard to yield and protein content.

Socio-economic and institutional factors

Bean growing is usually not very profitable for the farmers. Cultivation expenses, especially labor, are higher than the returns received. Often, small farmers fail to estimate the cost represented by the family's work and the outside labor, and end up loosing money without realizing it.

Based on figures taken from the SSS, to grow 1 ha of beans from planting to harvesting costs Fr60,000. For an 800 kg/ha production sold at Fr25/kg, gross earnings amount to Fr20,000; therefore, this means a loss of Fr40,000. It is evident that the small farmer does not calculate all the cultural practices and labor costs involved.

The deficient marketing, transportation and storage services, which explain in part why small farmers sell their crops at a low price right after harvesting, can play an important role in the expansion of bean growing. Thus far, GRENARWA, SILO project and OPROVIA cannot guarantee the marketing and storage of beans in all the municipalities of the country; nevertheless, those are their objectives.

An important problem in consumer acceptability is the development of hard seedcoats during several months' storage, which prolongs cooking time. To prevent this GRENARWA decided to rotate their stock during the year.

The national policy is to intensify bean growing by promoting the use of selected seed and climbing varieties, together with the application of rational cultural practices. Extension services for beans have established demonstration plots at all levels in accordance with the country's administrative organization. Although there is room for improvements, results can be observed in certain areas where progressive farmers adopted better production practices.

Rwanda's Bean Program

The five-year development plan (1976-81) contemplates an increase of 47.5% in bean production, i.e. from 135,600 t in 1976 to 200,000 t in 1981. Parallel to this production increment, the national development plan foresees a total increase of 6% in cultivated area, i.e., from 164,300 ha in 1976 to 174,000 ha in 1981, the annual increase being 1.2%. During this same period, annual yield per hectare should go from 800 to 1150 kg/ha, as shown below:

Year	Estimated yield (kg/ha)
1976	800
1977	800
1978	790
1979	950
1980	1050
1981	1150

In order to achieve these goals the cultivated area is to be expanded by teaching crop rotation and better cultural practices to farmers through extension work; by using trellises on 25% of the area planted to climbing beans; by extending the use of climbing beans and new selected varieties to high altitude regions; by promoting the use of bush varieties in dry, low and intermediate altitude regions; by using adequate storage methods; by putting into practice research results from ISAR and by training personnel.

It is known that the Rwanda population is growing very rapidly, whereas arable land remains unchanged. Intensification of agriculture is the only alternative. The additional number of young couples needing some land to cultivate is 40,000 per year. At present, the only way in which these couples can obtain a piece of land is from their parents or relatives, thereby reducing the total cultivated area per family which ranges from 7700 m^2 in the high altitude region of Gisenyi to 212,000 m^2 in the low altitude region of Kibungo (national average = 94,000 m^2). Therefore, it is necessary to improve yields by promoting adequate cultural practices such as crop rotation, planting dates, and the application of fertilizers.

At the present time only traditional cultural practices are applied in Rwanda. Phytosanitary products, organic or chemical fertilizers are rarely used. Land is never left to fallow in certain regions of the country due to pressure for land. These problems, according to the national development plan, will be solved with teaching of appropriate cultural practices through extension work.

To obtain good bean yields, the variety used plays an important role. Climbing varieties almost double the yield of bush varieties (as an average, 1500 vs 800 kg/ha). However, their selection depends among other factors on the altitude; climbing varieties (e.g., Cajamarca) are normally adapted to high and intermediate altitude regions and bush varieties to low and intermediate altitudes. The main problem in high altitude regions is to find trellises.

Research on beans is conducted by ISAR, which succeeded INEAC in 1962. ISAR's objectives and selection stages are briefly described below. Local and introduced varieties are subjected to comparative regional varietal trials prior to release to farmers. The main purpose of this selection process is to find well adapted high yielding dry bean varieties with good protein content, resistant to diseases and acceptable to consumers. From results obtained so far, the collection and testing of these accessions and others from bordering countries should be continued or intensified. The on-going varietal selection trials, with emphasis on resistance to anthracnose, seed palatability and color will continue.

The following cultural practices will be emphasized: physical support for climbing beans by means of trellises or other crops, associated crops, relay crops, use of organic and chemical fertilizers and inoculation.

An agricultural extension service has been created within the Ministry of Agriculture to work in four fronts: crop, industrial and horticultural production, and small farmers. Extension work on beans falls under the crop production division.

The national development plan contemplates training of technical personnel at all levels. By the end of the 1976-80 period, there will be 1490 agricultural instructors, that is, one instructor for every 500 farmers; 298 extension workers, that is, one for every five instructors; two agronomists category A2 per municipality, one A1 agronomist and one A0 agronomist per county. The county A0 agronomist and his assistant work in close cooperation with the county veterinarian, forming a team responsible for the agricultural development of the county. As such they participate in all programs having to do with agriculture, animal science, forestry, pisciculture and other rural activities.

Seed Production and Distribution

The Belgium-financed Selected Seed Service (SSS) functions within the Ministry of Agriculture and is responsible to the Agriculture Extension Office. It was initiated in 1964 to multiply seeds selected by ISAR and to distribute them among the farmers. The SSS has five multiplication centers (100 ha in total), where small quantities of seed from new varieties provided by ISAR are multiplied until there is a sufficient amount to be distributed among the municipal agricultural demonstration fields (CCDA). One ton of seed per variety is the amount usually produced depending on availability of land.

Seeds are disinfected with malathion and Ceresan (ethylmercury chloride) and stored until they are sent to the counties or purchased directly by the municipalities. At present, the SSS is building warehouses in every county, with an individual capacity of up to 100 t.

The municipal demonstration fields serve for the dissemination of cultural practices and selected seeds, and are used for secondary multiplication of seeds that will be planted in demonstration fields at the sector level. Farmers buy seeds from these fields according to their needs.

Bean seed produced and distributed during the last five years amounted to 15% of the total seed crop produced of 655.382 kg (Table 11).

Table 11. Amounts of bean seed produced and released over the last five years in demonstration fields.

Year	Area (ha)	Bean seed (kg)
1974	18.37	8,375
1975	25.16	16,809
1976	21.59	21,169
1977	20.81	21,195
1978	23.95	31,021
Total	109.88	98,569

In Rwanda there is no seed control laboratory to assess seed quality of domestically produced and marketed, or imported seed. Therefore, no certification can be made. No seed legislation has been drawn up yet.

As far as seed distribution is concerned, the SSS cooperates closely with the agronomists working in the counties and municipalities. It is at present the only institution in Rwanda that produces the seed to be multiplied for the agricultural projects and demonstration fields. The indirect distribution of seeds operates at the farmers' level. There is no private or official seed society in Rwanda in charge of collecting and handling farmers' seed.

Achievements

Dissemination of selected varieties. As mentioned above, the selection of bean cultivars depends on the altitude and rainfall pattern. Several varieties are now adopted by farmers, for example, Var. 1/2 is grown in low rainfall regions, particularly in the Kibungo and Bugesera counties; climbing varieties Bayo 158 and Wulma in the low and intermediate altitude regions of the county of Kigali; bush variety Bataaf in low and high altitude regions; and climbing varieties Gisenyi 1 and 2, Cajamarca and Inyumba in certain areas of Gisenyi, Ruhengeri and Byumba counties.

Research. In variety evaluation trials conducted at Rubona, Karana and Rwerere, the best local varieties were surpassed by new introduced ones; thus, in 1979, 14 varieties (Frejol Tostado, Mutitei, Actoran, Var. 11, Emma and Var. 6443, among others) in Rubona, and five varieties (Sabre, Plano Baron, Norda, Richmond Wonder and Jamapa Incremento) in Karama, surpassed the yield of bush variety Bataaf. Var. 1/2 was also surpassed by Munyu 1 and Nkanga in Karama. Of 119 climbing varieties (e.g., Urunyumba 1,3, 4 and 6; Gisenyi 1, 2 and 3; C8, C10, C13, C15, C16, Phénoméne, Nyirakabuye jaune tachetée, Amarillo Auro, Magabali, etc.) tested in Rubona, 38 proved to be better than the control Wulma. Thirty-one climbing varieties (C8, Rwerere 14, Gisenyi 2, Urunyumba 4 and 6, etc.) appeared promising at Rwerere, while 54 out of 124 climbing varieties gave higher yields than the control at Karana. Of the 70 semiclimbing varieties evaluated at these same stations, 31 were promising.

In the comparative varietal trials carried out at Rubona and Rwerere in 1979 with 8 and 15 varieties, respectively, Gisenyi 2-bis was better than the control Wulma at Rubona; Urunyumba 472312 and Rwerere 14 surpassed the control Cajamarca at Rwerere. Bush varieties Emma, Munyu and Caru 3 and climbing varieties Gisenyi 1 and Gisenyi 2 were the best in the comparative trials conducted in Rubona in 1978. Bush variety Raido Grado was as good as the control Var. 1/2 in Karama.

Results of planting density trials with climbing and bush varieties have shown that only the highest and lowest densities gave statistically different significant yields.

The absence of trellises or maize as support reduced yields of climbing beans, whereas the utilization of one wooden stick per yield site produced highly beneficial results. Similarly, spraying with fungicides, such as Ceresan or Dithane, increased climbing bean yields significantly.

The following varieties are being multiplied for future release: bush varieties Bataaf, Emma, Var. 1/2, Mélange Jaune 1; semiclimbing Kicaro and Inyumba; and climbing Wulma, C10, Urunyumba, Bayo 158 and Cajamarca.

Future Plans

The main goals of the bean research program for the 1980-84 period are:

Breeding and cultural practices:

- To continue and intensify the introduction and evaluation of germplasm from rural regions and bordering countries
- to conduct evaluation trials with climbing, semiclimbing, bush and green bean varieties
- to carry out evaluation trials with varieties obtained from genetic selection
- to conduct comparative varietal trials with climbing, semiclimbing and bush beans
- to carry out multilocation comparative trials with the best varieties from the different ISAR research stations
- to compare the best climbing and bush bean varieties in monocropping and mixed systems
- to study different support systems (e.g., wooden trellises, *Pennisetum* sp., maize, maize stalks, etc.)
- to study the profitability of trellises in different regions
- to do research on planting practices that farmers can easily adopt
- to select varieties resistant to anthracnose
- to investigate preventive disease control measures
- to select varieties with high protein content
- to conduct trials on the application of chemical and organic fertilizers.

Seed selection and storage:

- To strengthen demonstration fields for the multiplication of the best bean varieties, as well as extension work at the municipal and sector levels

- to distribute small-scale equipment among the municipal demonstration fields to facilitate agronomic practices such as plowing, hilling and spraying
- to give "incentive bonuses" to the best municipal demonstration fields
- to multiply the best new varieties produced by ISAR (e.g., C10, Urunyumba 3, Gisenyi 1, Emma, Mélange Jaune 1).
- to build county warehouses and encourage their building in the municipalities
- to encourage the use of metal containers for seeds and to demonstrate their effectiveness in preserving seeds alone or with phytosanitary products with low toxicity level (e.g., malathion)
- to enlarge the storage capacity of the GRENARWA warehouses
- to build silos in all the municipalities (a long-term program).

Summary

Beans are a highly important food staple in Rwanda. Daily per family consumption varies from 1.0 to 2.5 kg, depending on the season and the region. Beans are consumed as tender, fresh pods; tender, fresh seeds; dry seeds; seeds without integument; and leaves. They can be cooked alone or with other foods (cereals, tubers, plantain, etc).

Beans are grown using traditional cultural practices, but the demonstration fields at the municipality and sector levels are doing positive extension work, teaching improved agricultural practices to the farmers. This is confirmed by progressive farmers who adopted planting in rows, used trellises and selected seeds.

Bush, climbing and semiclimbing varieties are the types cultivated in Rwanda. All three types can be found in the local varieties - which are cultivated in mixtures - in the varieties selected by ISAR, and in introduced varieties. Planting distances are 40 x 10 cm, 40 x 20 cm, 30 x 10 cm or 60 x 15 cm, according to the bean type, i.e. bush or climbing. Except for progressive farmers, cooperative and student groups, seed is sown manually or broadcast.

Beans are cultivated up to 2000 masl in all agricultural regions of Rwanda, the most productive being Imbo, Impara, the shores of Lake Kivu, the Central plateau, Mayaga and part of the Eastern plateau. Climbing varieties are grown in intermediate and high altitude regions.

Total bean production for the last year, according to the 1978 Annual Report from the Ministry of Agriculture, was 170,231 t on 214,939 ha; 71% of the total production is consumed directly and 29% is marketed.

Marketing is done by middlemen who raise prices considerably between harvest and periods of scarcity. Prices range from Fr15 to Fr31 between those periods, with the producer receiving the lowest price. To correct this situation the Rwanda government created OPROVIA, a marketing agency; also, the GRENARWA project in charge of building warehouses with a total projected capacity of 10,000 t (7150 t at present), and the SILO project responsible for the building of 88-ton silos. Both projects market beans and other stored cereals at reasonable prices. At the silos, farmers can withdraw beans for their own purpose at the original price plus storage expenses.

The following are the main factors limiting production:

- The use of bush varieties which yield half and even one third less than climbing varieties; lack of trellises has hindered the widespread use of climbing varieties.
- Fallowing or chemical fertilizers are seldom used to improve soils, and so are other phytochemical products, especially insecticides and fungicides to treat seeds.
- High costs which make bean cultivation unprofitable.
- Inadequate marketing at harvest which forces the farmers to sell at too low a price.
- Lack of extension personnel.

With regard to seed production and distribution, five centers (100 ha in total) multiply the seed selected by ISAR. As an average, 20 ha are used for multiplying bean seed. The SSS distributes small quantities of seed produced among the demonstration fields which are in charge of secondary multiplication and of making seed available to the farmers. There is no national laboratory to control and certify seeds, and seed legislation is non-existent.

Some promising climbing varieties, yielding from 2000 - 4000 kg/ha without chemical fertilization, are already being released. The main ones are Cajamarca, Bayo 158, Urunyumba 3, Gisenyi 1 and 2, Var. 54, C10 and Wulma. The best bush varieties are Bataaf, Var. 1/2 (with a 78 day growth cycle and adapted to low rainfall regions), Emma and Mélange Jaune 1.

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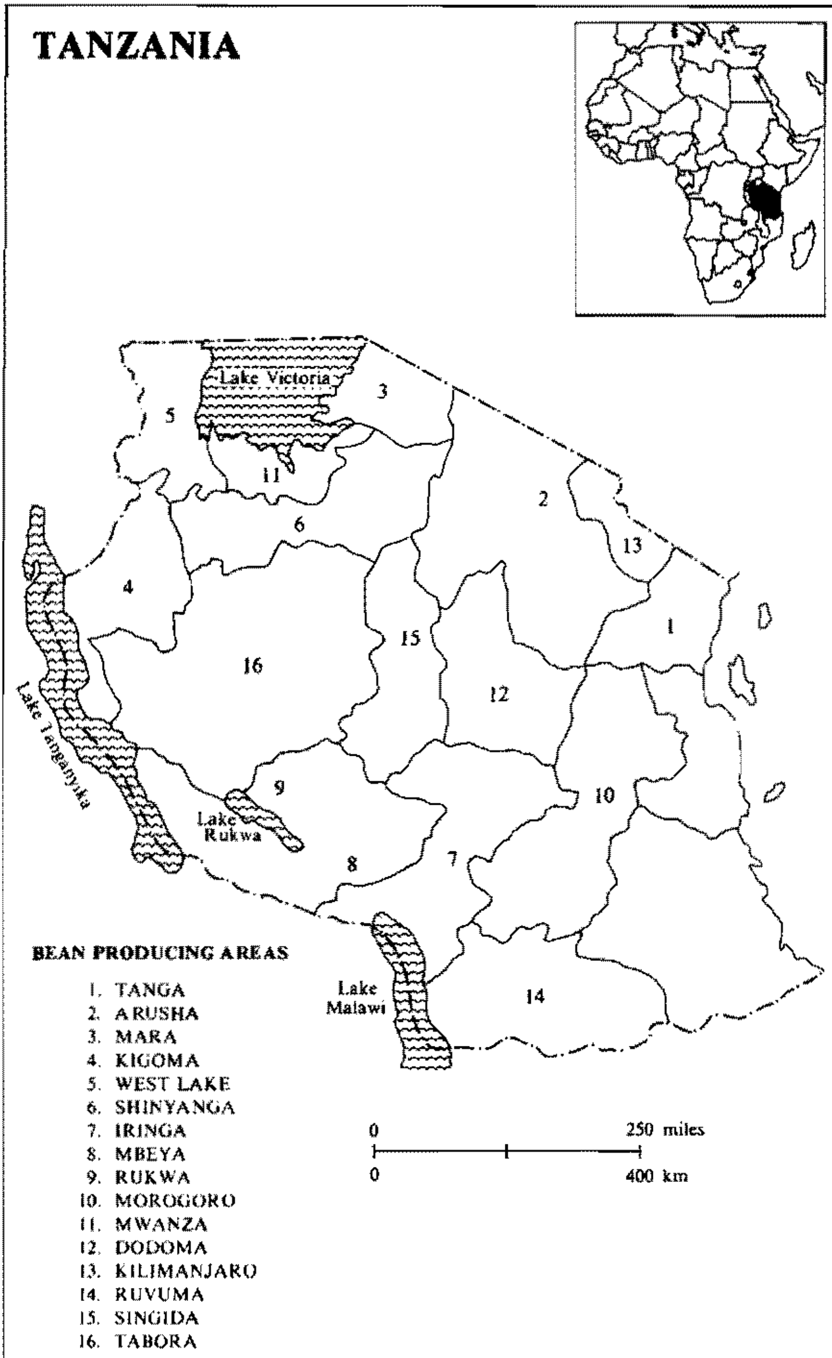
TANZANIA
Lake Victoria
5
3
11
2
6
13
4
1
15
16
12
Lake Tanganyika
9
10
Lake Rukwa
8
7
Lake Malawi
14
BEAN PRODUCING AREAS
1. TANGA
2. ARUSHA
3. MARA
4. KIGOMA
5. WEST LAKE
6. SHINYANGA
7. IRINGA
8. MBEYA
9. RUKWA
10. MOROGORO
11. MWANZA
12. DODOMA
13. KILIMANJARO
14. RUVUMA
15. SINGIDA
16. TABORA
0
250 miles
0
400 km

Bean Production in Tanzania

A.K. Karel
B.J. Ndunguru
M. Price
S.H. Semuguruka
B.B. Singh

Importance of Beans

The common bean, *Phaseolus vulgaris* L., is the most important grain legume crop grown in Tanzania. Like maize, beans constitute one of the staple foods in many parts of the country. Its protein content supplements that of cereals, tuber and plantain.

The common beans are grown in Tanga, Arusha, Mara, Kigoma, West Lake, Shinyanga, Iringa, Mbeya, Mbinga, Rukwa and Morogoro districts of Tanzania (see map). According to the Food Crop Products Statistics Report of the Tanzanian Ministry of Agriculture, 92,650 tons of beans were produced in 1964; this production increased to 287,000 tons in 1977, that is a yearly increase of 40%.

Beans are chiefly grown for local consumption, and a small portion of the produce is marketed. Surplus produce is exported raw or canned to earn foreign exchange. Some progressive farmers produce seeds for export to the European canning industry.

Beans and other legumes are grown with cereals in Tanzania as in other Eastern Africa countries under mixed farming.

Types of Beans, their Introduction and Distribution

Phaseolus vulgaris is known by various names such as french beans, kidney beans, haricot beans, garden beans, dwarf beans, snap beans, string beans, bush beans, pole beans, common beans and dry beans. In Eastern Africa in general and Tanzania in particular, they are usually referred to simply as beans.

The beans grown in Tanzania are traditionally of a natural genetic mixture commonly referred to as "mixed beans". Most of these mixtures have a great diversity of seed sizes, colors, and are determinate in habit; indeterminate non-climbing semi-bush types and indeterminate climbing types are also grown.

Beans originated in Central and South America and were probably introduced in Tanzania in the early 18th century, but there is no clear evidence of their status before the beginning of this century.

In the 1930's, new varieties particularly for canning purposes, were introduced in Arusha. Fifty two additional introductions were made from the United States, Central and South America, Puerto Rico, Belgium, France, Japan, Australia, South Africa, Ethiopia, Kenya and Uganda in 1960 and 32 selections in 1961 from Kenya and Uganda (Macartney, 1966a).

Until 1962, beans were grown predominantly in Arusha, Kigoma, Mbeya, Morogoro, Tanga and West Lake districts. However, with the realization of the importance of beans, the areas under production have expanded considerably in the above districts, as well as in Mwanza, Rukwa, Shinyanga and Iringa.

Bean Crop Environment

Beans are generally grown in higher and wetter areas of Tanzania. Sowing is done after the peak rainfall of April in the plains of Makunyi and Arusha. In the Southern highlands beans are planted in December. They are best suited for 1000 to 2400 masl altitudes. Their importance is minor in coastal areas.

Although beans are a warm season crop, they do not thrive or give maximum yields with temperatures above 30°C during the flowering and seed-setting stages. Above this temperature flowers abort and blind pods are common; also high temperatures during maturation can cause the testa to split. Emergence is poor below 20°C and growth ceases at 10°C.

A relative humidity of 50% is suitable for good seed setting. Bean growing areas generally lie within rainfall ranges from 500 to 2000 mm; generally, rainfall increases with altitude. The crop requires well distributed rainfall for the nearly three month growing period followed by one month of dry season, but cool weather is necessary for drying of pods. Yields are considerably reduced by a prolonged dry season. Similarly, too much rainfall results in excessive vegetative growth and can adversely alter the quality, color and germination capacity of seeds harvested. Maximum production is claimed to occur when 30-40 cm of rainfall occur over a 10 week growing period followed by four weeks of dry, sunny and cool weather before harvest (Macartney and Watson, 1966). Heavy and prolonged rains result in serious soil erosion.

Beans are grown on a wide range of soils except heavy and acidic ones.

Bean Cropping Systems

Although beans are grown both in the short rain as well as in the long rain seasons in some parts where there is bimodal rainfall, they are more commonly cultivated during the long rain season in most bean producing areas of Tanzania such as Arusha, Iringa, Kigoma, West Lake, and parts of Mbeya regions. As rainfall periods are variable in different areas (e.g. Arusha, March to April; Tanga, October to November and March to May; Morogoro, November to December and March to May), the time of planting is variable in different areas. Beans are sown at a time which allows them to mature in dry weather. As short rains are very irregular in most parts of Tanzania, short-term varieties are advisable for that season.

The land for planting beans is ploughed as soon as the previous crops have been harvested. Seeds are mostly broadcast over land and lightly hoed into the soil or by making holes and planting one or two seeds in them or putting seeds in rows. When sprinklers or surface irrigation are used, the crop is normally planted on ridges. The depth of planting varies from 2.5 to 4 cm.

Spacing of bean cultivars with particular growth habits varies with the soil fertility and moisture. Yield of determinate habit cultivars responds to changes in density and tends to be maximum at a spacing where they produce a closed cover at full growth and maximum leaf area, whereas indeterminate cultivars are able to compensate for spacing differences (Leakey, 1970). Spacing, however, may be more important in relation to the economics of production than to actual yield figures per hectare. Other important factors are the higher cost of seed per hectare, and the quicker ground cover and consequent lower weeding labor required at close spacing. More insidious interactions involve a tendency towards higher rates of disease spread and severity and the greater incidence of pests at high plant densities resulting from microclimate effects. It is thus clear that optimum density is a complex concept and may have little transferable value between different environments and agricultural systems.

Macartney (1966b) conducted a single season experiment on the spacing of Mexico 142 white haricot beans (indeterminate) in a season of usually low rainfall in Tanzania. There were no significant differences in yield between populations ranging from 39,326 to 119,778 plants per acre (44,080 to 134,259 plants/ha, respectively) but the mean seed weight, as well as the number of pods per plant, were higher at the widest spacing. He concluded that criteria such as the convenience of mechanized tillage and other operations were far more important than the biological ones in the choice of spacing. Macartney has also suggested that beans are better grown on ridges than on flat land. He recommended planting of haricot beans in double rows on three feet, flat topped ridges. Experiments conducted in 1978 indicated that plant population at 266,667 plants per acre (298,907 plants/ha) give the highest yield of beans (Anon., 1979a).

In general, the spacing of bean seeds varies from 45-80 cm between rows and 10-25 cm within the rows. However, a spacing of 60 x 10 cm is considered optimum in most parts of the country.

Beans are grown both as pure stand as well as intercropped. Intercropping and mixed cropping of beans and other legumes with non-legumes, particularly cereals, is a traditional practice among the peasant farmers in Tanzania. Beans are more commonly intercropped with maize than with any other cereals. When intercropped with maize in the short rains, the indeterminate climbing types are planted using maize as support. Climbers are preferred mainly because the beans mature under wet conditions and the support keeps the pods from the ground. Bush types are generally grown during the long rain season as a sole crop.

Fertilizer application increases yield. However, small farmers use cowdung almost exclusively as fertilizer. Root nodules in beans are sometimes absent or very small and hence the amount of fixed nitrogen is usually very small. This is evidenced by leaf yellowing. Investigations conducted at Ilonga Agricultural Research Institute during 1976-77 showed significant yield responses to either N or P or both. In 1977-78 a yield increase as high as 250% was recorded with application of 60 kg N and P_2O_5 per hectare in comparison to the unfertilized control (Anon., 1978a).

Bean cultivation in most parts of Tanzania depends on rainfall. When irrigation is practiced, it is advisable to withhold water application during the early stage of growth when the root system is developing. Under irrigation it is necessary to provide sufficient water during flowering. When the seed pods are plump and well filled, no further application of water is needed (Macartney and Watson, 1966).

Production, Trade, Storage and Utilization

Production. Arusha, with an annual production of 64,431 t is the biggest bean producing area in the country. Mbeya, Kigoma, Tanga, and Morogoro also produce large quantities. Production in other regions is mainly confined to the inmediate local requirements. Table 1 shows bean production statistics for different regions.

Bean yields are very low, usually between 200 to 670 kg dry beans per hectare (Jakobsen, 1976a). With improved varieties, good husbandry and better pest and disease control, up to 1500 kg/ha can be harvested. The highest yield with some local varieties was recorded at Uyole Agricultural Centre (IUC) with about 3000 kg/ha (Anon., 1976). The low yields are associated with diseases and pests, as well as with low yield potential of varieties in use.

Table 1. *Phaseolus* bean production in Tanzania, from 1963 to 1977.

Regions	Bean production (t)			
	1963-64	1968-69	1973-74	1976-77
Arusha	12,196	4,658	20,000	64,431
Dodoma	340	304	1,200	400
Iringa	2,845	599	4,305	4,500
Kigoma	20,123	13,030	18,600	35,086
Kilimanjaro	6,870	3,500	1,000	1,800
Mara	609	1,321	-	-
Mbeya	17,176	10,163	19,910	27,000
Morogoro	8,333	4,980	8,500	5,323
Mwanza	101	3,049	290	18,313
Rukwa	-	-	15,234	23,217
Ruvuma	606	2,000	4,520	15,000
Shinyanga	274	95	11,261	200
Singida	355	800	141	120
Tabora	355	500	15	3,205
Tanga	12,250	16,000	27,361	61,350
West Lake	10,163	40,000	56,859	27,000
Tanzania	92,596	100,999	189,196	286,945

Source. Bulletin of Crop Production Statistics, 1963-64 to 1977-78. Data collected and compiled by Statistics Section, Planning Division, Ministry of Agriculture, Dar es Salaam, April 1979.

Beans are largely produced for local consumption with some surplus for distribution to other parts of the country. In the early 1930's some farmers in the Northern region started growing beans for seed on a large scale. In North Tanzania, white haricot beans are produced mainly for export. The bean seed industry ranks sixth in importance among agricultural exports of the country.

With the early maturing varieties, the period from sowing to harvest is about 12 weeks. With indeterminate canning type haricot varieties, some pods dry off while others are still green. The crop in such areas is harvested when the area around the hilum of the seed in unriped pods begins to show the color of the seed at maturity. After the drying period, which may take up to a week depending on the weather and extent of drying in the field before harvesting, beans are threshed with sticks, either directly or when packed in sacks.

Some farmers who grow beans for seeds uproot the plants. The dry plants are piled on sheets with layers of grass or straw and kept there for about a week. Threshing is done by a tractor driving over the dry plants. Seeds are protected from damage by the coating of straw. Winnowing is then done by hand or mechanically, at the threshing site.

Once threshing is done, the bean seeds are sieved to remove remaining trash, broken and very small beans. Some large scale farmers first fumigate or dust beans with insecticide before sieving. The seeds may be polished by high speed admixture with sand dust. Sometimes they are sorted out by specific gravity. Such an operation is common in Arusha where farmers generally grow canning beans for export. Otherwise, seeds are sorted out by hand by peasant women. The beans are bagged normally in 100 kg bags.

Trade. Excess beans are often channeled to the local and urban markets and organizations like the National Milling Corporation (NMC). Since beans are generally grown in association with other crops, reliable, nationwide production data are not available. The small amount of beans sold to NMC reflects the fact that beans are primarily produced for local consumption. Thus, in 1978 about 24,700 t were purchased by NMC in comparison to only 7484 t in 1976 (Anon., 1978c).

The largest urban market for beans is Dar es Salaam which is the commercial center, government site and largest city in the country. The Dar es Salaam market is generally supplied from June to October by Moshi, Morogoro, Mbeya and Iringa areas. Retail prices of dry beans are quite variable in different parts of the country depending on demand and supply. Table 2 shows the trend in prices of beans between 1972 and 1980. These prices are the official government-fixed prices but the commercial price is actually higher approaching 7 shillings* per kg depending on the season. The increasing trend in bean prices is not only due to costs of production, transportation and marketing, but also to frequent supply shortages.

Table 2. Local market prices of bean in shillings* per kg, 1972-80.

Beans	Year							
	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80
Grade I	0.85	0.85	1.50	1.75	2.00	3.50	3.50	3.50
Grade II	0.65	0.65	1.30	1.35	1.75	2.75	2.75	2.75

Source: Tanzania Food and Nutrition Center (TFNC), 1980

* 1 shilling = US$ 0.1212

Because of their excellent quality and high seed germination, Tanzania seeds are in great demand on the world market for canning or for the green vegetable market. By 1948 exporters started subcontracting the crop to cope with the increasing overseas demand. This has expanded from about 12,000 tons per annum in 1964 to about 25,000 tons now.

Bean seeds for export are grown in large farms—both private and nationalized—mainly in Arusha and Kilimanjaro regions under contract with overseas seed companies. Exact hectareage is difficult to establish but some sources put it over 50,000 ha. In addition to guidelines from the Tanzania Seed Board, extensive advice, seed and credit for inputs and for purchasing farm machinery are given by the seed companies to their contracted farmers to ensure product quality and their loyalty to the individual company.

Storage. Storage conditions are not adequate and consequently beans get infested by pests. In many cases, beans are kept in small bins close to the production areas. Thus, weevils move from the bins to the field and vice versa. Many farmers store beans in mud granaries which are difficult to clean and are, therefore, a permanent reservoir of weevils. Some farmers dry the beans well so the adult weevils emerge and fly away, thus reducing infestation. The farmers are adviced to clean the granaries and desinfest them with 1.0% lindane before storing the beans.

For protection against insects, particularly bean bruchids, *Acanthoscelides obtectus,* and cowpea bruchid, *Callosobruchus chinensis,* the grains are mixed with 0.1% lindane dust at the rate of 250 g/100 kg prior

* 1 shilling = US$ 0.1212

to storage. The dusted grains are placed in bags and these are dusted on the outside with 1.0% lindane at the rate of 50 g/bag and kept in large granaries which have been cleaned and sprayed.

Utilization. Beans are widely consumed by the rural and urban populations of Tanzania. They are mostly consumed as whole grains. The bean seeds are cooked in a number of ways. The most common one is to boil them with maize until both are soft. This mixture is either eaten alone or with green vegetables. In some parts of the country, green vegetables, bananas, etc., are added after 2-3 hours of cooking. The mixture is then pounded into a paste. Boiled or fried bean paste is also eaten alone or with "ugali"* in most parts of the country. Green bean pods are also used as vegetable, particularly in urban areas. The leaves are boiled and eaten as a spinach by many people.

Bean consumption is considerably higher in Tanzania than in neighboring countries. Consumption, however, seems to be seasonal, according to price and availability of other food stuffs; prices are high when other foods are scarce and little cash is available.

Sometimes the straw is used as forage. However, no research work has been done on this aspect, and its potential as a cattle feed is not clearly known. The plants are also used as green manure.

Factors Limiting Production

General constraints

The predominant rainfed production is markedly seasonal thus surpluses and waste occur unless efficient preservation and processing methods were found, and supply guaranteed in the preharvest period. In order to meet the subsistence bean requirements through the year, production will have to be based on supplementary irrigation for certain periods of the year, but water is not always available and irrigation practices are not always common. The heavy and prolonged rains in some areas result often in serious soil erosion. Traditional practices often predominate over improved husbandry techniques.

Biological Constraints

Varieties. In Tanzania pure lines are grown on a small scale by only a few small farmers. Most farmers grow genetic mixtures usually referred to as

* A type of porridge made by slowly stirring maize meal in boiling water until it thickens.

"mixed beans". These contain a variety of seeds in some cases, whereas in others the seed type is fairly uniform. It is difficult to give the exact number of varieties grown in the country. In many cases the same variety is referred to by a different name in different parts of the country. Bush type Canadian Wonder, which produces large purple seeds, is very popular. Other common varieties used by farmers include Masonga (light purplish), Nkongi (white with black stripes), Kambani (pinkish), T8 (white), Mexican 142 (white) and Selian Wonder (dark purple).

Most of the varieties used by farmers are low yielders on account of their disease and pest susceptibility. The seeds of improved varieties are expensive, therefore, the farmers rely on whatever is locally available. Furthermore, the farmer does not take the risk of using the expensive and newly improved varieties unless a part of the crop can be sold for cash at reasonable and attractive prices.

Pests. Insect pests attack every part of the bean plant, from roots to the pods and seeds, and grains in storage. Some of the important pests attacking the growing bean plants are summarized in Table 3.

Ootheca bennigseni Wse., Col., Chrysomelidae: This leaf eating beetle appears in the early stages of growth and causes serious damage, sometimes leading to death of plants. The larvae live in the soil and can damage the root system. The infestation can be avoided to some extent by late planting, and controlled by spraying with 25% DDT formulation.

Ophiomyia phaseoli Tryon., Dip., Agromyzidae: This is a major bean pest in Tanzania commonly known as beanfly. It lays eggs on the upper surface of young leaves near the petiole. When the eggs hatch, the larva bores down inside the stem just above ground level. The damage is caused by the larvae feeding on outer tissues of the stem resulting in swollen cankerous areas (longitudinal cracks) which are readily seen when the plants are uprooted, and in leaf yellowing. The seedling may become severely stunted or die. Pupation takes place near the surfaces of the stem where the larvae feed.

Late infestation does not have serious effects on the plant. The beanfly damage is more prominent in hot season from November to March than in April. Therefore, planting of beans after March decreases damage. Good protection can be obtained by seed dressing with 40% aldrin at the rate of 40 ml per 10 kg of bean seeds.

Aphis fabae Scapoli, Hom., Aphididae: Bean aphids are serious bean pests in Tanzania. They are found in clusters around the stem, growing points and leaves, and causing infested leaves to distort and yellow. The plants are desiccated and eventually die. They also act as vector of virus diseases. Infestation is particularly severe during dry spells. It can be prevented by avoiding planting during dry spells or late in the season. Seed dressing with menazon (saphizon) at 600 g/ha gives control for four weeks after planting. It is particularly useful when early infestation is expected. Later infestation can be controlled by metasystox or endosulfan at 500 g/ha.

Coryna apicornis Guen., Col., Meloidae: Commonly known as pollen beetle, the adults feed on the open flowers, pollen and anthers. Normally it is not a serious pest, but ocassional losses have been reported in the Eastern region. Their control is difficult due to their mobility, but chemical control is seldom needed. A 25% DDT formulation has been found effective.

Mylabris spp., Col., Meloidae: Blisterbeetle or flower beetles are common but minor pests of bean flowers. The adults are difficult to control as they are strong fliers. If infestation is severe, 0.25% DDT spray is effective.

Taeniothrips spp., Tys., Thripidae: Two species, *T. sjostedti* and *T. nigricarnis*, are bean flower pests. Of these, *T. sjostedti* is more common and nymphs and adults sometimes cause serious damage to bean flowers, leading to abortion. Lindane and 25% DDT formulations effectively control the flower thrips.

Acanthomia spp., Hym., Coreidae: Two species of the spiny brown bugs, *A. horrida* Germ. and *A. tomentosicollis* Stal., are the main pod sucking insects causing premature drying and shrivelling of pods. Seeds remain small or do not develop at all. The insects introduce the fungus, *Nematospora phaseoli (N. corveli)* in the pods and seeds. Although of common occurrence, they are not serious pests. Adults and nymphs are equally harmful. Materu (1968, 1970) has studied the biology and population dynamics of the two species of *Acanthomia* in Tanzania. When control is warranted, a spray of endosulfan or DDT is effective.

Nezara viridula L., Hym., Pentatomidae, also attacks pods and seeds. The feeding punctures cause necrosis with resulting fruit spotting and deformation or if attacked when very young, pods shed. Best control is obtained by spraying with 0.5 liter of 20% lindane or 35% thiodan; 0.8 liter of 18% dieldrin are also effective.

Hodotermes mossambicus Hagen, Isop., Hodotermitidae: Harvester termites, species that cuts bean stems and pods and take them to their underground nest. A spray of 0.1% dieldrin will give effective control. Sometimes a dieldrin/bran bait (30 cc of 40% dieldrin in 1 kg of bran) is effective.

Maruca testulalis Geyer, Lep., Pyralidae: This pod borer is one of the most serious bean insects in Tanzania, attacking flowers, pods and seeds. Early instar larvae feed on floral parts whereas later instars bore into the pod end and eat seeds. The presence of *Maruca* in pods is characterized by the presence of frass around the entrance hole. A good control is obtained with 800 g a.i./ha of 35% Thiodan when applied before larvae enter the pods.

Heliothis armigera Hb., Lep., Noctuidae: The larvae of American bollworm* are a serious pest of beans in Tanzania. The young larvae feed on the flowers and the young pods, but the main damage is caused by the older larvae burrowing into the pods and eating the developing seeds. DDT and endosulfan sprays control American bollworm effectively if they are applied when the larvae are still young, that is, when the plants are in the early pod growth stage.

Acanthoscelides obtectus Say, Col., Bruchidae: Bean bruchids are the most serious pests of stored beans in Tanzania. Infestation starts in the field and continues in storage. Bean bruchids lay eggs on the green pods; the larvae feed inside the seeds; infestation increases as adults emerge in the stores and lay their eggs losely among beans.

Callosobruchus chinensis L., Col., Bruchidae: Cowpea bruchids are also found to infest beans both in the field and in stores. However, they are generally not as serious a pest as *Acanthoscelides*. Infestation starts in the field and increases when the infested pods are taken to farm stores.

Both bean bruchids and cowpea bruchids are effectively controlled by dusting beans with 1% lindane dust. The sacks in which the beans are stored are also dusted with lindane for additional protection. The stores should also be sprayed from time to time with 50% WP of lindane at the rate of 200 ml per gallon of water.

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* The common name American bollworm is a misnamer because *H. armigera* does not occur in America although the closely related *H. zea* does. However, *H. armigera* is more commonly called American bollworm in Eastern Africa.

Table 3. Insect pests of beans in Tanzania

Species	Family	Plant part attacked	Nature of damage	Control measures	Economic importance*
Ootheca bennigseni Wse.	Chrysomelidae	Foliage	Chewing of leaves of young seedlings and plants; cause foliar distortion; damage may lead to death.	25% DDT formulation effective	I/M
Ophiomyia phaseoli Tryon.	Agromyzidae	Stem, leaves and petiole	Larvae feed on outer tissues of stem resulting in swollen longitudinal cracks; leaves turn yellow giving the plant droughted appearance. Seedlings are severely attacked.	Seed dressing before planting with 40% aldrin at the rate of 40 ml per 10 kg of bean seeds. Early planting and use of resistant varieties are important.	I
Aphis fabae Scapoli	Aphididae	Foliage, tender stem and growing points.	Suck plant sap from leaves and stem particularly in dry weather. Infested leaves often cupped or distorted and then turn yellow. Plants eventually die.	Seed dressing with menazon (saphizon) at 600 gm/ha gives good control for 4 weeks after planting. Late infestation controlled by metasystox at 500 gm/ha.	I/M
Coryna apicornis Guen.	Meloidae	Flowers	Feed on pollen and destroy the anthers.	25% DDT formulation effective.	L
Mylabris spp.	Meloidae	Flowers	Feed on floral parts and destroy them.	25% DDT formulations effective	L

*Economic importance of pests: I = Important, M = Moderately important, and L = Less important.

Table 3. Insect pests of beans in Tanzania (continued)

Species	Family	Plant part attacked	Nature of damage	Control measures	Economic importance*
Taeniothrips sjostedti	Thripidae	Floral buds and flowers	Feeding injury characterized by distortion, malformation and discoloration. Injury sometimes leads to abortion of flowers.	25% DDT and lindane formulations	M
Taeniothrips nigricornis	Thripidae	Floral buds and flowers		25% DDT and lindane formulations effective	M/L
Acanthomia horrida Germ.	Coreidae	Pods	Suck sap from pods and cause their premature drying and shrivelling.	Endosulfan or DDT gives effective control	L
Acanthomia tomentosicollis Stal.	Coreidae	Pods			L
Nezara viridula L.	Pentatomidae	Pods, seeds and leaves	Feeding punctures cause necrosis resulting in deformation or pod shedding if attacked when very young.	0.5 litre of 20% lindane, or of 35% endosulfan (Thiodan) or 0.8 litre of 18% dieldrin is effective	L
Hodotermes mossambicus Hagen	Hodotermitidae	Stem and pods	Cut the stem and pods and take them to entrance of their underground nest.	0.1% dieldrin gives effective control; dieldrin/bran bait is also useful.	L

*Economic importance of pests: I=Important, M=Moderately important, and L=Less important.

Table 3. Insect pests of beans in Tanzania (continued)

Species	Family	Plant part attacked	Nature of damage	Control measures	Economic importance*
Maruca testulalis Geyer	Pyralidae	Flowers, pods, seeds and leaves	Early instar larvae feed on flowers and later instar feed on seeds in pods. Presence of *Maruca* is characterized by frass around the entrance hole.	800 g a.i. per ha of 35% endosulfan (Thiodan) gives good control in early stages before larvae enter pods.	I
Heliothis armigera Hb.	Noctuidae	Flowers and pods	Young larvae feed on flowers and young pods. Main damage is caused by old larvae burrowing into the pods and eating the developing seeds.	DDT and endosulfan (Thiodan) control early instar larvae	I
Acanthoscelides obtectus Say	Bruchidae	Seeds	Larvae feeds inside the seed and makes tunnel almost to the surface leaving seed coat and form a window at the end of tunnel through which adult comes out.	Effectively controlled by 1% lindane	I
Callosobruchus chinensis L.	Bruchidae	Seeds			L/M

*Economic importance of pests. I=Important, M=Moderately important, and L=Less important.

Diseases. They probably account for more severe bean losses than insect pests in most parts of Tanzania. Diseases affect the bean crop in two ways: by causing direct loss of yield and by reducing the quality of the seed whereas the yield may or may not be reduced. Some of the most common bean diseases recorded in Tanzania are listed in Table 4.

Bean rust *(Uromyces phaseoli).* Rust can cause severe damage to susceptible bean varieties. It is considered to be economically important next only to anthracnose. In a severe outbreak, leaves become deformed and shed early.

Rust can be avoided by growing resistant varieties; Macartney (1966a) found Tengeru No. 8 highly resistant to bean rust; it is now commonly used for canning. Macartney and Watson (1966) summarized the following measures to minimize losses: avoidance of varieties known to be susceptible; early planting in areas where rust is known to be severe; complete destruction of infected plants which otherwise act as a source of infection to adjoining crops; control of out-of-season bean crops, which act as a source of spores and cause a more rapid build up of the disease in the main crop.

Halo blight. Caused by a *Pseudomonas phaseolicola* bacterium. It is more common in cooler or wetter parts of Tanzania. The bacterium affects both yield and quality of the seeds in the pods. Halo blight does not seem to affect bean yields in most seasons. Only a low level of leaf infestation and occasionally pod infestation are observed. Crop rotation, destruction of crop residues and the use of disease-free seed are important precautions. Dithiocarbamate sprays give good control. Little work on selection of resistant varieties has been done in Tanzania.

Anthracnose. It is considered to be the most important bean disease in Tanzania. The disease is caused by *Colletotrichum lindemuthianum.* Anthracnose causes reduction in yield and quality of seeds. Use of disease-free seed, destruction of crop residues, crop rotation and use of resistant varieties are important precautions. Dithiocarbamate sprays give effective control.

Angular leaf spot. Caused by *Phaeoisariopsis griseola.* It is widespread in Tanzania. As the name suggests, the symptoms are angular brown and irregular spots on the upper surface of the leaves. The disease is spread by infested seed and trash, by wind and by rain splash. The precautions include the use of clean seeds, crop rotation and destruction of crop residues. Only 5-10% of the farmers use clean seeds.

Table 4. Common bean diseases in Tanzania.

Common name	Caused by	Plant parts attacked	Nature of damage	Control measures	Economic importance*
Bean rust	*Uromyces phaseoli*	Pods and seeds	Small, dark green round spots surrounded by a narrow ring of yellow tissues with an orange-to-brown pustule containing spores on the underside of the leaf. Infestation severe in more humid parts.	Use of resistant varieties, early planting and destruction of infested plants.	I
Halo blight	*Pseudomonas phaseolicola*	Leaves and pods	Cause dark irregular spots on leaves and pods. Bacteria form yellow-to-brown irregular spots on leaves surrounded by a halo green tissue. Affects both appearance of pods and seeds in the pods.	Crop rotation, destruction of crop residues and use of clean seeds. Dithiocarbamate gives good control.	L
Anthracnose	*Colletotrichum lindemuthianum*	Leaves, stem, petiole and pods	Cause brown or black spots on the underside of leaves, stem, petiole and pods. Stem infection in young plants fatal; reduce quality of seeds.	idem	I

* I = Important, M = Moderately important, L = Less important.

Table 4. Common bean diseases in Tanzania (continued)

Common name	Caused by	Plant parts attacked	Nature of damage	Control measures	Economic importance*
Angular leaf spot	*Phaeoisariopsis griseola*	Leaves and pods	Cause angular brown and irregular spots on upper surface of leaves; ocassionally the spots occur on pods in wet weather.	Use of clean seeds, crop rotation and destruction of crop residues are recommended.	I/M
Bean common mosaic virus	*Marmor phaseoli*	Leaves and seeds	Cause yellowing and mottling of leaves, distortion of leaves and shoots, stunting of plants and reduced flowering.	Virus-free seeds recommended. No control measures used.	M
Bean yellow mosaic virus.	*Marmor manifestum*	Leaves	idem	idem	L
Mildew	*Ramularia phaseolina*	Leaves	Cause large, indistinct angular spots of pale green color on leaves.	No control measures used.	L

* I=Important M=Moderately important. L=Less important.

Mosaic. According to Macartney & Watson (1966) there are two different mosaic diseases in Tanzania, common and yellow mosaic. Common mosaic is transmitted via the seed whereas yellow mosaic is not. Although of common occurrence in Tanzania, mosaic virus rarely affects the crop yield. No control methods are used in Tanzania. However, it is highly recommended to plant virus-free seeds.

Mildew. This is a common but not serious fungus disease caused by *Ramularia phaseolina.* Little is known about the disease. In other countries, mildew is usually caused by a different fungus, *Erysiphe* sp., although the symptoms are similar.

Nitrogen fixation. Several unsuccessful attempts have been made with *Rhizobium* inoculation to increase bean yields. Such is the case in Tanzania with soils previously grown with beans (Macartney, 1964).

Socio-economic constraints

The farmer always expects to obtain adequate returns from his crops, but severe diseases, pests and other constraints often reduce yields and sometimes these are not enough even to buy seeds for the next season. With improved varieties, cultural practices, pest and disease control, the farmer can hope to get more profits. However, because of unreliable rainfall, on which the peasant farmers rely completely for their crop, they do not take the risk of using expensive improved varieties, unless they are sure of a good profit in return.

Labor is generally not a problem in bean production in most parts of Tanzania, even though harvesting coincides with late harvesting of cotton and sorghum. Further, as bean yields have not increased much, in spite of improved cultural practices, the farmers have diverted their labor force to more productive crops. Production is not planned in relation to marketing/demand possibilities. Due to disorganized production, the marketing pattern is also disorganized, except for the few farmers that grow beans for marketing and export. But in general, there is no response from farmers to market demands. The marketed surplus is of variable quality and unfit for commercial marketing. Due to lack of rainfall and of proper irrigation facilites, seasonal shortages are common and result in varied marketing patterns. As a consequence, there are no marketing facilites such as packing, grading, and bulking of beans.

The main transport constraints are poor roads in most regions, and diesel oil and petroleum shortages. Long distances from production areas make transport of beans to markets expensive. The railway network does not cover the country and particularly does not reach places where beans are produced. Moreover, there is a shortage of rail wagons in the country.

In many areas there is a sociological bias against consuming certain types of beans due to ignorance about their eating qualities and varied uses. Most consumers have strong preferences for certain types and pronounced dislike for others. Pigmentation and size are important in consumers' acceptance of a particular bean. Large, dark red, pinkish and purple seeds are preferred to other colors in most parts of Tanzania. People also prefer varieties with good flavor. Varieties with a minimum soaking period are preferred because they need less cooking time. Hard seed coat varieties are therefore less preferred.

Institutional constraints

Two main constraints to bean production in Tanzania are the lack of agriculture training facilities and the shortage of research and extension staff. According to a 1975 survey there were only 25 extension workers and of these only one was a graduate research worker (Anon., 1975). There is an urgent need for at least one senior officer assigned to each bean producing region. Since 1975, research and extension staff have been recruited in bean growing areas, particularly Mbeya, Arusha and Morogoro. The Horticulture Training Institute of Tengeru, near Arusha, gives training in bean cultivation.

Marketing. It is predominantly the concern of the NMC which buys the crop from the farmer, transports it and sells it either directly or to other wholesalers. These or the cooperatives fix the producer price in relation to the expected market price and provide financial support to producers. These services are reflected in a certain margin over the selling price. Only by improving the marketing process can retail prices be lowered and, at the same time, return to the farmer increased.

Seed Production, Processing and Distribution

The export of bean seed to Europe started in 1936. The Tanganyika Export Seed Growers' Association was formed in 1947 to improve and maintain their quality. Later on, a Tanganyika Seed Board was created.

Before that, farmers were selecting their own seed and a few prosperous ones were importing seed, sometimes not suitable to Tanzanian climatic conditions.

Between 1969 and 1972 four foundation seed farms were established by the Ministry of Agriculture with assistance from the United States Agency for International Development (USAID). They are located at Msimba, Arusha, Kibaha and Dabaga (Iringa). A training program was implemented with USAID support to train local staff in management of seed multiplication projects. Since then, the Tanzania Official Seed Certification Agency (TOSCA), with headquarters at Morogoro, is responsible for seed certification. It is controlled by the Seed (Regulation of Standards) Act of 1973, revised in 1976 as Seed Regulation 1976. Only varieties designated by the committee are eligible for certification.

A bean seed testing laboratory was established in the late fifties by the Ministry of Agriculture in the Northern Research Center at Tengeru. The laboratory reports on the purity of seed, germination ability, anthracnose and halo blight infections and general field aspects.

In order to help with seed improvement and distribution, the Ministry of Agriculture established the Tanzania Seed Company (Tanseed) in 1973 and authorized private seed companies such as Sluis Brothers and Pop Vriend to produce improved seed.

Three important bean research institutes of the Ministry of Agriculture are located at Ilonga, Lyamungu and Uyole. Successful new varieties obtained by them are approved by the Ministry's Seed Production Committee for certification. The seed is multiplied mostly at the Arusha Foundation Seed Farm.

The first generation of breeder's seed, produced in the government seed farm and controlled by TOSCA, is the foundation seed; this is bought by Tanseed to produce certified grade seed. These seeds are sold to the agricultural development offices in all bean growing areas of the country.

A second generation of certified grade seed is called common grade seed. The farmer plants this or certified grade seed and produces milling grade beans which are sold to NMC. Seed production and distribution in Tanzania are summarized in Figure 1.

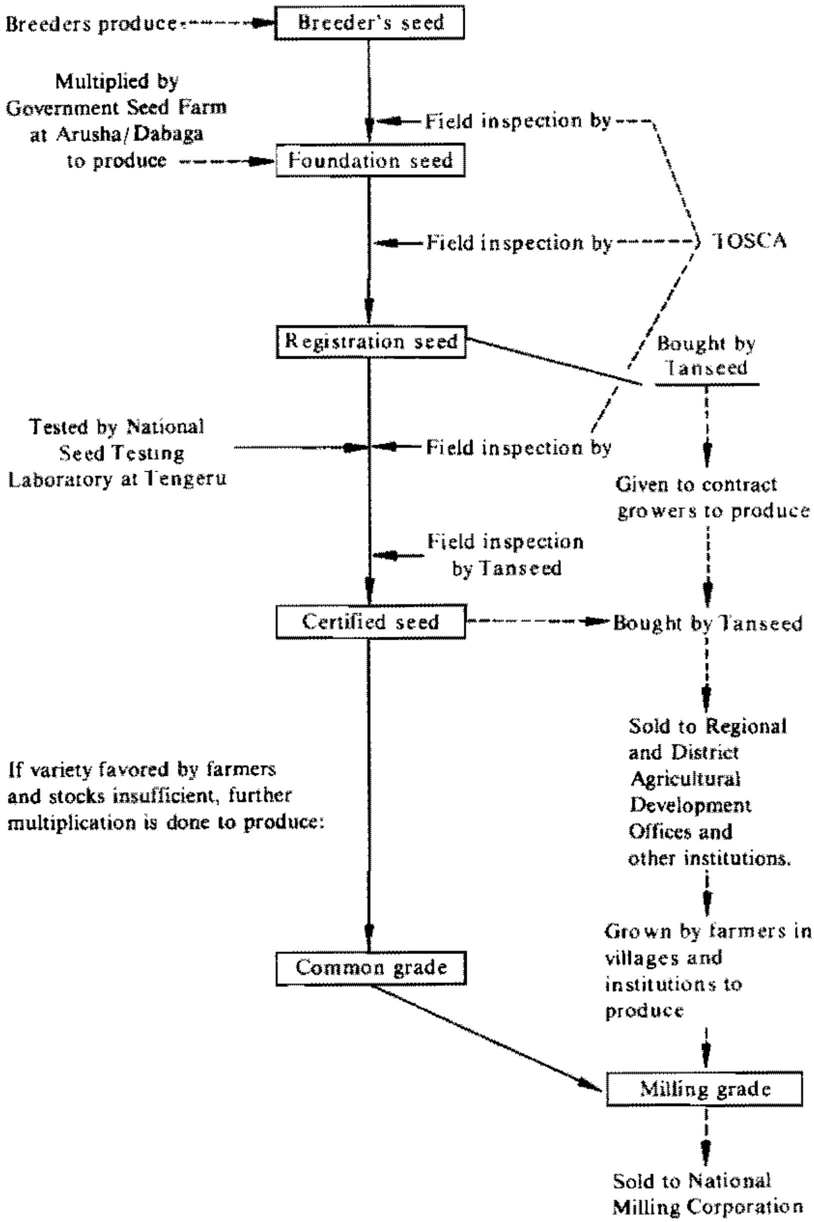

Figure 1. *Bean seed production and distribution in Tanzania.*

Description of Country Bean Program

In view of the potential economic value of the Tanzania haricot beans for canning, a research program was started in 1959 at the Northern Research Center, Tengeru, to produce varieties to meet commercial and agronomic requirements. This program, completed in 1965, released two seed varieties, Tengeru No. 8 and 16, for exporting farmers (Table 5). These two varieties were found to be highly resistant to bean rust and most other diseases, of acceptable seed color and size, good flavor and excellent soakability.

The bean program was initiated again in 1971 at Uyole Agricultural Centre (UAC), Mbeya, with research on agronomic aspects of bean production. The program was transferred to the Horticulture Research Section of the Ministry of Agriculture in 1974. When it was first initiated at Mbeya, its objectives were: to identify reasons for the low yields obtained by farmers in the Southern highlands; to select a high yielding cultivar resistant to the major diseases in the Southern highlands and easily acceptable as food for the poor; to search for improved cultivars of the

Table 5. List of bean varieties released in Tanzania.

Name of variety	Year of release	Important features
Tengeru No. 8	1965	Erect bush type. High yielding variety highly resistant to bean rust and other diseases, acceptable seed color and size, with good flavor and excellent soakability.
Tengeru No. 16	1965	Idem; slightly smaller seed size.
T3	1979	Semidwarf high yielding variety resistant to rust and angular leaf spot. Small oval red seed. Good acceptability.
Kabanima	1979	Dwarf high yielding variety resistant to rust and angular leaf spot. Big size long seeds with stripes and lightly purplish spots. Very good acceptability.

Source: Macartney and Watson (1966). Seed Production Committee meeting for release of bean varieties held at Morogoro, Tanzania, 30 November 1979 (working paper).

white haricot beans (for export and canning); to develop a seed multiplication program for the selected cultivars ensuring the producers pure-type, disease-free seeds; to prepare recommendations with the cooperation of the Ministry of Agriculture and Extension staff for use by the farmers.

A collection of many local and introduced types and germplasm of several hundred varieties has been made since 1973 at Uyole, Ilonga and Lyamungu. By 1975-76 a total of 1046 germplasm lines had been collected from different sources. Cultivars were discarded from the collection and the best lines were kept for further evaluation.

The bean improvement program was extended in 1975-76 under the National Grain Legume Research Project with the aim of working systematically on the improvement of beans. Trials were carried out in different ecological conditions, e.g., Mbimba in Mbozi district, Mitalula in Rungwe and Ismani in Iringa and at the Ilonga Agricultural Research Institute (IARI). Later bean research was concentrated at UAC, Lyamungu, and IARI and to some extent in the Northern Research Center, Tengeru, where bean research, in fact, had started in the fifties. Work at Tengeru, however, had concentrated on beans for export. In view of the importance of beans in Tanzania, it was felt that this crop needed a full time research team of its own. Therefore, the Ministry of Agriculture developed a Bean Improvement Program in 1979 with headquarters at Lyamungu and a substation at UAC. The present and projected staff for the program are: one agronomist, one pathologist and several technical cadre staff, stationed at Lyamungu; and one plant protectionist stationed at Uyole.

Research on bean improvement in Tanzania includes the following:

Agronomic research. To evaluate promising bean varieties, trials were conducted at IARI until 1976. The varieties were Alderman, American King, Radiom, Blue King, March Beauty and Purple Flat. Alderman and Blue King gave the best yield performance. Since 1976, under the grain legume improvement program started in 1973-74, the varietal trials have been carried out in farmers' fields in Ilonga and Mbeya regions.

Results from varietal trials at UAC (Anon., 1979c) have so far shown big varietal differences in resistance against fungal diseases. Those found promising include T3, T8, and some newly introduced cultivars, such as TS, T23, YC-2, P692-A, Sumbawanga B, UAC116, UAC71, EAI 2530, which are still under test. T3 was developed from LR-3-72 from Thika, Kenya. The presence of black coloration in T8 threatens its wide acceptance, although it is one of the highest yielding cultivars. Efforts are being made to improve its color.

A bean plant density trial with Canadian Wonder was started in 1978. Results so far indicate that plant population at 266,667 plants/acre (298,907 plants/ha) gives highest yield (Table 6). The trial is being continued until sufficient information about the optimum plant density is obtained.

Following a preliminary fertilizer response trial in 1976-77, which gave significant yield response to either N or P or both at most locations, in 1977-78 a fertilizer response trial was started under the grain legume village trial program in Ilonga, Mbeya and Iringa regions. Significant yield increases have been obtained in both N and P applications in all places (Figure 2). This work is in progress and by 1980 some conclusive results are expected.

Table 6. Yields of Canadian Wonder when planted at five different densities at Ismani.

Density (plants/ha)	Yield[1] (kg/ha)
298,907	1359 a
373,633	1246 ab
224,180	1164 bc
448,360	1121 bc
149,453	1066 c

[1] Means are average of six replications. Means followed by the same letter do not differ significantly at the 5% level.

Source: Anon., 1979a.

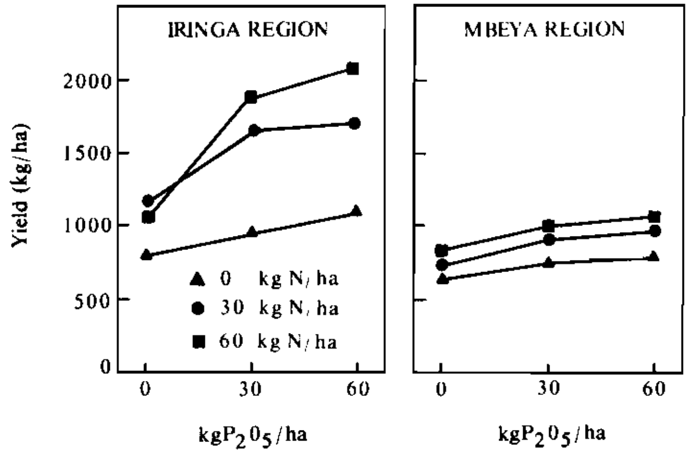

Figure 2. *Beans response to N and P, village trials, Iringa and Mbeya regions.*
Source: Anon., 1978a.

Trials on time of planting beans are in progress to find out if farmers can grow two crops in one year. Preliminary results indicate that farmers in Mbeya and Rungwe districts who have been growing only one crop annually, can grow beans twice a year, one crop during the start of rains in November-December and the other during March-April.

A trial on bean/maize intercropping was started in 1978 to find out the effects on bean production.

Breeding research. The grain legume breeding program was started in 1975 at Ilonga to develop high yielding and widely adapted varieties of beans and other grain legumes. The investigations are being conducted on the following lines:

Tanzania *Phaseolus* uniform cultivar trials have been in progress since 1976 when 1046 germplasm lines were evaluated at Ilonga, Uyole and Lyamungu. Fifty-six lines were selected on the basis of freedom from diseases, agronomic attributes and yield potential; these were further evaluated in 1977 at Ilonga and Lyamungu. The best 20 varieties, including Canadian Wonder as a check, were evaluated in multilocational trials during 1978 and 1979. The grain yield of these selected varieties at different locations are presented in Table 7. It shows that P311-A.L. outyielded all other varieties at all locations; overall yield was 2089 kg/ha as compared to 1296 kg/ha for Canadian Wonder. P311-A.L. is fast growing and resistant to anthracnose, rust, angular leaf spot and mosaic. However, it is a black seed variety and as such it does not appeal to farmers. Therefore, it is being used as a parent in hybridization to develop new high yielding varieties. Other varieties which appear better than the Canadian Wonder include T3, T23, YC-2 and P692-A. These have desirable seed color and mature at the same time as Canadian Wonder. These are being further evaluated in multilocational trials.

Forty-eight newly selected lines or varieties are being evaluated in a Tanzanian *Phaseolus* yield trial along with Canadian Wonder as a check at Lyamungu, Maruku, Ismani and Tengeru. At Ismani, Santa Anna, P323, PR-15-R-52, P512, Rupus, P692, Negromeration, P757 and P309 yielded significantly higher than Canadian Wonder. After reviewing performance of the lines at other locations and their reaction to various diseases, these will be further evaluated in the next season.

Some trials on control of important bean pests have been undertaken. It has been found that 600-800 g a.i. DDT and 800 g a.i. endosulfan (Thiodan) give effective control of insects; 0.1% lindane dust at 250 g/100 kg beans gives good control of bean and cowpea bruchids in storage.

Table 7. Performance of 20 *Phaseolus* varieties in Tanzania uniform yield trials in 1978 and 1979.

Bean variety	Yield performance (kg/ha)						
	Ilonga 1977	Lambo 1978	Gairo 1978	Gairo 1979	Ismani 1979	Tengeru[1] 1979	Mean
T3	865	1848	1490	1880	1194	626	1317
T5	840	1616	1170	1580	1556	500	1210
T8	1090	1150	2100	1350	1864	1100	1442
T23	1155	2168	1590	1310	1268	1130	1629
YC 2	1048	2013	1170	2330	1472	980	1502
SR-169	1045	1810	1010	1456	1662	580	1261
SR-267	1240	1688	1030	1440	1246	756	1233
P311-A.L.[2]	1895	2818	2260	2130	1896	1536	2089
P569-A	1275	1055	1340	1700	1446	626	1240
P692-A	1350	1523	1120	2540	1108	826	1411
95/128/74	1048	1633	1200	1790	1248	850	1295
AA/2/5/6	1270	1433	850	1680	1234	920	1231
G.N. Nebraska	835	1170	1090	1590	1310	886	1147
G.N. Valley	-	1795	960	1520	2110	300	1337
GNU131	1208	1268	640	1186	1758	280	1057
G.N. Emerson	840	1700	850	2320	1164	340	1202
Supermetis	1170	1263	1010	1320	1484	866	1186
H_2 Red Mexican	1493	1300	995	1416	1384	110	1116
Monroe	978	1466	750	1320	1394	360	1045
Canadian Wonder	1069	1525	1190	1556	1850	586	1296

[1] There was a severe attack of rust, angular leaf spot and mosaic at Tengeru which caused general reduction in yield.
[2] P311-A-L. remained free from all diseases.
Source: Anon. 1979b.

Not much work has been done on weed control. Work so far suggests that M.C.P.B. (4-4 chloro-2 methylphenoxy butyric acid) can be effectively used on wet soils as a preemergent herbicide.

Research at the university. Research is being conducted at the University of Dar es Salaam, Faculty of Agriculture, at Morogoro, by staff of the Crop Science Department. The work includes assembling and evaluating germplasm to determine the relative yield potential of plants with different growth habits and their response to intercropping. Plant structure and physiology are being studied to seek traits that will favor higher yields. The insect pest complex is being investigated too. The importance and virulence of *Colletotrichum lindemuthianum* isolated in *Phaseolus* beans and their reaction to different isolates of the fungus are studied in the Southern highlands of Tanzania. Response to *Rhizobium* inoculation, by which the nitrogen fixing ability of beans can be maximized is also studied together with the distribution of fixed nitrogen in different parts of the plant. No significant effects of *Rhizobium* inoculation have been found.

Future Plans

With the establishment of the Bean Improvement Program in 1979 bean research ranks first in the food crop research and production priorities, and efforts are being made to further intensify research on every aspect of bean production. The proposed plan of research activities is outlined below:

Breeding. Collection, evaluation and maintenance of additional germplasm lines from CIAT and other sources; identification of sources of resistance to anthracnose, rust, angular leaf spot, halo blight, bacterial blight, and common mosaic virus; hybridization of related parents possessing desirable characters with respect to disease and insect resistance, yield and seed quality; evaluation of segregating generations and selection of desirable progenies; evaluation of the selected progenies in preliminary and advanced trials at several locations in Tanzania; seed multiplication and release of the best varieties in different regions.

Agronomic work. It will be concentrated on critical management factors and development of practical and economic production practices. The ultimate goal is to develop recommendations for the farmers. Some specific objectives are:

To determine the optimum plant density for bush and climbing types of beans both in monocropping and in maize intercropping; to determine the best planting dates for the different bean growing areas; to determine the most effective and economical herbicides for farmer use; to determine the optimum and most economical rate of fertilizers for farmer use; to evaluate fungicides, select the most effective and determine the most effective and economical rate for farmers.

Entomological work. It will include: studies on insect pest complex of beans; control of major insect pests, such as bean fly, aphids, pod borers, pod-sucking bugs, bean bruchids, etc. The effects of various insecticides are to be evaluated, and the most economical doses of selected insecticides will be suggested; selection of bean varieties resistant to important insect pests from the available breeding materials and imported improved varieties.

Achievements

The investigations carried out so far in Tanzania have produced information on planting times, spacing, fertilization and cultural practices for the improvement of bean yields. These studies have also suggested ways to avoid and manage pests, diseases, weeds and other constraints, although a lot of work is still needed on these aspects.

Two varieties, Tengeru No. 8 and 16, were released in 1965 following an improvement program on haricot beans for canning started in 1959 to produce varieties that could meet commercial and agronomic requirements. These varieties are now commonly used by farmers who produce canning beans for export.

The Bean Improvement Program, started in 1971 to increase the yields and quality of beans in the country, released in 1979 two improved varieties, T3 and Kabanima. In addition to being high yielders, these varieties are resistant to most diseases and produce good quality grains acceptable to Tanzanian consumers.

Summary

The common field beans *(Phaseolus vulgaris)* form an important source of proteins (18-32% in dry grains) with high concentration of lysine and tryptophane. Like maize, they constitute the staple food in many parts of Tanzania. They are more commonly referred to as "bean". Beans traditionally grown are a natural mixture commonly known as "mixed beans".

Beans are grown extensively in well-drained soil, high in organic contents, at high altitudes, 450 to 1500 masl, with rainfall ranging from 500 to 2000 mm, and temperatures of 21-30°C, and 50% relative humidity.

Beans are cultivated in short as well as in long rain seasons, but more commonly during the latter. They are grown as a monocrop or intercropped with cereals, usually maize. When cultivated as monocrop usually a determinate variety is grown at a seed spacing of 60 x 10 cm. When intercropped with cereals such as maize, usually an indeterminate climbing variety is preferred. Most farmers do not use irrigation with exception of a few commercial farmers in North Tanzania.

Beans are commonly produced in Arusha, Iringa, Kigoma, Mara, Mbeya, Mbinga, Morogoro, Rukwa, Sumbawanga and West Lake

regions. The yields are generally low ranging between 200 to 670 kg/ha. The majority of beans produced are for local consumption. The excess is often channeled to local and urban markets, and scheduled organizations such as the National Milling Corporation. Some bean seeds for canning are exported to Europe and other countries by commercial farmers in the Arusha area.

Storage conditions in farms are usually poor and consequently the seeds are infested by insects. The best method of storing beans is to mix the grains with 0.1% lindane dust a 250 g/100 kg, and dust 1.0% lindane at the rate of 50 g/bag when the seeds are stored in large granaries.

The beans are commonly boiled with maize, and eaten alone or with vegetables. In some parts, boiled or fried bean paste is also eaten with "ugali". Green bean pods and leaves are used as vegetable and spinach, respectively. Beans are also used as forage, manure, etc. Bean consumption is seasonal varying according to price and availability of other food stuffs.

Production constraints stem from the use of low yielding varieties, heavy disease and pest infestation, weeds, low nodulation and poor agronomic practices. Socio-economic problems such as cost and return of crop, labor, marketing, transportation of produce, lack of research and extension staff, together with lack of proper marketing organizations, are also important constraints.

In order to provide good quality bean seeds to farmers, Tanzania now has a well organized seed production and distribution system supported by seed multiplication farms, seed testing laboratories, seed companies, and a Seed Production Committee constituted by the Ministry of Agriculture, besides the official Seed Certification Agency.

The Ministry of Agriculture's research stations and institutes and the University of Dar es Salaam at Morogoro are conducting breeding, agronomic, entomological and pathological trials to improve the quantity and quality of beans in the country.

The work done so far has been encouraging. Four varieties, Tengeru No. 8 and 16 (canning bean varieties for export), T3 and Kabanima (for local use), have been released since the Bean Improvement Research Program was started in the country.

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Bean Production in Uganda

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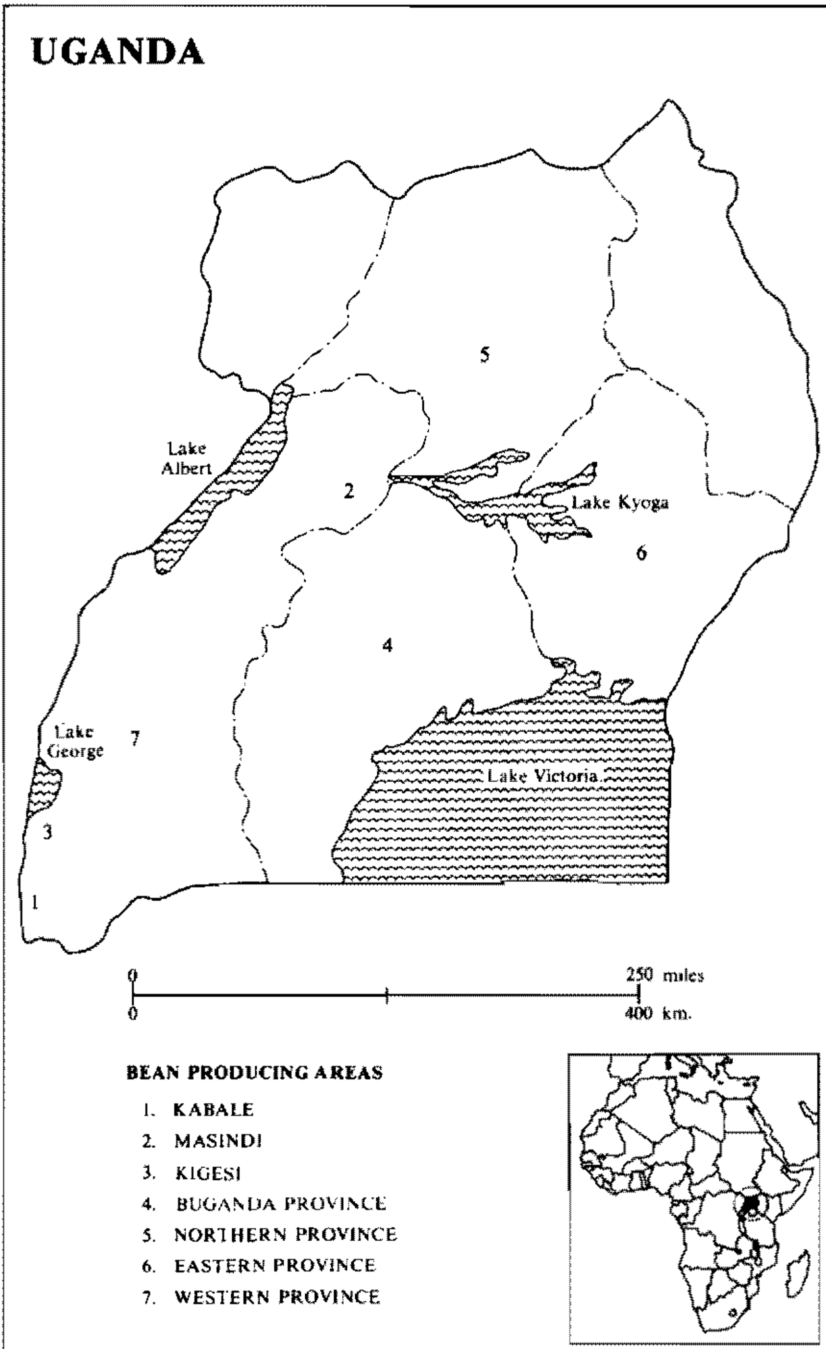
Importance of Beans

Uganda is an agricultural country, and the prime objective of its Department of Agriculture is to conserve its basic food supplies. Therefore, high priority is given to food crop production. Common beans (*Phaseolus vulgaris* L.) are one of the main crops grown for food, as illustrated in Table 1, which shows how the area devoted to beans compares with that used for the starchy food crops and the other grain legumes. The acreage under beans has been consistently exceeded only by the acreage under plantains (*Musa* sp.), ragi or finger millets (*Eleusine coracana* (L.) Gaerth), and sorghum (*Sorghum bicolor* (L.) Moench). More beans than cassava were planted in 1920, 1925 and 1930, but in later years cassava took over. Early in the century the acreage under sweet potatoes used to exceed that of beans but since 1950 the acreage has been quite close for both crops, and in 1955 and 1965 more beans than sweet potatoes were planted. The Department of Agriculture annual estimates show that since 1916 the beans acreage has consistently exceeded that of other legume crops grown in the country. Groundnuts are second in position. In terms of yield production, however, the figures for beans and groundnuts are often very close, and in some years more groundnuts than beans are produced (Anon., 1916-1971).

The importance of beans in Uganda is not only expressed by their large acreage but also by their role in the fight against protein-calorie malnutrition. This problem would be otherwise highly prevalent in the country since the basic food is mainly starchy food. This is shown in Table 2 which indicates the amount of protein in the different food crops used in Uganda.


UGANDA
5
Lake
Albert
2
Lake Kyoga
6
4
Lake
George
7
Lake Victoria
3
1
0
250 miles
0
400 km.
BEAN PRODUCING AREAS
1. KABALE
2. MASINDI
3. KIGESI
4. BUGANDA PROVINCE
5. NORTHERN PROVINCE
6. EASTERN PROVINCE
7. WESTERN PROVINCE

The 22.1% average protein content of beans is far more than the amount available in any of the staple foods. Therefore, beans clearly improve the otherwise protein-deficient diet of Ugandans.

Table 1. Average area under food crops in Uganda, 1920-1975.

Year	Area (000 ha)						
	Plantain	Cassava	Sweet potato	Millets	Beans	Ground-nuts	Pigeon and field peas
1920	243	6	91	170	37	9	53
1925	350	28	153	268	56	16	25
1930	333	70	159	363	84	39	37
1935	394	128	197	470	113	58	48
1945	335	191	193	593	151	143	63
1950	349	199	200	661	185	138	105
1955	566	233	209	700	214	170	89
1960	618	242	239	736	233	171	85
1965	553	447	348	864	371	233	106
1970	1425	538	373	893	373	250	92
1975	1097	618	550	796	407	243	93

Source: Annual Reports of the Uganda Department of Agriculture, 1920-1975.

Table 2. Calories and basic nutrient content in beans and other foods commonly eaten in Uganda.

Food	Calories (per 100 g)	Protein (%)	Fat (%)	Carbohydrates (%)
Kidney beans				
(*P. vulgaris*)	341	22.1	1.7	61.4
Maize				
(90-96% extraction)	360	9.3	4.0	73.5
Cassava flour	338	1.5	0.6	81.5
Sweet potato	121	1.6	0.2	28.5
Matoke (plaintain)	135	1.2	0.3	32.1
Ragi (finger millet)	329	7.4	1.3	77.1

Source: FAO Reports, 1968.

Types of Beans, their Introduction and Distribution

There is no exact information as to when beans were introduced in Uganda. However, Purseglove (1969) reported that they were brought by Spanish and Portuguese travellers. The influence of these people on the

Eastern Africa coast lasted between 1498 and 1740 (Matson, 1962). Therefore, a conservative estimate would be that beans arrived in Uganda in the 18th century. Although they have been with us for a relatively short period, there is no clear evidence of their status before the beginning of this century. The Department of Agriculture did not refer to bean cultivation in Uganda until Snowden (1913) reported that various edible beans were grown as green manure in a Kampala plantation. Uganda imports of beans between 1909 and 1913 were valued at £21, £34, £529 and £125 for each year, respectively (Anon., 1909-1915). Uganda seriously started growing beans in the 1920's with most of the introductions being made then (Mukasa1970).

The available cultivars vary considerably in their plant habit, agronomic and yield characters. The farmers traditionally grow land races. It is therefore possible to find the determinate, indeterminate and the climbers all in one field. The non-climbers are more widely cultivated than the climbers which tend to be of some importance only in Kabale district (see map). The white haricot types are popular in Masindi district but not elsewhere mainly because of the sliminess they acquire after cooking. Over the rest of the country the bean types generally have large plump seeds with soft taste. The seeds should imbibe water when dry so as to resemble the fresh seed in taste. Consumers prefer the large seeded, plump red-mottled types. The purple and red are next in preference while the pale and white colours are not liked. Small black-seeded types are hardly ever eaten except during times of scarcity and occasionally in the Northern region.

Bean Crop Environment

Uganda lies within 900-1500 masl, except for Kabale district which largely lies within 1500-2100 masl. Higher altitudes are those of mountains like Mt. Elgon, Mafumbira and the Rwenzori range. Crop farming, including bean cultivation, is practiced within 900 and 2100 masl. The climate of Uganda, with the exception of the mountains, is typically tropical and it favors bean cultivation. The mean monthly maximum temperature ranges between 22.2 and 23.9°C at Kabale, in the coldest zone, and 28.8-35.2°C at Kitgum, the hottest zone. Most of the country experiences two rainy seasons extending from March to May and August to December. However, in the north of the country the second rains come earlier than it would be expected from the zenithal position of the sun, and the two rainy seasons are sufficiently close together to constitute a single rainy season extending from April to September (Jameson, 1970). The Department of Agriculture recommends planting two crops a year in the bimodal rain season areas, the sowing dates being March-April and

August-September for the first and second season crops respectively (Anon., 1972). However, in the Lake Victoria crescent zone, rain falls almost throughout the year and here farmers tend to plant beans whenever they feel there will be sufficient moisture for the crop. The peak of planting is still at the beginning of each main rainy season; in the Northern part of the country. normally two crops, one after another, are raised within the one long rainy season. The growing of bush or climbing type of beans has no direct relationship with the length of rainfall. The rainy seasons are long enough to support a crop of any type of beans. What determines the type grown is the variety type of seed and the type of crop it is associated with. For example, in Kigesi climbing beans are grown in association with sorghum whereas in the Buganda, dwarf beans are interplanted with potatoes.

The Uganda soils are varied in texture and to a lesser extent in color and structure. The pH of the soils ranges from 5.0 to 6.8, but in Kabale district, a pH up to 4.2 is widely found. The farmers plant beans on any type of soil, and the crop will do well except on highly acid soils (Mukasa, 1970).

Bean Cropping Systems

Subsistence farming is the main farming system in Uganda. It is practiced all over the country, though to a lesser extent in pastoral areas like Karamoja, parts of Ankole and Teso. The farms are normally just a few hectares in size. Beans are one of the crops within this subsistence farming system. They are sometimes grown in a few large farms mainly owned by government departments. In the Rift Valley, irrigation farming is practiced and beans are grown under furrow irrigation.

Beans are normally planted in fields which have been previously used for other crops. This is because farmers feel this crop does not require much from the land in terms of fertility. It is only when beans are interplanted with other crops, that they will get a chance to grow on newly opened land. They are rarely planted in pure stand.

According to Department of Agriculture estimates (Anon., 1966), more than half of the bean plots are interplanted with other crops. These include cotton, cereals, groundnuts, sesame (simsim), cassava, potatoes and newly established coffee and banana plantations. The most common mixture is that of cereals and beans (Anon., 1966).

Farmers plant well below the optimal density even when they grow the crop in a pure stand. A rough estimate would be that they plant about 2/3 of the optimum density.

The spacing used in interplanting varies with the crop. For example, in Buganda region, when beans are interplanted with sweet potatoes, the bean seeds may just be broadcast immediately after planting the potato vines. In other cases the seeds are planted on top of each mound and less often in the interspaces between the mounds. In the Western region, especially in Kabale district, sweet potatoes are planted in ridges and the beans are planted in the inter-ridge spaces. When beans are interplanted with maize, cassava, coffee or plantain, they are sown as cover crops in the inter-row spaces. When planted in pure stand, the farmer normally uses a small hoe, cuts the soil and sows one or two seeds as he moves forward. In such cases the spacing comes to roughly 30 x 30 cm. This cut-and-sow practice is widely used all over the country and is found suitable for the non-climbing types of beans. However, in Kabale district, where climbers are sometimes grown in pure stand, planting is done in rows at a spacing of about 60 cm between the rows and 30 cm in the rows; when they are broadcast in pure stand, farmers will put a stick where a cluster of twining branches meets, so that more than one plant will make use of the same stick.

Traditionally, beans are planted on the flat areas; however, in the swampy areas of Kabale district, ridges are used for proper drainage. The Department of Agriculture (Anon., 1972) recommends to plant beans in a clean seed bed and then weed once or twice before flowering. This is generally practiced by the farmers. In research stations, however, it is often necessary to weed at least once after podding to ensure a clean crop at harvest time.

Bean cultivars grown in Uganda generally take 70 to 90 days to mature (Mukasa, 1970). It is estimated that beans stay on the field for 87, 95, 96 and 109 days in the Northern, Buganda, Eastern and Western regions, respectively (Anon., 1966). The crop stays longest in the field in the South West (Kabale district) because of the effect of low temperatures.

During harvesting, whole plants are pulled out and dried on the yard under direct sunshine. The seeds are then threshed out and further dried. The seeds considered dry and ready for storage have around 13.5 to 15% moisture content. The dry seeds are winnowed and then stored in tins, baskets or gunny bags and are put out in the sun periodically to avoid build up of weevil populations. In some areas, wood ash or banana juice are added to the seeds to protect them against storage pests. The discolored seeds are normally sorted out just before cooking, planting or marketing.

Production, Trade, Storage and Utilization

Production. The Department of Agriculture started to make annual estimates of the area under beans in 1916, which that year amounted to 54,675 ha. Figure 1 shows the average area devoted to beans from 1920 to 1975. It steadily increased from 1920, and by 1965 a tenfold increase had been achieved.

The annual estimates up to 1977 show that the largest area under beans in any one year was reached in 1971 with 459,000 ha of arable land under beans. In the following six years it ranged between 309,000 and 434,000 ha. On a regional basis, the Western and Eastern regions have devoted more land to beans than the other regions although in 1970 the Northern region had improved its position from one with the least acreage to one with the highest.

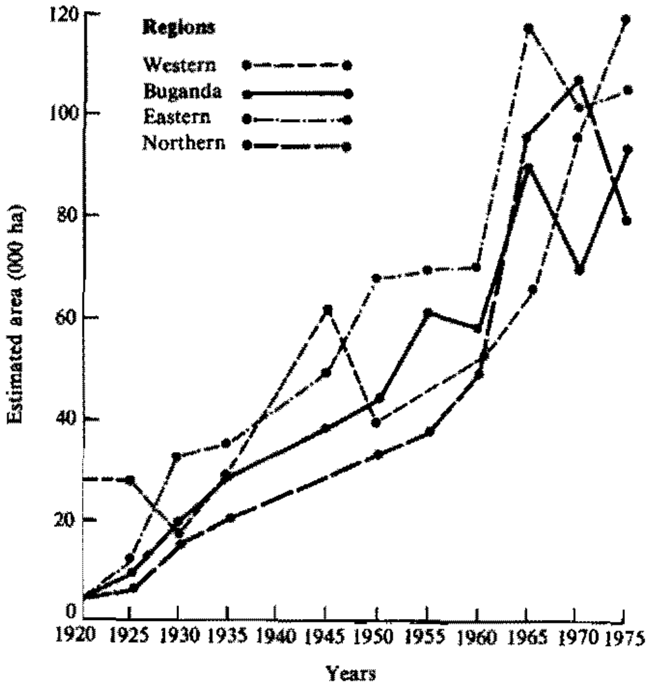


Figure 1. *Estimated area under beans in the different regions of Uganda.*
Source: Department of agriculture, Annual Reports.

It is difficult to estimate the amount of beans produced in the country. This is because of the yield fluctuations from crop to crop and also due to the fact that a farmer traditionally harvests several times from the same plot and consumes the fresh seeds; the rest is left on the field to dry. The yields vary from cultivar to cultivar, and the yields from mixed types of beans will therefore vary with the composition of the cultivars. The yields also vary depending on whether the beans are grown in a pure or mixed stand. Environmental and biotic factors also cause yield variations from location to location and from season to season. There is hardly any seasonal difference in the amount of beans produced, so roughly half of the yearly output will be produced in a season. Research data also show great fluctuations in cultivar performance even when high levels of management are practiced. In spite of the many factors affecting bean yield and production, attempts have been made to produce some yield estimates. According to Leakey (1970) the average yield is 560 kg/ha for beans in pure stand and 390-450 kg/ha for mixed crops. The annual production estimates are only available for recent years. Table 3 shows annual bean production between 1971 and 1977.

Table 3. Estimated bean production and area planted in Uganda, 1971-1977.

Year	Production (000 t)	Area planted (000 ha)	Calculated yield (kg/ha)
1971	221.8	459.0	483
1972	236.8	309.0	766
1973	170.4	359.0	474
1974	196.3	408.0	480
1975	325.8	407.3	800
1976	337.1	434.9	775
1977	252.5	338.3	746

Source: Unpublished data in annual reports of the Planning Division, Department of Agriculture.

Trade. Being basically a subsistence crop, beans are mainly grown for home consumption. However, some are left over for the markets as shown in Table 4. Buganda was leading in the amount of beans sold although it was not the leading producer (Department of Agriculture, Annual Reports, 1947-1952). This seems to be because people in this area used to distaste dry beans and used to sell them off in days of plenty.

Presently beans are better accepted as food in Buganda, and marketing is done with all regions in the country. In Kampala and other towns in the Lake Victoria crescent zone both fresh and dry beans are available in the market all year round (Nye, 1940).

The price varies slightly with the location and season but tends to be cheapest during the peaks of harvesting. The minimum government prices to be paid to farmers by licensed buyers during 1965 were 44 cents per kg of dry beans in Mengo district and 40 cents in the rest of Uganda*.

Table 4. Estimated amount of beans marketed in different regions of Uganda, 1947-1952 (in t).

Year	Region			
	Western	Eastern	Northern	Buganda
1947	337	141	-	2546
1948	143	-	-	1214
1949	106	-	4	4117
1950	250	-	4	4060
1951	256	-	1	1657
1952	135	-	-	1109

Source: Department of Agriculture, Annual Reports, 1947-1952.

In 1966 the price was 44 cents all over the country from January to June and 40 cents from July to December. The prices remained the same in the late 1960's. However, in 1971 a rise took place. One color beans sold for 50 cents while the mixed color types sold for 45 cents/kg (Anon., 1964, 1971). Further increases have occurred in recent years, and in 1978 one color and mixed color beans sold for SH 3.30/kg and 2.90/kg, respectively. The same sources indicate that in 1978 in the Kampala market, 1 kg of fresh beans in their pods sold for SH 15 on average, while 1 kg of dry bean seeds sold for SH 20. In September, 1979, fresh beans in their pods and dry seeds were selling for SH 30/kg and SH 40/kg, respectively. Beans are marketed by both private traders and a para-governmental body known as the Produce Marketing Board which started marketing beans in 1971 when it purchased 1355 t from farmers. Between 1972 and 1977 the board purchased an average of 85 t each year.** During the years 1978 and 1979 no purchases could be done by the board because of the low price it was prepared to pay to farmers as compared to the rising price offered by private traders.

In the 1960's Uganda beans were exported to Kenya. In later years there was no organized export system, but some beans were still being exported on an *ad hoc* basis (Table 5).

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* 1US$ = 7.5 U SH; 1 U SH = 100 U cents.

** The abrupt fall in tonnage was caused by the declaration of the famous "economic war" followed by the departure of Asians. The government failed to control prices because of shortages. As a result the Produce Marketing Board could buy very little from farmers because of the low government prices it was offering as compared to private buyers.

Table 5. Beans exported to Kenya and their value, 1966-1971.

Year	t	U SH
1966	7,488	3,672,940
1967	16,891	6,392,480
1968	6,135	2,863,140
1969	1,804	1,189,055
1970	5,820	5,146,301
1971	3,816	3,740,559

Source: Miscellaneous reports of the Produce Marketing Board (unpublished).

Utilization. Traditionally beans are grown largely for their full size fresh seeds which are harvested when the pods begin to ripen. The dried seeds from fully ripened pods are cooked after soaking but are less esteemed than the fresh beans. Cooked beans may be served whole or may be mashed and served as a sauce. Groundnuts stew or green vegetables may be added to the beans. The use of green pods as a vegetable was gaining grounds in urban areas in the 1960's but the trend was reversed in the 1970's when the green pods became too expensive for the consumers. In a few cases when other vegetables are scarce, the young leaves are picked just before the plant flowers. These leaves are steamed and served as a vegetable. In some cases the cooked beans are mashed and mixed with sweet potatoes and served with the gravy from the beans or with another sauce.

Since in most cases the bean crop is grown for home consumption, the family consumes as much of the crop as it needs when it is still ripe and fresh. Whatever dries on the field is processed and stored or sold off. Dry beans are popular in institutions like hospitals, schools and prisions.

Factors Limiting Production

Constraints to bean production in Uganda are mainly the lack of suitable cultivars, inadequate cultural and agronomic practices, diseases and pests. Some of these problems prevail because either research has not yet found the answers or the message has not yet reached the farmer. Also, the farmer may disagree with the recommendations as they imply in most cases extra cash or labor.

Cultivars. Most farmers grow land races. The cultivars which have been selected at research stations have made limited impact due to seed multiplication and distribution problems (see page 180). In the early 1960's

Banja, Mutike 4, Canadian Wonder, Bukalasa and Abundance were the cultivars improved and recommended for better seed type and yield (Leakey, 1970). These cultivars were commonly found at experimental and other government stations but their cultivation outside these centers was limited. In 1968, K20 was released. It is high yielding, palatable and has good resistance to three of the important bean diseases: bean anthracnose *(Colletotrichum lindemuthianum)*, angular leaf spot *(Phaeoisariopsis griseola)* and bacterial blight (mainly *Xanthomonas phaseoli)*. However, its spread in the country has bean limited due to seed production problems.

Fertilizer use. As would be expected from the variety of cultivars, soils, and crop husbandry practices, no generalized fertilizer recommendation can be made. Stephens (1967) obtained significant yield increases on the acid sandy loam Buganda soils after applying double super phosphate at a rate of 145 kg/ha: 180 kg/ha over a control yield of 530 kg/ha. In the same experiment, nitrogen, as ammonium sulphate, at a rate of 34 kg/ha, gave a mean increase of only 60 kg/ha over the control. He reported a significant interaction of nitrogen, phosphate and sulphur. At Namulonge, Jones, cited by Leakey (1970), working with much higher control yields, regularly obtained 25-50% yield increases with Banja 2 beans on a well balanced fertilizer mixture of 240 kg/ha each of calcium ammonium nitrate and single super phosphate, and 120 kg/ha of potassium chloride. In treatments with lime only, Jones obtained significant but reduced responses. Some fertilizer trials have been carried out on farmers' plots using Banja 2. In one group of experiments, nitrogen and phosphate fertilizers were applied at three levels in a factorial experiment. The best treatments varied with the locations, as shown in Table 6.

Table 6. A factorial fertilizer experiment with beans showing only the best treatments at several locations in Uganda.

Site	Soil type	Fertilizer	Yield (kg/ha)		Yield increase
			control	treated	(%)
Hoima	Clay loam	N_1P_1	1494	1733	16.0
Kariri	Clay loam	N_2	1227	1482	20.8
Sembabule	Brown loam	N_2P_1	963	1510	15.7
Bukomero	Brown clays	N_2	1289	1549	20.1
Koja	Yellow red loams	N_2	989	1052	6.3

N_1 = 125 kg/ha ammonium sulphate
N_2 = 250 kg/ha ammonium sulphate
P_1 = 125 kg/ha single superphosphate

Source: Fertilizer Development Extension Scheme, Kawanda (unpublished data).

Although this work was carried out in a few locations, it indicates the great variation in fertilizer requirements for particular areas of Uganda. Extensive work is required before countrywide recommendations can be formulated. In their absence, the Research Division of the Department of Agriculture offers to make individual tests on farmers' soils and give recommendations. However, these services are not used by most farmers, and therefore continued and unknown losses in bean yields occur due to the use of poor and depleted soils.

Planting times. One of the problems that affect bean production in Uganda is the time of planting. In a one-season trial at Kawanda, five planting dates were tested: beginning of March, mid-March, beginning, middle and end of April. The crops planted at the beginning and middle of March gave significantly ($p = 0.05$) higher yields than the other crops (Mukasa, 1965). This indicated that the bean crop should be planted early in the season and therefore timed for the right amount of moisture required for its growth. Most farmers, through experience, have an idea as to when beans should be planted. However, they generally plant whenever they feel there will be sufficient moisture for the crop. In some cases the farmer cannot plant his beans on time because of the work pressure at the beginning of the rainy season. Since beans are a short time crop (70 to 90 days), they are planted after other crops like maize, groundnuts, sweet potatoes and cotton. The consequences of untimely planting are threefold:

- Crops that are planted too early may suffer from excessive rain at harvesting time and the seeds may rot or be stained in the field;
- late crops may suffer from inadequate moisture, since part of the growing cycle may fall within the dry season;
- susceptible plants succumb easily to diseases and pests and continuously serve as a ready host as well as reservoir of inoculum.

Therefore, unless the crop is planted at the proper time, the yields may be drastically reduced due to environmental conditions. Although the proper planting time is known and observed al least on government farms, sometimes heavy yield losses occur due to unpredictable changes in the rainfall regime. This is a countrywide problem except on a few farms where irrigation is used.

Plant population. Optimum plant populations tend to be specific for cultivars with particular growth habits, soil fertility and moisture levels. It is obvious, therefore, that the optimum plant population is not known for any bean cultivar in the various areas of Uganda as no experiments have been conducted under controlled moisture levels in those areas. However, Mukasa (1965) evaluated a number of spatial arrangements (Table 7) using representative cultivars of determinate (Banja) and indeterminate habit (No. 35). He kept the 60 cm interrow spaces but varied the inrow spaces from — exactly — 2.5, 7.6, 15.2, 22.9, 30.5 to 45.7 cm. Generally the higher seed rates gave higher yields, but this depended, to a certain extent, on the amount of rainfall. Mukasa's data (1965) suggested that Banja should be planted 2.5 - 7.6 cm interrow during years with good rainfall, but in poor rainfall years higher interrow spacing would be desirable. With indeterminate cultivars he reported that 60 cm between the rows was suitable. This appeared to be a compromise for the plant's habits and is currently the Department of Agriculture recommendation. New cultivars which have come up from the breeding work at Kawanda, like K20, K113 and K114, have different growth habits from either Banja (determinate) or No. 35 (indeterminate). It may be necessary to re-examine their optimal spacing although they were selected at the 60 x 10 cm. spacing. It has not been established to what extent spacing reduces bean production in farmers' plots. This is because different farming systems are used. When the land races are planted with other crops, lesser yields are obtained than when harvested in pure stands. The pure stand yields have been estimated at 630 kg/ha. Those mixed with coffee or with cereals and all other crops are 490 and 350 kg/ha, respectively (Anon., 1967).

Table 7. Spacing and seed yield trials with beans at Kawanda and Bukalasa, 1963-1965.

Bean variety	Location	Year	Yield (kg/ha)						LSD
			60x46	60x30	60x23	60x15	60x7.5	60x2.5	(5%)
Banja 2	Kawanda	1963	705	712	1072	962	1117	1159	205
		1964	195	252	293	371	504	715	113
		1965	372	504	593	648	705	660	86
	Bukalasa	1963	1055	1456	1639	1645	1958	2116	253
		1964	1187	1672	1804	2054	1774	1891	395
		1965	515	639	646	943	792	804	199
No. 35	Kawanda	1963	315	367	393	407	432	366	N.S.
		1964	130	235	353	260	415	471	113
		1965	494	507	442	449	432	318	81
	Bukalasa	1963	1110	1509	1337	1651	1628	1286	N.S.
		1964	998	1198	1313	1436	1283	1436	268
		1965	766	925	943	998	1068	935	N.S.

Source: Kawanda Department of Botany, Annual Reports, 1963-1965.

Weeding. Beans, like other crops, suffer from weed competition. Mukasa (1970), showing no quantitative data, recommended to plant beans in a clean seed bed and to weed once or twice before flowering. Sakira (unpublished data) reported that the best results were obtained if weeding was done early between the second and third week from planting and that continuous weeding was uneconomic. Farmers try to weed the crop whenever it appears necessary but sometimes this cannot be done in time due to labor shortages. As a result the crop often suffers weed competition which reduces yields.

Diseases. Bean disease problems are very complex. When serious work on beans started in Uganda in 1960, efforts were directed to discover the causes of poor yields. It was claimed that disease was the most important factor limiting production (Mukasa, 1961). About 20 bean diseases have so far been identified, the important ones being anthracnose, *Colletotrichum lindemuthianun* (Sacc. and Magn.) Scribner; rust, *Uromyces appendiculatus* (Pers.) Unger; angular leaf spot, *Phaeoisariopsis griseola* Sacc.; and the bacterial blights: *Xanthomonas phaseoli* (E.F. Sm.) Dows, *X. phaseoli* var. *fuscans* (Burk.) Starr and Burkh and *Pseudomonas phaseolicola* (Burk.) Dows. The damage these diseases cause alone or in combination vary with the cultivar and environmental conditions. At their worst, the crop may be completely destroyed. Since 1960 the bean breeding program has emphasized selection and development of cultivars resistant or tolerant to these diseases. The two improved cultivars Banja 2 and K20, which have so far been released, have shown high resistance to most of the anthracnose races and to the bacterial blights. Cultivar Banja 2 has shown high resistance to rust, but K20 is badly affected in some seasons. Fungicidal control trials show that both cultivars are tolerant to angular leaf spot under Kawanda or similar conditions (Sengooba, unpublished). Unfortunately, these improved cultivars have had limited distribution because there is no efficient seed producing and distributing mechanisms. Therefore, farmers continue to loose unknown quantities of production due to the use of cultivars with low resistance to these diseases.

Pests. Important bean pests in Uganda have been listed by Ingram *et al.*, 1970, and include: Bean aphids *(Aphis fabae)*, bean fly *(Melanogromyza* sp.) and the pod borers *(Maruca* sp., *Heliothis* sp.). Ingram (1965), using early and late planted trials in Kabale districts, studied the effect of 0, 1 and 3 applications of menazon (Saphizon or Aphex 70) for the control of bean aphids. No aphid damage developed on the early planted crop but on late plantings (mid-May) the attack was so severe that flowering was totally prevented on the one-spray and control plots. Plots sprayed three times gave a few pods and a yield of 200 kg/ha.

This experiment was repeated using ten insecticides: menazon, endosulfan, fenitrothion, oxydemeton-methyl, phosphamidon, dimethoate, dicrotophos, bromophos, thiometon, formothion and an unsprayed control. None of them gave effective control. Ingram (1967) concluded that no worthwhile insecticidal control of *A. phabae* on beans would be achieved during the dry season and suggested that peas should be used as an alternative trap crop. Byaruhanga (1969) evaluated the use of 25% DDT, dimethoate and endosulfan for the control of bean aphids, thrips and borers under Kawanda conditions. The thrips were effectively controlled, but the populations of aphids and borers were low and, therefore, no conclusions could be drawn. The treatment showed no significant yield increase and it was therefore concluded that although the aphids, thrips and borers caused damage to the bean crops, the extent of the damage depended on environmental factors.

The bean fly can reduce the bean stand drastically, and severe damages have been recorded at times from different parts of the country. Nyiira and Byaruhanga (1972) investigated varietal susceptibility to the bean fly complex throughout twelve months. The infestations were higher during the dry months and lower in the wet periods. Greathead, cited by Leakey (1970), reported that most of the locally adapted lines were resistant to the bean fly due to their ability to produce adventitious roots and having sufficiently thickened hypocotyls to withstand parasitism. Control of bean flies is obtained by dressing bean seeds with aldrin or dieldrin at the rate of 14 g/3 kg seed (Anon., 1978). In general, field pests can cause severe damage but have been sporadic and localized, and consequently insecticidal treaments have not showed significant yield increments (Davies, 1970).

While field pests cause non-significant loss in bean production, the damage caused by storage pests is significant. Davies (1959) reported that storage pests of the Bruchidae family cause considerable damage and should therefore be controlled. Byaruhanga (1973) estimated that 22.9% weight of stored beans is lost due to storage pests. Davies (1959) recommended the use of 0.04% lindane dust at 227 g per 90 kg of beans. Lindane (gamma-BHC) has been used at research stations for control of these weevils but the results have not been satisfactory. Byaruhanga (1975) tested a number of insecticides for the control of storage pests in maize and the best results were given by malathion which was therefore recommended for other grain crops. Recently Karamura (unpublished) evaluated the effect of malathion and Pirimiphos-methyl, and his findings indicated that the latter is more effective (Table 8). Pirimiphos-methyl gave significantly better kill than malathion and is still under assessment for possible use to dress bean seeds in storage.

Table 8. Bruchids killed under different treatments at varying storage periods.

Period of storage (months)	Bruchids killed (%)		
	Malathion	Pirimiphos-methyl	Untreated control
1	0	87	2
2	42	99	2
3	69	83	6
4	49	92	12
5	26	91	19
6	32	73	20

Source. Storage Entomology Report. Kawanda Research Station, 1979 (unpublished).

The farmers try by different means to protect their beans from weevil damage. Some depend on putting their harvests out in the sun periodically, others use wood ash or banana juice to treat their seeds before storage. Ndyanabo (unpublished) evaluated the use of ripe banana juice for the control of bean weevils and found that it quite effectively protected the seeds apparently by hindering hatching of the bruchids (Table 9).

Table 9. Effect of ripe banana juice on bruchids and their damage to stored beans (*P. vulgaris*).[1]

Period of storage (months)	Treatment	Mean number of bruchids[1]		Bored beans[1] (%)
		dead	alive	
2	Banana juice	2.5	2.5	1.86
	control	0	928.75	73.68
4	Banana juice	11.0	10.0	1.96
	control	48.5	many	69.00
6	Banana juice	32.5	20.0	9.0
	control	783.7	67.0	78.88

[1] In 1000 g seed samples.

Source. Storage Entomology Report. Kawanda Research Station. 1976 (unpublished).

Description of Country Bean Program

Work on beans is carried out by the Research Division of the Department of Agriculture and by Makerere University. The program is based at Kawanda Research Station. Currently there are three projects: french bean breeding, white haricot bean breeding, and bean pathology.

French bean project. Prior to 1960 little research had been done on beans in Uganda. The Research Division had occasionally established observation plots and yield trials (Leakey, 1970, Mukasa, 1961). A few introductions were made of unimproved material with poor seed quality and relatively low yields. Between 1955 and 1957 a World Health Organization team carried out a survey in Uganda and reported a widespread occurrence of protein and riboflavin deficiency and an alarming prevalence of "kwashiokor" (malnutrition), especially among the children of plantain-eating segments of the population. The team recommended supplementing the deficient diet with animal or plant protein. In response, the Department of Agriculture started a bean breeding program, and Mukasa was assigned to work full time on bean improvement (Leakey, 1970). Its main objectives were to provide the farmer with high-yielding and disease-resistant cultivars of desirable agronomic types and locally acceptable culinary qualities (Mukasa, 1961). From the beginning of the program, it was apparent that diseases were the main factor limiting yield potential. Emphasis was therefore put on selecting disease resistant materials. The agronomy of the beans had also to be taken into account but no full time agronomy program was started.

By 1960 there were only 50 cultivars which had been collected by Hirst (Leakey, 1970). The first step was therefore to put together a collection of land races and cultivars available in Uganda. Most of the land races which came in were highly mixed and had to be hand sorted, first according to their seed characters, then planted and again sorted on similar growth habit, pod appearance and maturity period (Mukasa, 1971). Introductions were made from Britain, U.S.A., Holland, Ecuador, Sudan, Venezuela, Australia, Israel, Brazil, France, Belgium, Peru, Guatemala, Bolivia, Nicaragua, Kenya, and Tanzania (see collection book at Kawanda). In addition, 130 lines were added resulting from the breeding work (see collection book). At the moment there are some 700 cultivars in the Kawanda collection.

Anthracnose was severe during the wet early part of 1960. Mukasa (1960) used this opportunity to screen the collection for anthracnose resistance. Among the cultivars screened, No. 86, No. 37 and No. 35

(Anon., 1961) were apparently resistant or tolerant to diseases especially to anthracnose, and high yielding. Attempts were made to select from Mutike 4, and four anthracnose-resistant lines were selected and bulked. In one quarter of an acre planted with Banja, 13 plants showed resistance to anthracnose. These were grown in progeny rows and artificially inoculated using diseased bean straw. Five lines were confirmed resistant, three of which were bulked to form Banja 2, which matured earlier, outyielded the original Banja and was resistant to all anthracnose races except the gamma race.

The hybridization programs have all been geared towards the four objectives listed (page 171). In the first hybridization program, a cross between Banja 2, resistant to anthracnose, and No. 15, a palatable line, was made. Two promising lines were obtained which were subsequently crossed to No. 77 for good seed characters and resistance to angular leaf spot, and to No. 78 for vigor and resistance to angular leaf spot (Leakey, 1970). The segregating progenies from these crosses gave rise to a number of promising lines many of which can be found in the breeders collection. Lines K12, K18, K19, K20, and K28, which outyielded Banja 2 (Tables 10, 11) were selected from these crosses.

Mutike 4 which had at one time been one of the recommended varieties with desirable large seeds and field tolerance to most diseases was used as a common parent to which Banja 2, No. 77 and No. 78 were crossed. In addition to donating resistance to anthracnose (Banja 2) and to angular leaf spot (No. 77 and No. 78) Banja 2 and No. 77 were also used to lighten the seed coat of Mutike 4 to that of the desirable red mottle bean. The resultant F_1 generations were crossed to each other. Line K25 was selected for its outstanding resistance to all races of anthracnose occurring in Uganda.

In 1963-64 an attempt was made to form a type of composite cross with a wide genetic base as is done in outpollinated crops. Twelve cultivars: three black seeded, vigorous, disease resistant types; three popular food types; three imported large seeded, determinate types; and three good quality but disease-susceptible ones were crossed in pairs. Crosses were then made among the F_1 and F_2 generations. The resulting population was left to breed naturally for three generations giving rise to what was looked at as a panmixia population. There was no outstanding line from this cross, but the few selected ones were useful breeder material for their wide genetic base. Leakey (1970) made diagramatic illustrations for all the crosses mentioned above.

Table 10. Variety trial and yield results in bean districts, 1970.

Bean variety	% of Banja 2	Yield (kg/ha)									
		Mubuku	Bukulasa	Kawanda	Namulonge	Namyoya	Nabbongo	Kibale	Aduku	Abi	Mean
Banja 2	100	1899	607	426	952	1356	1546	665	317	152	785
K12	111	1763	727	542	1134	1492	1641	-	347	152	870
K18	110	1899	773	607	1068	1627	1627	489	447	149	861
K19	110	1356	806	727	1242	1763	1587	569	529	149	865
K20	118	2170	708	537	1102	1763	1831	692	401	124	925
K22	106	1899	741	800	1050	1627	1410	529	206	136	833
K23	112	1899	876	735	1031	1492	1574	-	204	105	883
K24	112	1763	764	724	1022	1763	1438	-	241	155	878
LSD 5%		256	NS	93	90	187	NS	NS	111	NS	

Source: Botany Annual Report, Kawanda Research Station, 1970-71.

Table 11. Variety trial and total yield results, bean districts, in second season, 1972.

Bean variety	Yield (kg/ha)																
	Bukulasa	Namulonge	Kawanda	Namyoya	Kyembogo	Bulindi	Mubuku	Kigumba	Kibale, 1st. season	Nabbongo	Ikulwa	Serere	Abi	Aduku	Mean for 1972	Mean for 1970, 1971, 1972	% of Banja 2, 1972	% of Banja 2, 1970, 1971, 1972
Banja 2	909	1440	2034	1926	697	949	1180	271	755	461	1845	1112	457	596	1045	954	100	100
K28	1032	1769	1370	2781	770	922	1343	434		665	1926	1167	388	651	1191		114	
K19	963	1906	2007	2495	823	949	1289	353	1010	407	2007	1085	315	596	1158	1074	111	113
K20	990	1847	1831	2238	825	896	1274	325	961	340	2170	1085	105	665	1111	1087	107	114
K12	515	1606	1288	2455	718	841	112			447	2170	976	163	611	1075	1031	103	108
K18	1003	1603	1654	2509	650	896	1031	285	1145	516	1872	867	399	611	1074	1059	103	111
K17	731	1654	1112	2103	820	976	949		857	289	1845	896	321	705	1020		98	
K22	692	1901	1208	2075	732	922	760		814	289	1926	407	157	705	974	959	94	101
LSD 5%	217	211	353	312	NS	NS	271		NS	25	NS	NS	138	NS				
C. V. %	18.6	9.49	17.5	10.5	14.4	9.6	10.5		43.3	25.6	19.1	13.0	37.1	19.4				

Source: Botany Annual Report, Kawanda Research Station, 1972-73 (unpublished).

The crosses from 1961 to 1966 have formed the nucleus for further improvement. In 1969 single crosses were made between two lines selected from the 1963-64 hybridization program and eight lines from 1964 crosses of Banja 2, No. 15, No. 77, and No. 78. The best lines from this program are included in the collection from K71 to K105. Table 12 shows their performance in evaluation trials as compared to K20.

In 1971 Mukasa tried to further improve the yield, general resistance and palatability of K18, K19, and K20. He used Leakey's selection No. 345 and K25, both of which have similar characteristics. Single crosses were made and the pedigree method was used in selecting from the segregating progenies. After only four to five generations, seven improved lines were selected as follows: line K111 from cross No. 345 x K20, lines K112, K116, K119 and K121 from cross No. 345 x K19; line K114 from cross K25 x K18; and line K113 from cross K25 x K20. Unfortunately, it has been very difficult to obtain reliable figures from the districts, but whenever data were available, all these lines have outyielded K20 in every season at different locations. Table 13 gives yield figures of the preliminary yield trials at Kawanda.

In addition to Kawanda, Makerere University has also been working on bean breeding since 1967. In that year Leakey (1970) used some lines from the Kawanda hybridization program for testing at Kabanyolo at high fertility level and low disease incidence.

The superiority of K20, however, was not superseded by these selections, and a hybridization program was then initiated. Later, an induced mutation program was started in 1972. The performance of some of the elite selections in this program is shown in Table 14.

The trial at Kawanda was planted in very wet weather up to flowering; then dry conditions set in. The initial wet growing conditions encouraged rust and angular leaf spot diseases, and the dry conditions at podding time resulted in the observed reduced yields normally expected in the first rain seasons. The second rainy season at Kabanyolo was dry initially and became wet after flowering. The plants could not benefit from the wet conditions, especially those that had started flowering, resulting in low yields. The first rain seasons of 1978 came earlier than expected and then disappeared resulting in abnormally low yields at Kawanda.

Table 12. Variety trial and yield results in bean districts, second season, 1973.

Bean variety	Yield (kg/ha)											
	Bukulasa	Kawanda	Kamenyamiggo	Kigumba	Mubuku	Serere	Abi	Aduku	Namyoya	Bulindi	Nabbongo	Variety Mean
K20	1036	1069	807	680	1819	889	413	1634				1043
K79	1818	1514	987	738	2298	908	671	1995				1366
K84	1753	1508	1017	557	1613	715	413	1625				1150
K71	1538	1386	777	724	1656	818	498	1737				1139
K85	1411	1206	658	613	1532	748	511	1680				1044
K88	1460	1176	807	448	1532	565	470	1478				992
K86	1582	1302	718	473	1301	476	579	1248				959
K83	1520	1178	867	434	1263	370	470	1283				923
K20									1272	953	1166	1130
K77									1549	979	1674	1400
K78									1411	842	1913	1288
K70									1367	1169	1375	1303
K76									1291	953	1614	1286
K80									1286	842	1614	1247
K82									940	1182	1076	1066
K75									1125	815	1136	1025
LSD 5%	448	164	NS	359	341	359	268	302	NS	388	68	
C.V. %	10.7	9.8	26.2	2.2	16.2	19	18.7	16.7	24.7	20.4	19.6	

Source: Botany Annual Report, Kawanda Research Station, 1973-74 (unpublished).

Table 13. Bean yield trial at Kawanda, 1973-74.

Bean variety	Yield (kg/ha)			Average
	1973, 2nd.	1974, 1st.	1974, 2nd.	
K20	1375	1866	1208	1483
K111	1938	1733	1300	1657
K112	1812	1983	1325	1706
K113	1980	2183	1616	1926
K114	1602	2208	1500	1770
K116	1458	1858	1766	1694
K119	1442	1800	1225	1489
K121	1602	1958	1433	1664

Source: Botany Annual Report, Kawanda Research Station, 1973-74.

Table 14. Seed and protein yield of selected Banja 2 mutants and controls at two testing centers, 1972.

Bean variety	Seed yield (kg/ha)				Protein yield (%)
	Kabanyolo		Kawanda		Kabanyolo
	2nd.rain 1977	lst.rain 1978	lst.rain 1977	lst.rain 1978	lst.rain 1977
Banja 2 *	887	568	1150	558	23.4
K20 **	735	272	1208	550	-
Rwanda 9 **	700	1016	1025	350	25.4
B 17/2/3/5	1057	1170	2991	64	24.2
B 11/2/5/2	609	1101	1075	566	24.2
B 21/2/12	805	1509	1125	316	22.8
B 14/1/3	618	975	-	-	23.7
B 7/1/1	599	975	-	-	23.9
B 7/1/2	638	899	-	-	24.2
B 17/p/3/1	1063	1128	-	-	24.2

* Parental line
** Control varieties

Source: Rubaihayo, P.R. The performance of Gamma-ray induced mutants of three pulse crops *In: Seed Protein Improvement by Nuclear Technique*. IAEA, Viena, 1978.

Haricot bean breeding. Haricot beans have not received much attention in Uganda. Most selection work of rust-resistant types was done in Tanzania, and their selection, Mexico 142, with seed acceptable for canning purposes, was introduced in Uganda in the late 1960's.

Makerere has a program to improve the Mexico 142 seed protein and yield through hybridization and induced mutations. Under the mutation program, Mexico 142 was treated with gamma rays, and among the superior lines obtained are 7/2/2/4/7, 7/6/3/3, 14/4/1/7, 7/2/20 and 7/2/38, which proved high yielding (Table 15) and resistant to rust. Unfortunately, some have shown susceptibility to bacterial blight.

Explanations given in connection with Table 14 also apply to these results. In both tables instability of performance by different mutants and varieties is obvious indicating the high influence of the environment on genotypic performance.

Table 15. Seed and protein yield of selected Mexico 142 mutants and controls at two testing centers, 1977-78.

Variety	Seed yield (kg/ha)				Protein yield (%)
	Kabanyolo		Kawanda		Kabanyolo
	2nd.rain 1977	lst.rain 1978	lst.rain 1977	lst.rain 1977	lst.rain 1978
Mexico *	622	2224	583	500	26.5
Kabacuara **	1339	3156	991	583	28.5
Nep2**	817	3071	1233	583	26.5
7/2/20	738	2625	1000	683	29.3
7/2/2/14/3	841	1368	925	725	29.3
7/2/38	967	2605	1083	614	29.5
7/2/2/4/7	732	1796	1258	783	28.5
21/2/20	1864	2464	1073	708	28.2
21/2/14/4/2	1128	2493	983	750	27.0
24/4/7	873	1764	1300	658	29.0

* Parental line
** Control varieties

Source Rubaihayo, 1978, *op.cit.*

Bean pathology. As soon as it was observed in 1960 that disease was a major factor limiting production, a pathologist was appointed to work alongside the breeder. He first carried out a survey and identified the main bean diseases and their causal organisms. Useful cultivars in the collection —as determined by the breeder— were periodically planted in different parts of the country. Presently 220 cultivars are included in this trial. Its purpose was then and still is to study and keep a watch of the changes in disease incidence and severity on the different cultivars. In particular, these trials are used to detect new anthracnose races.

Fungicidal spraying trials were conducted and yield gains were obtained though sometimes insignificant. Simbwa-Bunnya (1972) conduced a fungicidal spraying experiment and reported that of the four fungicides tested for control of bean diseases at Kawanda Research Station, Dithane M45 (zinc + maneb) was the most effective at the rate of 3.4 kg/ha. This Dithane M45 treatment gave the highest increase in yield which amounted to 135% and 43% over the control during the first and second trials, respectively.

In recent years, Sengooba (unpublished) carried out a series of angular leaf spot-fungicidal control experiments using Dithane M45, Brestan 60 (triphenyl-tin acetate) and Benlate [Methyl (butilamine carbamyl) benzimidazole carbamate]. Cultivar Banja 2 was used, and the variables were rate, frequency and number of applications; with each of the three fungicides the most effective control was given by the weekly applications. The best treatment was with Benlate sprayed at the rate of 1 kg/ha during the three seasons the trial was in effect. This reduced the number of *Phaeoisariopsis griseola* lesions per leaflet to 0.7, 1.7 and 9.5 as compared to 89.7, 32.4 and 56.0 which were recorded on the controls. Spraying was started at two weeks from planting and the number of applications was varied from one to seven. The plants sprayed at least four times with either Benlate or Brestan 60 or those sprayed five times with Dithane M45 had significantly less disease than the controls. A slight infection of rust and floury leaf spot *(Ramularia phaseoli)* developed on the crop; the disease was effectively controlled by all the three fungicides while rust was only controlled by Dithane M45 and Brestan but not by Benlate. The yield data revealed no significant differences in yields of the plots under different treatments. It was concluded that it was not economical to use fungicides on Banja 2 under Kawanda conditions.

Research on pathological aspects was first centered on bean anthracnose. Specimens were continuosly collected from different parts of the country. The isolates so obtained were typed using Schreiber (1932) and

Hubberling (1961) differentials in order to establish *Colletotrichum lindemuthianum* races present in Uganda. Leakey and Simbwa-Bunnya (1972) reported that the Uganda results tend to confirm the separation of races into two major groups: 1) a group comprising Alpha and the related Delta races is pathogenic chiefly on small-seeded viny and indeterminate bush cultivars; 2) a group of Beta and the related more virulent Gamma races which is mainly pathogenic on determinate bush cultivars especially those with large seeds. Presently it is the pathologist's task to collect and maintain isolates of these anthracnose races and test the breeder's promising lines whenever requested.

Some work has also been done on the epidemiology and control of angular leaf spot. The variation in the pathogenicity of the causal organism, the transmission and the effect of environment of the development of the disease have been investigated. Results indicated much variation in the pathogenicity of a number of P. *griseola* isolates. However, it has not been confirmed how stable this variation can be. The fungus has been found to be seed borne and straw borne but the main source of inoculum appeared to be the volunteer and off season crops. The disease development was favored by both high relative humidity and rainfall, and the best temperature, as determined by both laboratory and field studies, was around 23-27°C; 30°C was found be too high for this disease.

Other than selection, no work has been done yet on rust and the bacterial blights in the Research Division. However, Howland and Macartney (1966) collected rust samples from Uganda, Kenya, and Tanzania. The rust isolates were types using Dr. Zaumeyer's differentials (obtained from Beltsville) and eight races were identified. Six of these races were found to occur in each of the three countries, often together in the same locations; more than one race may be found on one plant.

Seed Production and Distribution

In 1968 the Government of Uganda initiated efforts with the assistance of the British Government to set up a Seed Multiplication Scheme (SMS); beans have been one of the main seed crops handled under this scheme. The breeders, who are actually government breeders, release their varieties through a National Research Committee and the variety is handed over to SMS which is also government run. Material goes through the traditional process of classification as foundation, registered and certified seed before it is eventually purchased by farmers for commercial production.

At the time of initiation of the project, seed production, except for foundation seed, was done under contract with private growers and under supervision of SMS officials. The growers would be given seed, assisted with ploughing their farms, and the harvest was collected by SMS for processing. This system worked reasonably well for some years until about 1974 when most of the seed was lost to the open markets due to the price differential.

Since 1977, the seed has been produced on government seed farms operated by SMS itself. The main problem resulting from this system was the lack of multiplication seed. The situation was worsened by the Liberation War, at which time SMS suffered severe damage. The dry seed is processed by the seed factory, where seeds are cleaned, graded, and dressed with Fernsan-D (a fungicide-insecticide containing Thiram and gamma-BHC) and packed for sale or further multiplication. The seed is marketed by the Uganda Cooperative Central Union, a farmers' primary association through which, it is anticipated, the seed will reach them. Pricing of the seed is periodically reviewed by a seed pricing committee which is formed by the SMS management, Union officials, Department of Agriculture officials and a farmers' representative. The bean seed is currently packed in a 7 kg pack which sells at U SH 47.50 and plants 0.1 hectare.

It is estimated that 500 tons of bean seed would be required to meet the annual demand. The SMS has never been able to meet more than a fifth of this due to various problems.* Recently, however, the Uganda Government and the European Economic Commission have worked out a program to boost seed production, which should improve the situation.

Achievements

- The breeding program has made available to farmers two improved high yielding and acceptable disease-resistant cultivars. There is promising and higher yielding material in the pipeline.

- The variation in the pathogenicity of bean anthracnose, angular leaf spot and rust-causal organisms, as they occur in Uganda, is fairly well understood. The screening for resistance to anthracnose and angular leaf

*SMS problems are again a result of the "economic war": transport for seeds and seed inspectors became increasingly difficult, labor was difficult to obtain as many workers acquired former Asian shops and moved to the city or small towns. Like the Produce Marketing Board, SMS was also offering low prices to growers as compared to the open market.

spot can therefore be done under artificial conditions and the results are obtained faster than in field conditions. Unfortunately, in the case of rust isolates of the various races and differentials are not available.

- Though not yet exhaustively, the use of fungicides and insecticides has been evaluated and suitable procedures have been identified.

Future Plans

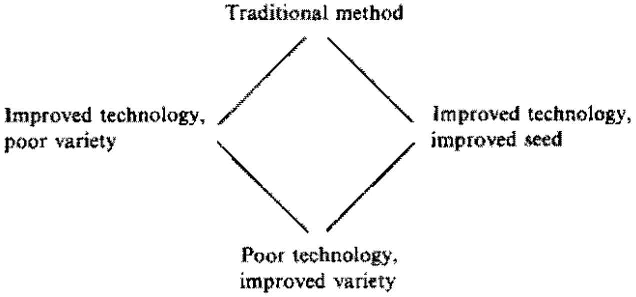
Pathology: More work will be carried out to establish or to keep track of the variation in pathogenicity of the organisms causing the important diseases in the country. Research will be carried out also to identify faster methods for testing breeder lines for disease resistance.

Breeding: Development of high yielding, disease-resistant varieties with improved protein content and quality, cooking quality and better plant architecture.

Agronomy: Research is needed on optimum populations in relation to spatial arrangement and density. Intercropping trials will be revived, as well as fertilizer trials. Chemical weed control methods will be looked into.

Effects of planting dates will be investigated in connection with the nitrogen flush which occurs during the first two weeks of rainfall.

Extension: Demonstrations on selected farmers' plots will be done using the diamond method so that the rest of the population can see the benefits of improved technology:



Summary

Beans are one of the main food crops in Uganda. They are an important source of protein since animal protein is limited and expensive. A wide range of land races and improved cultivars are grown in association with other crops; no irrigation is used. Beans are eaten fresh or dry or sold locally. There is little export of this product.

The main factors limiting production are the use of unimproved seed, incidence of diseases and pests, poor agronomical and cultural practices. Research on those problems has been done but not exhaustively. The beans research program has been involved in producing acceptable high yielding, disease-resistant varieties. A great emphasis has been put on isolating and identifying disease-causing organisms. Some work on haricot beans involving the use of mutagenic agents has been done at Makerere University with some promising results. Unfortunately, the breeders' material has not spread widely due to seed production problems.

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Bean Production in Zambia

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Importance of Beans

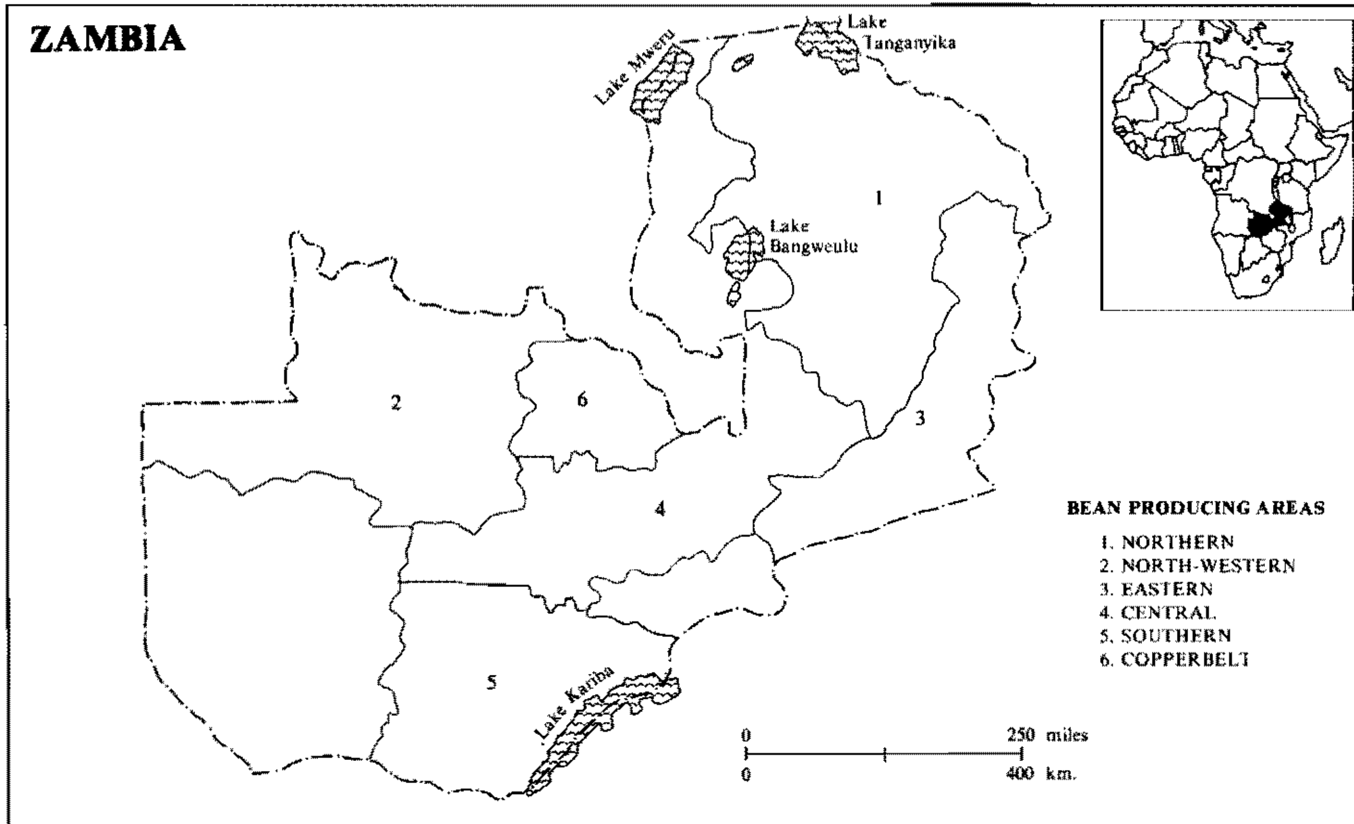
As it is the case in other developing countries, the importance of protein in the human diet in Zambia cannot be overstated. While animal protein is available, it is often beyond the financial resources of most of the Zambian population. In this context, the importance of edible legumes as sources of protein as well as other nutritional requirements is evident.

Legumes are grown throughout the country, the most common ones being groundnut (*Arachis hypogaea* L.), groundbean or bambara groundnut (*Voandzeia subterranea*), cowpea (*Vigna sinensis*) and beans (*Phaseolus* spp). The popularity of beans among the population is underlined by their ubiquitous presence in most markets as well as their very high prices.

Recognizing the importance of beans in the local diet, the Government of the Republic of Zambia embarked on an ambitious breeding program in the early sixties to develop suitable varieties for production. Recently in 1978 the Government took another important step to boost production by liberating market prices of beans and bean seed.

Types of Beans, their Introduction and Distribution

The most widespread bean is the common or field bean *(Phaseolus vulgaris* L.). Apart from occasional variety introductions, most of the available varieties were imported from South Africa or from neighboring


ZAMBIA
Lake Mweru
Lake Tanganyika
Lake Bangweulu
Lake Kariba
1
2
3
4
5
6
BEAN PRODUCING AREAS
1. NORTHERN
2. NORTH-WESTERN
3. EASTERN
4. CENTRAL
5. SOUTHERN
6. COPPERBELT
0
250 miles
0
400 km.

countries and Europe. Smallholders in the villages grow their own mixed strains and very occasionally pure stands of white, speckled sugar or yellow sugar beans. The officially recommended variety Canadian Wonder (first introduced by the Chitambo Mission about 1937) was never really accepted by the Zambian farmer. This is not surprising as the variety, originally bred as a green snap bean, has poor cooking qualities as a dry bean. Various speckled sugar bean strains for use as dry beans, and Victory and Long Tom as snap beans, were also available.

Beans were in evidence in the North and Northwestern provinces, and practically absent in the South. They appeared in the Eastern, Central and Sothern provinces in the sixties. Thus beans are currently found in almost all areas of Zambia (see map).

Bean Crop Environment

Bean varieties have been selected primarily for high rainfall areas (1100-1500 mm per year) mostly in the North, although the crop is planted in lower rainfall areas (700-1000 mm per year). The altitude, rainfall, temperature ranges, and soil types in the different bean production areas are summarized in Table 1.

Bean Cropping Systems

Cultural practices. Beans are grown either under improved management on a commercial basis or under traditional management as a subsistence crop. The time of planting varies according to location but it is usually between the beginning of December and the end of February, Commercial production practices are detailed in Advisory Sheet No. 10 (Anon., 1979). Under traditional management, oxen or hand cultivation by hoe are used. There is no specific planting time as long as sufficient soil moisture is likely to be available. The main crop is planted during the rainy season, while a dry season crop is not unusual, especially in "dambos" (depressed areas of high moisture content). The crop is grown mostly on ridges or mounds, usually intercropped with maize (*Zea mays* L.), sweet potatoes, groundnuts (*Arachis hypogaea* L.) or cassava (*Manihot esculenta*). Fertilizer is not applied, and the plant population varies considerably.

Farming systems. At the commercial level beans are grown as a sole crop in rotation with other crops, while in traditional systems it is intercropped with maize, sweet potatoes, groundnuts or cassava. To improve soil texture and nutrient content traditional farmers incorporate grass into the soil.

Table 1. Bean crop environment in bean growing provinces of Zambia.

Province	Altitude (masl)	Rainfall (mm)	Temperature (°C)					Soils
				Maximum		Minimum		
			Mean	October	July	October	July	
Northern	1200-1700	1100-1500	17-22	30-32	15-21	15-17	8-12	Strongly leached red clays, red brown loams or sandbelt.
Central and Southern	1000-1300	750-1000	22-30	30-35	20-25	15-20	5-10	Sandbelt, red brown loams, red and black clays (moderately leached)
Copperbelt	1200	1000-1500	17-22	30-32	22-25	15-17	5-7	Leached and sandbelt
Eastern	1200	900-1100	20-25	30-35	22-27	15-20	7-12	Red brown loams or sandbelt.

Source: Soils and Weather Maps, Soil Survey Unit, Mount Makulu Research Station, Chilanga, Zambia.

Irrigation. It is primarily used by seed growers who avoid rainy season plantings in order to minimize disease problems.

Production, Trade, Storage and Utilization

Producing areas, yield levels, production statistics. Major bean production is in the high rainfall areas of the Northern and Northwestern provinces followed by medium rainfall areas (700-1100 mm) in the Eastern, Central and Southern provinces.

Yields vary with type of management applied. In traditional farming systems yields average 400-600 kg/ha, while improved management can boost them to 800 kg/ha. Under commercial management, expected yields vary between 800 to more than 1000 kg/ha and some go as high as 1000-2000 kg/ha.

Production statistics (Table 2) of marketed dry beans are not representative of actual production because a considerable proportion of the beans never reaches the National Agricultural Marketing Board or Provincial Cooperative Unions as the beans are either locally consumed or marketed.

Table 2. Bean production in different provinces of Zambia for the period 1971-78.

Province	Production		
	In 1971-78 (t)	Total %	Per year (t)
Central and Lusaka	172.08	9.60	21.51
Copperbelt	36.72	2.05	4.59
Eastern	282.69	15.78	35.34
Luapula	67.77	3.78	8.47
Northern	956.52	53.39	119.57
North Western	41.49	2.32	5.19
Western	53.10	2.96	6.64
Southern	181.35	10.12	22.67
Total	1791.72	100.00	223.97

Source: Department of Agriculture, Annual Report of the Extension Branch, 1978, Lusaka, Zambia.

In 1976, 626 tons of preserved beans valued at Zambian Kwacha* 311,000 were imported (Annual Statement of External Trade, Central Statistics Office, Lusaka). Thus, production is still far short of the demand. In the Third National Development Plan of the Republic of Zambia, the total internal demand for beans by 1983 is estimated at 21,000 t, while production is estimated at 30,000 t.

Marketing channels and prices. The bulk of the beans produced is sold as dry beans, but green snap beans are also marketed. Produce can be sold to the National Agricultural Marketing Board or to the Zambia Horticultural Company. Individual farmers can also sell their produce to supermarkets or to individuals who resell it in open markets; farmers may also set up their own stalls at the open markets. As a result of high demand and short supply of beans, the price of dry beans has reached exhorbitant proportions. The latest price of dry beans in supermarkets was Zambian Kwacha 2/kg.

In order to boost production and thereby stabilize bean prices the Government freed prices in 1978.

Storage practices. Home storage is practiced on a small scale. Insect infestation and damage are avoided in various ways: by mixing beans with malathion dust (100 g or 0.1% a.i. per 90 kg seed) and placing them in a container or tight storage bin.

Also, beans are mixed with sand and placed in containers. The sand prevents movement of the insects thus precluding mating and subsequent laying of eggs. Injury from scraping with the sand leads to dehydration and eventual death. Beans are also treated with oil or ash and stored in a tightly closed container. They are less commonly stored in airtight containers: depletion of the oxygen supply leads to death of insects that may have gained access into the container at the onset.

In large scale storage, beans are packed in bags whose surface is sprayed with fenotrothion or Pirimiphos-methyl, and stacked in a storage room. The room is fumigated with methyl bromide every four months.

Utilization. While most of the currently recommended bean varieties are popular, consumers prefer certain types, such as those which require shorter cooking time. Color preferences are for white, yellow and speckled sugar beans.

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* 1 Kwacha = US$ 1.25

The different parts of the plant are utilized in various ways. Dry beans are boiled in different ways and consumed as such, or they are pre-cooked and preserved in cans. Dry beans are also utilized for the preparation of "kachasu", a distilled alcoholic beverage.

Green, stringless beans are cooked in various ways. Beans are also consumed green, that is, near physiological maturity. Shelled green beans are boiled as a vegetable as are the tender green leaves to which groundnut flour is sometimes added.

Factors Limiting Production

Biological

Bean varieties. Before 1966, absence of any systematic varietal selection particularly for resistance to diseases made bean cultivation difficult. With the inception of the bean breeding program in 1966, and the subsequent introduction of selected varieties (Table 3), there has been considerable improvement in bean production.

Diseases and pests. Diseases which can reduce bean yields in Zambia are listed below. The first six are probably the most serious: anthracnose *(Colletotrichum lindemuthianum)*, angular leaf spot *(Phaeoisariopsis griseola)*, rust *(Uromyces appendiculatus)*, scab *(Elsinoe phaseoli)*, halo blight *(Pseudomonas phaseolicola)*, common blight *(Xanthomonas phaseoli)*, root knot nematode *(Meloidogyne* spp.), leaf spot *(Alternaria* sp.), target spot or Ascochyta leaf spot *(Ascochyta phaseolorum)*, mildew *(Oidium* sp.), ashy stem blight *(Macrophomina phaseoli)*, and collar rot or Southern blight *(Sclerotium rolfsii)*.

The most important bean pests are: beanflies *(Ophiomyia* spp.) which can greatly reduce stands, and leaf eating beetles *(Mylabris* sp.).

Nodulation. Inoculum application with *Rhizobium* strains is not a recommended practice at present. Limited experimentation during 1970-71 did suggest that inoculum application could be beneficial at low rates of nitrogen application. The Soil Microbiology Section proposes to carry out *Rhizobium* strain selection for beans.

Table 3. Bean varieties introduced in Zambia and released to growers after a brief selection, 1966-1970.

Variety	Origin	Type	Environment[1]	Disease susceptibility[2]	Expected yield (kg/ha)[3]
Misamfu speckled sugar	Local (commercial seed)	Sugar bean	High rainfall	Susceptible	L: 500- 800 M: 800-1000 H: 1000-1500
Misamfu stringless	South Africa	Stringless snap bean	High rainfall	Resistant to anthracnose; susceptible to all others	L: 500- 800 M: 800-1000 H: 1000-1500
Mexican 142	Kenya	Canning dry bean	High rainfall	Moderate resistance	L: 500- 800 M: 800-1000 H: 1000-1500
White cooking	Germany	Large grain white cooking bean	Low rainfall	Susceptible (but early maturing)	L: 500- 800 M: 800-1000 H: 1000-1500

1 High rainfall = 1100-1500 mm; medium rainfall = 700-1000 mm; low rainfall = 300 mm.
2 Disease susceptibility to rust, anthracnose, and angular leaf spot.
3 L,M,H = Low, medium or high management, respectively.

Source: Sarmezey, A.A.V., 1977a.

Socio-economic and Institutional

The most important factor limiting bean production is the non-availability of seed. Beans are widely popular as a highly nutritious food and sell at very high prices on local markets. This factor coupled with hitherto low prices for seed did not encourage growers to produce bean seed.

The presently recommended varieties are primarily adapted to the high rainfall areas of the Northern province. Research is needed to introduce bean varieties suitable for the medium to low rainfall areas of the Central and Southern provinces.

Description of Country Bean Program

A systematic introduction of bean varieties began in September, 1966. Before this, varieties were introduced into the country by non-professionals, and some materials were brought in from South Africa for inclusion in experimental trials. Experimental work primarily concentrated on such factors as plant population, method of planting, seed dressings, and fertilizer requirements.

The objective of the bean breeding program since its inception in 1966 was to produce high yielding varieties which at the same time were acceptable to the Zambian consumer.

At the beginning of the breeding program, varieties were obtained from Europe, South Africa, Uganda and entered into the variety collection for initial screening under the high rainfall conditions of the Northern province. It soon became clear that varieties susceptible to anthracnose, angular leaf spot and rust would not succeed in the Northern province conditions. The breeding program that followed aimed at producing varieties with low disease susceptibility, acceptable quality and yielding capacity. To this aim a short-and long-term approach was adopted. In the short-term approach, single plant selection and mass selection methods were used to identify established collections for early release. After a brief period of selection, four varieties were released to the growers (Table 3). A long-term hybridization program was initiated to produce a small-to medium-sized white grain bean and a medium-sized speckled sugar bean for dry consumption.

An agronomy program was started in 1969 to supplement the breeding work. This program seeks essentially to investigate nutritional requirements,planting density, management and cultural practices, disease and weed control, inoculation, crop rotations, and varietal aspects of production under the different soil and climatic conditions found in Zambia.

The nutrition trials have established the importance of nitrogen, phosphorus, and residual lime in most areas of Zambia, and of sulphur at two experimental sites. Disease control is done primarily through varietal resistance, while herbicides are recommended to control annual grasses and most emerged, broadleaved weeds. Cultural and management practices have been discussed previously, and detailed results of the trials conducted are given in the Research Memorandum No. 20 of the Department of Agriculture. At the moment the bean program consists of variety trials at different locations and an intercropping trial with maize.

Seed Production and Distribution

The Seed Services within the Research Branch of the Department of Agriculture are responsible for all seed production according to the regulations laid down in the Seeds Act. Seed Services receive the cooperation of the Zambia Seed Producers Association in seed production. The seed is processed on the Seed Services farm, and after certification it is sold to the National Agricultural Marketing Board which distributes it. There are no private seed companies involved in seed production and distribution.

The rules and standards for bean seed certification are: Parental seed: basic or certified seed; minimum field inspections: one or two after harvest; isolation: 50 m; previous cropping: no beans during the previous 12 months. Field inspection: no more than 0.1% undesirable plants, at vegetative maturity; no more than 0.1% plants infected with seed borne diseases at or after flowering. Seed inspection: seed to meet current phytosanitary regulations; minimum purity: 99%; minimum germination: 80%.

Achievements

The bean breeding program introduced four varieties suitable for production (Table 3). Another introduction in 1977 was variety Copperbelt 609, a cross between Nanzinde x Tengeru 14RR, which needs further testing. It is a small, white cooking bean, suitable only for the high rainfall areas.

The Nanzinde variety is recommended as a standard variety for agrotechnical experiments. It is high yielding with small, flat to round grain, dark red in color and with a black eye. It has low susceptibility to diseases but poor flavor; thus, it is not popular among consumers.

Bean yields have been raised. In experimental plots dry bean yields of up to 1110 kg/ha have been recorded, with the highest yielding varieties averaging 1416 kg/ha. Agronomy work has resulted in production recommendations (Anon., 1979).

Production of bean seeds has been standardized and centralized under the Seed Services.

Future Plans

Research on beans has yielded useful results and at the same time it has highlighted the following areas needing further work: breeding for multiple resistance to diseases and pests, selection of suitable varieties for low rainfall areas, inoculation with suitable local strains of *Rhizobium*, mixed cropping with beans, suitable small scale equipment for planting and harvesting, extension services to promote bean production.

Summary

The most widespread bean in Zambia is the common or field bean *(Phaseolus vulgaris* L.). It is consumed primarily as a dry bean which is boiled before eaten.

Bean production is mainly concentrated in the North, although some production is found almost everywhere in the country. The altitude in bean growing areas ranges between 1200 and 1700 masl with an annual rainfall of 700-1000 mm in some areas and 1100-1500 mm in others; mean temperatures are between 22-25°C and 17-22°C, respectively. Soils are strongly to moderately leached, red or black clays, red brown loams or sandbelts. Improved management is applied in commercial operations, and traditional management at the subsistence crop level; in the former, beans are grown as a sole crop with fertilizer, herbicides and protective chemicals; they are usually part of rotation schemes. Expected dry bean yields under high management may reach beyond 1000 kg/ha. Under traditional management, beans are grown primarily as mixed crops, additional inputs are usually not applied, and the actual yield averages 600 kg/ha.

While production statistics are not available, the Third National Development Plan estimates dry bean demand by 1983 at 21,000 tons and production at 30,000 tons.

Beans are marketed through the National Agricultural Marketing Board or individually by producers at open markets. After harvest beans may be stored in containers of various types with the addition of sand, ash, or chemicals (malathion dust). Large scale storage is done in jute bags which are surface treated with fenotrothion or Pirimiphos-methyl with subsequent fumigation of the storage area with methyl bromide.

Bean production is hampered by several factors, the most important one being the non-availability of improved seed. As a result production lags behind demand and consequently prices tend to be exhorbitantly high.

Biological restricting factors include such diseases as anthracnose, *(Colletotrichum lindemuthianum)*, angular leaf spot *(Phaeoisariopsis griseola)* and rust *(Uromyces appendiculatus)*. The most important insect pest which causes early death of plants is the beanfly, *Ophiomyia* spp.

Bean research begun in 1966 with the breeding program which within four years released four bean varieties for the high rainfall (1100-1500 mm) Northern areas. The breeding program has concentrated on varietal selection and hybridization to produce high yielding varieties acceptable to consumers.

Seed production is controlled by the Seed Services of the Research Branch and is subject to crop inspection and seed certification rules.

Future breeding work will concentrate on multiple disease and pest resistance and introduction and selection of varieties suitable for low rainfall (750-1000 mm) areas.

The agronomic program will continue to investigate *Rhizobium* inoculation and mixed cropping systems.

Publications

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Anon., 1979, **Beans** (*Phaseolus vulgaris*), Department of Agriculture, Advisory Sheet No. 10.

Melhuish G.C., 1978a, **Beans** *(Phaseolus vulgaris)*. **A review of agronomic investigations, 1969-1976,** Research Memorandum No. 20, Research Branch, Department of Agriculture, 57p.

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Sarmezey, A.A.V., 1977a, **Beans** (*Phaseolus vulgaris*). **Breeding and variety experiments. 1966-1976,** Research Memorandum No. 18, Research Branch, Department of Agriculture, 30p.

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Summary of Country Reports

Aart van Schoonhoven

Country reports, containing the various aspects of bean production, were presented by Burundi, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia. Each of these reports was of high standard, containing a wealth of information and data on the bean production situation in the respective country. Their authors deserve to be complimented for their effort time and dedication to this work, which formed the true basis for this workshop.

The seven country reports can be summarized as follows:

Importance of Beans

Beans are an important and cheap source of protein with an amino acid composition complementary to that of maize, the staple food of the region. They are also an important carbohydrate source. In most areas in Eastern Africa, beans are the most important food legume, with an annual production exceeding 1.5 million tons. Yields in the region range from 400-700 kg/ha.

Consumption of beans is mostly in the form of dry beans. However, green-shelled beans, tender leaves and green inmature pods, in that order, are also consumed. To a lesser degree beans are produced for the canning industry in most countries, while Kenya and Tanzania produce seed for the export market.

Besides direct consumption, beans provide cash income for the producers, who are usually small holder farmers.

Bean Types Produced

The majority of bean production in Eastern Africa is of the determinate or indeterminate bush varieties. The importance of the climbing types increases with the duration of the wet season or with higher altitudes. The latter is usually accompanied by higher precipitation or moisture availability. Climbing beans are particularly important in Malawi, Southern Tanzania, Rwanda, Burundi and Northern and Western Uganda. A major reason why climbers are not more widely grown is the difficulty of harvesting.

Beans are thought to have been introduced by Spanish and Portuguese traders in the 16th and 17th centuries, together with maize. In more recent years germplasm has been introduced in all countries from other areas of the world in attempts to improve local production.

The consumer preference is for large seeded types, with small seeded ones least preferred. Red, red-mottled, purple-mottled or brown-to-light brown mottled beans are preferred over other colors, while white seeded beans are preferred for the canning industry. The Canadian Wonder seed types are most preferred, followed by Calima types. Black-seeded types have very low acceptance, although they are found.

Strength or rigidness of color and size preferences vary from region to region and are less prominent in Burundi, Rwanda and Zambia where beans of a variety of colors are grown and sometimes mixtures are even preferred. There is a strong market incentive for certain colors; however, higher priced beans are sometimes marketed with less preferred types, in order to sell all beans.

Production Environment

Beans are produced under natural rainfall, and planted in such time as to mature and ripen at the onset of the dry season. Very little bean production takes place under irrigation. In some areas, like Uganda, early maturing bean varieties are planted any time soil moisture permits germination.

Production takes place between 700 and 2000 masl, concentrated around 1200 to 1500 masl.

Production Systems

Beans are produced mostly in association with other crops. However, this varies greatly. In Malawi less than 6% of the total production is in monoculture, while in Eastern Kenya monoculture is practiced in 40% of the region. When beans are grown in association, maize is the most common partner, while crops such as plantain, cassava, pumpkin, groundnut, etc., often share the field with beans. Those for seed production or the canning industry are grown in monoculture.

Planting densities are often below those recommended as optimal by experiment stations. The planting pattern is at random, and mostly in the same hill when planted with maize. The planting dates are adjusted to the initiation and termination of the rains, which varies with the latitude. Most important regional planting dates are February-March and October-November. Therefore, April and December are the best time for visits to commercial bean fields in many areas.

Weed control is considered a major production problem causing severe losses. Weeding is mostly manual and often coincides with other peak labor demands; labor shortages were frequently mentioned to occur, although intermediate technology may provide solutions.

Harvest. Most commonly, mature beans are pulled by hand, dried in the field, and threshed by beating the plants with sticks. The fresh green-shelled beans are picked in several rounds.

Trade. Production estimates for beans are very difficult to make as only a small percentage of the total production enters the marketing channels. Post harvest price collapse was mentioned to occur.

Reports state that 61% of the total African bean production takes place in five countries: Kenya, Rwanda, Tanzania, Burundi and Uganda. The highest per capita bean consumption in the world occurs in Rwanda and Burundi, with up to 50 kg legumes consumed per person each year.

Storage. Storage technology is insufficiently developed, especially at the farm level although adequate storage facilities are available in some places. Normally, simple and inadequate storage structures are used, and losses of stored grain caused by insects are reported to be as high as 23%.

Control of storage insects is recommended with 1% lindane or malathion powder, while more traditional methods include the use of ash or sand to fill up intergranular spaces, or to coat beans with vegetable oils. Tobacco leaves or dust mixed with stored beans were mentioned to reduce bruchid attack.

Consumption. Not only are beans grown with maize, they are usually consumed together as well. It is common to soak beans to reduce cooking time and thus save fuel. Subsequently the beans are cooked, sometimes with various spices added, and eaten with or mixed with maize porridge or dough. Also maize and beans are commonly cooked together. Small children were reported to be fed a mixture of beans, groundnut and maize, to prevent "kwashiorkor". Green-shelled beans and tender leaves are eaten cooked.

Factors Limiting Production

The principal limiting factor to bean production is considered to be the susceptibility of beans to diseases and pests, while production technology and seed availability are also important constraints to production increases.

Due to consumer preferences, often the best disease resistant or highest yielding variety cannot be grown. Diseases are the principal factor limiting production as a large number of them attack beans, and their severity in terms of yield reduction is high for most of them. The following list of disease priorities was summarized from the country reports:

Anthracnose: It is considered the most important disease by five of the six countries (excluding Burundi, Table 1); when each country listed their five most important diseases, anthracnose was mentioned six times; angular leaf spot six times (however, it was ranked as the third or fourth most important); rust, five times (ranging from second to fifth in importance); BCMV four times; bacterial blight (probably excluding halo blight) three times; halo blight, twice (however, in Kenya it is considered the most important disease), while Ascochyta leaf spot was mentioned once. However, it is believed that BCMV virus may be more important than generally stated. Resistance sources to the above diseases are often available, but, not in acceptable grain types or in proper combination with other diseases.

Other diseases like bean scab do occur in Africa, but are not reported in Latin America.

The bean fly is the most important insect pest. Resistance sources are given in the literature, which are based on rapid secondary rooting. Aphids and leaf feeding beetles are causing damage, but the extent of it needs more research.

Table 1. Disease priorities[1] given by each country.

Country	Anthracnose	Halo blight	BCMV[2]	ALS[2]	Rust	CBB[2]	Ascochyta
Kenya	3	1	2	4	5	-	-
Malawi	1	2	-	5	4	3	-
Rwanda	1	-	3	3	2	3	2
Tanzania	1	-	4	3	2	-	-
Uganda	1	-	-	4	3	2	-
Zambia	1	-	4	3	2	-	-

1 First priority = 1; low priority = 5
2 BCMV = Bean common mosaic virus; ALS = Angular leaf spot; CBB = Common bacterial blight.

In general the farmer does not control diseases and insects with chemicals. Neither do farmers use disease-free seed, which contributes to the severity of diseases. However, participants from several countries stated that unavailability of certified seed was the main reason for not using it, and that farmers would use it if available.

Other production constraints include unreliable rainfall patterns, very low planting densities (possibly for reasons of moisture availability or disease avoidance), suboptimal association patterns with other crops, including relative planting dates, inadequate weed control, and insufficient fertilizer use. Drought and the latter two are considered to be the most important production constraints after pests and diseases.

Economic constraints to increased production are very important. Often bean prices fluctuate too much to provide incentives to farmers to use additional inputs. On the other hand, in countries like Kenya, with high bean prices, farmers will not use inputs as the risk of bean production is too high. If, for instance, drought destroys a bean crop, used inputs are lost. Government price controls have often acted as hindrances to increased bean production.

From most reports it was clear that the size and continuity of the bean research programs and their additional responsibilities with other crops limit the development of profitable technology. Usually, and in decreasing order of availability, a research team is composed of a breeder, a pathologist, an agronomist and an entomologist, this being the minimum size for a program to operate. However, stronger integration within these teams and a better defined responsibility for research between Universities and Ministries of Agriculture can improve research potential to some degree.

Not only was the lack of research scientists mentioned, but also the lack of extension officers, and the communication gap between them, which was considered of great importance and one of the reasons why improved technology has not reached the farmer.

Besides the limitations in personnel, the level of training, the availability and exchange of scientific information were considered inadequate. Better access to literature and easier dissemination of information are needed. Research support at the experiment station is generally insufficient. Existing language barriers in Eastern Africa also limit free exchange of scientific information.

Research Achievements

Despite the small size of programs, much has been achieved over the past years. Production methodologies have been developed to overcome some of the constraints mentioned, new varietal introductions, individual plant selections or progenies from hybridization programs have been released, but have received varying degrees of adoption by farmers. Unavailability of seed and commercial unacceptability may have contributed to the lack of adoption. Despite such and other achievements much more will be needed to increase bean production in this region.

Conclusions

FAO estimates of bean production in Africa indicate that over the last 10 years bean production increased in Africa, but this was due only to area increases. In most cases this increase in area under production was partially offset by a productivity decrease of over 2% per year in some countries. Only in few countries, like Tanzania, were area increases accompanied by productivity increases. Part of the reason for reduced productivity is the replacement of beans by other less risky crops, like cassava and plantain — as reported for Uganda — which provide less protein to humans. In these cases bean production often was displaced to more marginal areas. To insure a growing population with a steady supply of adequate affordable protein, rapid solutions must be found to overcome the bean production constraints outlined in this report.

Summary of Panel Discussions

Agronomy

The panel discussed the wide area covered by agronomy, which includes regional yield trials of promising materials, plant density, cropping systems research, fertilization, weed control, crop physiology and stress studies, irrigation, and mechanization of the small producer. Out of this wide range of activities the following list of priority research areas was proposed:

Regional yield trials. To be carried out, on a permanent multilocational basis, with new releases from breeding programs. By deleting poor performers and adding new releases, such systematic regional trials should result in recommendations to farmers and to the seed industry of superior new genetic materials. Such trials should be conducted under the principal cropping systems and input levels used by the farmers. As a result, different varieties can be recommended for mono- and associated cropping systems and for different ecological zones. Cropping practices of small farmers should receive adequate attention.

Farm survey. The panel assigned high priority to conducting detailed farm surveys to obtain knowledge on major production systems and production constraints. The survey should also include storage practices and losses during storage, as well as sales of surplus production.

Weed control. Most bean plantings suffer severe losses from weed competition, and weed control costs reduce profitability of bean production. Thus, studies on weed competition should be conducted to give weed control recommendations to farmers. Depending on availability and cost of labor and the possible enrichment of soils by incorporation of weeds, herbicidal recommendations should be formulated.

Plant nutrition. Priority research should be directed to the use of *Rhizobium* for N_2 fixation, ability of cultivars to fix nitrogen, and inoculation techniques.

Cultivars should be tested for tolerance to low soil phosphorus, an important limiting factor, while the use of cheap phosphorous sources like rock phosphates should be studied. The use of farm manure and other organic matter, and their long term effect on soil fertility, texture and bean yields need to be studied. Profitability and risk of fertilizer applications should precede recommendations.

Cropping systems. Associated cropping patterns should be studied to improve bean yields since these are usually produced under such cropping patterns. Relative planting dates, plant populations, fertilizer and pesticide recommendations should be developed for such systems.

Plant population. Farmers usually plant at low densities in hill plots thus saving seed and labor. Research is needed on the effect of plant type or growth habit on yield and varying densities in order to develop the plant type acceptable to farmers.

Low priority research areas include crop physiology (most national programs are too small to have this type of scientific expertise available), stress studies (acidity, drought, irrigation), and mechanization. The last two concern large estates. Studies on small scale production mechanization, like the use of oxen for land preparation, planting and cultivation, could result in high pay-off in certain areas.

Breeding and Selection

Each country delegate presented information regarding the present production situation in their countries, information which appears in detail in the preceding country reports; they also described existing breeding programs and their capabilities, facilities for exchange of genetic material, technical assistance needs and future plans; mention was made of the experiment station and other publications in each country and their availability to other scientists in the region.

The main points extracted from the panel discussions were:

- Generally, genetic improvement programs are actively involved mostly in breeding for multiple disease resistance; genetic improvement is needed in both bush and climbing types; often resistance sources are not available; further training of research scientists is needed; preferred seed types are generally large- to medium-sized seed of red, red mottled or brown mottled types.

- CIAT agreed to send free of charge, for one year, literature abstract cards to all participants.

- Universities in the Eastern Africa region should be encouraged to compile and publish research findings from undergraduate research projects.

- Routine practices of *Rhizobium* inoculation in screening trials was supported.

- Screening of disease reaction should be preceded by a thorough identification of all races of the pathogen.

- A newsletter containing review articles and short notes should be produced and circulated regularly to Eastern Africa scientists.

- The possibility was discussed for arranging annual meetings of bean researchers in the region.

Plant Protection

Participants discussed the range of bean diseases and insect pests reported to occur in Eastern Africa. The major diseases included anthracnose, halo and common bacterial blight, rust, and angular leaf spot. Other diseases (minor or in restricted areas) included scab, web blight, powdery mildew, floury leaf spot, Ascochyta leaf spot, bacterial brown spot and viruses (BCMV).

Bean fly and storage insects are considered to be very serious in many areas. Little mention was made of nematodes, which probably reflects lack of trained personnel. Little mention was made of the presence of bacterial wilt, even though this disease occurs in various regions, according to Dr. C.L.A. Leakey.

Various countries have conducted some type of disease survey; however, it appears that little effort has been directed towards obtaining more specific disease incidence and severity data required to firmly establish priorities. Various countries have conducted specific studies on pathogenic variability of pathogens such as those causing anthracnose, rust, and angular leaf spot.

Table 1. Summary of priority diseases and pests of field beans in Eastern Africa.

Country	BCMV[1]	Halo blight	CBB[1]	Anthracnose	ALS[1]	Rust	Root rots	Ascochyta	Bean fly	Bean beetles
Burundi		x		x	x	x	x	x		
Kenya	x	x		x	x	x			x	x
Malawi		x	x	x	x	x				
Rwanda	x		x	x	x			x		
Tanzania	x			x	x	x			x	
Uganda		x	x	x	x	x				
Zambia	x			x	x	x				

[1] BCMV=Bean common mosaic virus; CBB=Common bacterial blight; ALS=angular leaf spot

The panel of participants then discussed research priority needs for Eastern Africa and recommendations for CIAT's assistance. The major points covered include the following:

- Training of national program personnel by CIAT is the most important and urgent need in Eastern Africa. Regional workshops should also be planned on a regular basis every 2-3 years.

- The participants strongly urged CIAT to develop differential varieties to screen local populations of pathogens, to identify effective sources of resistance, to monitor pathogens over time, and to help identify diseases actually present. These varieties would be an important tool to supplement needed country surveys of weeds, diseases, insects, and nematodes affecting bean production.

  The International Bean Rust Nursery (IBRN) and a similar nursery under development for anthracnose resistance may satisfy this request.

- The participants strongly urged CIAT to develop standard scales for measuring disease and insect damage as well as for evaluating disease resistance.

- Disease inoculation and evaluation procedures should be standardized to facilitate exchange of results and germplasm throughout Eastern Africa.

- High quality, disease-free seed production was considered to be vital and should receive much attention and support within every local program and country. However, many people felt that the farmers should be encouraged and trained to produce and maintain high quality seed on their own farms. Most seed production programs are oriented towards the European system which may not be able to handle the demand and distribution problems.

- Additional studies are required on other disease/pest control measures, epidemiology, biology, inheritance of resistance, storage pests, and effect of different cropping systems. The latter topic did not receive support from all participants.

Priorities identified may be summarized as follows:

Immediate priorities:

- Identification of pests, diseases and weeds and their economic importance (see also Summary of Country Reports)
- study of variability of pathogens;
- use of IBRN recommended for Eastern Africa;
- germplasm and evaluation: standardization of screening methods and keys for pests and diseases; screening for resistance to pests and diseases; genetics of resistance in collaboration with breeders.
- Promotion of production and distribution of disease free seed;
- studies on storage pests and their control.

Long-term priorities:

- Studies on the biology and ecology of pests and disease epidemiology;
- studies on effects of mixed cropping on pests and diseases;
- regional and international cooperation in development of bean protection practices.

General priorities:

- Regional and international cooperation in development of bean protection practices;
- regional meetings every two years.

Seed Production and Marketing

The seed production and marketing schemes of the following countries were briefly presented: Kenya, Uganda, Malawi, Tanzania, Rwanda and Zambia. They seemed to fall into somewhat different categories. In Kenya, a commercial seed company, Hortiseeds, is responsible for seed production of beans and other vegetables for which it makes some profit which goes to the organization and to the contract growers. Tanzania and recently Malawi were using a scheme whereby a national company produces seed on its own farms first and later on contract with large growers. In these cases the seed cost to the farmers is heavily subsidised in order to reach a price level above or very close to the ware price. In Tanzania for example, 10 kg bags cost 10 sh vs 5-7 sh ware price; in Malawi prices are 20 t/kg, and 12-20 t/kg, respectively*.

In Malawi the subsidy is paid by the government marketing organization, ADMARC; the price of production and treatment of the seed was reported to be about 75 t/kg. Contract growers are paid a price high enough to be economically worthwhile.

Zambia has a farmers' cooperative crop seed association which produces seed during the early stages of multiplication on its own farms; later on, it is contracted with suitably trained growers.

Seed certification schemes exist in all countries, and are managed by governmental or semi-governmental organizations. Obviously, the crops are inspected by the producing organization to ensure that they meet government certification standards.

Both a seeds act and plant breeders rights exist in Zambia. However, no production of certified bean seed has taken place due to recent political changes in the country.

In Uganda and Rwanda seed was produced entirely by the government mainly on their farms and sometimes under contract with growers. In Uganda the seed was sold by the Uganda Central Cooperative Union. However, after a period of success the seed scheme broke down due to serious inflation which caused the market ware price to rise many times above the price paid for seed.

In Rwanda the seeds were produced entirely in central and regional government farms and plots. The seed was sold at the same price as the ware crop. Rwanda has no seed certification schemes, but has the

* 1 sh=0.1212 US; 1 t=0.016 k; 1 k=0.82 US.

following quality requirements for their seed crop: Genetic purity (minimum), 99.5-99.9%; seed transmissible disease (maximum), 0.1-0.5% diseased seed, except for *Corynebacterium* with 0 tolerance level.

In some cases government pathologists assist with disease quality checks of the crop. It was generally agreed that production of disease-free seed is the most serious problem in all countries; breeding for increased disease resistance is seen as a long-term objective. However, isolation from other bean crops is generally used to try to reduce the spread of disease and possible outcrossing. A comment was made that excessive inspection for genetic purity, which involved much handling of plants, could greatly expedite the spread of disease. Isolation was also considered very difficult to obtain in the densely populated countries such as Uganda, Rwanda, Burundi, and Malawi.

There was considerable discussion on whether marketing of the seed should be subsidised. It was said that there is demand for seed by both countries giving and not giving subsidies. However, there is such a shortage of quality seed in all countries that demand always exceeds supply so there was no conclusion to this discussion. It was generally agreed that financial assistance would be needed in the earlier stages of multiplication to ensure enough quantities of basic or foundation seed.

The size of the seed package sold to the farmer varied considerably ranging from 100 g to about 10 kg, the latter a more common size. It was suggested that the large packages may be too expensive for the farmer who wants to try a small amount. Small ones obviously have higher production costs.

In Kenya, Hortiseed uses a seed bag with detailed agronomic instructions printed on the back with pictures and text, which was found to be very promising for the use of quality bean seed. It was considered that the use of quality seed accounts for less than half of the yield improvement of a good agronomic package. In Malawi a package consisting of credit for improved seed and fertilizer is available.

The most striking need in all countries is for more quality seed. When small amounts of disease-free seed are introduced, the crop is easily infected by surrounding unimproved crops. Possibly, efforts could be made to concentrate the limited efforts available in certain areas, providing them with an adequate supply of seed.

Most countries need more storage facilities if more seed is to be produced.

A good extension system to explain the benefits of improved seed and how to grow it was considered to be vital; it was also suggested that farmers be taught the best ways to save their own seed; this could become a major practice. The situation must be avoided whereby a farmer is converted over to use improved seed only to find that there is not enough seed for him to buy the following year, putting many farmers off. Publicity should be geared to the amount of seed available. It was hoped that the small farmer's success with hybrid maize lead them to try improved bean seed. A note of caution was sounded on the widespread use of improved seed, in that this could lead to the takeover of the crop by a single variety with the usual risks associated with it. This situation has been frequently observed in many other crops. Also in bean production varietal mixes are often used with good success, but these are not produced by the seed industry. Genetic purity may be therefore much less important than genetic identity. Obviously seed companies find it easier to produce a single variety rather than several.

In summary, one of the major constraints in bean production within the region is the non-availability of high yielding, disease and pest resistant clean seed at reasonable prices in the areas of production. Therefore, the panel concluded that the main needs are:

- Production and storage of larger amounts of good quality seed;
- extension information to farmers on the use of this seed;
- reliable and regular supply of quality seed located in convenient production centres;
- more emphasis on production of seed for the small farmer as opposed to large farmers, as well as teaching farmers how to produce and store high quality seed.

Training and Extension

Introductory remarks on training. Close examination of the information presented in the country reports shows that training of manpower in the various fields of agriculture is of crucial importance. For instance, the Malawi report indicates that there has not been a permanent breeder for grain legumes and that the program is currently without the services of an entomologist. The research assistants employed are high school graduates without agricultural training, hence requiring close supervision to obtain reliable research results. Also noted is the lack of trained personnel devoted to extension in beans. On the other hand, Tanzania had 25 officers in 1975 who were expected to cope with bean extension in 13 regions of Tanzania. The story is similar in the other countries, where in some instances expatriate workers are recruited on short contracts, and when they leave, gaps in the various disciplines of agriculture are created, or projects are abandoned altogether. Such are some of the constraints to improvement programs in grain legume production in Eastern Africa.

Training needs. They can be broken down as follows:

- High level manpower research scientists both at universities and ministries;
- technical. staff based at both universities and ministries;
- extension workers;
- farmer education.

High level research scientists. It was recommended that countries strive to establish a grain legume program with at least one well trained high level research scientist of at least MS calibre or its equivalent, with experience to lead the program. This staff member must preferably be a senior person responsible for grain legumes, preferably a breeder to be supported by an agronomist, a plant pathologist, an agricultural entomologist, an extension worker, an economist and a rural sociologist. Economic constraints and lack of personnel require that programs attend all legumes, and not beans alone.

Technical staff. It was noted that this kind of staff should be recruited at high shool graduate level or better. Technical staff at this level must be encouraged and rewarded by attendance to short refresh and in-service training courses and other incentives to pave their way for promotion, beside improving their performance.

Extension workers. Figures like those quoted above whereby 25 officers are spread over 13 working regions hamper production to a great extent. In such circumstances the need for training of more officers is obvious. Extension work is demanding and important. Thus the extension worker must be of a high caliber. He is under the obligation to translate the research findings and to be able to disseminate these findings to the farmer. Therefore it is important that scientists be involved in courses to ensure that the extension officers are updated on modern techniques of agriculture, and the research scientists are informed of shortcomings in new technology. Besides, in order to assist the extension worker the scientific staff must participate in preparation of extension bulletins that help extension workers make good recommendations.

Farmer education. The best way to train a farmer is to do so in his land. However, when manpower resources are limited, it is advisable to have a training center for selected farmers who will later be expected to share the knowledge they have acquired with their neighbor farmers. It is recommended that research workers spend some of their time at the farms collaborating with the extension staff in their demonstrations. Thus, translation of findings can be done, and a two-way communication is achieved.

The role of extension. It was emphasized that the extension agent at the grass roots level performs a dual role: he (or she) communicates improved methods to the farmer, identifies farmers' problems and communicates them to the research worker. In order to do this effectively, the extension agent must know and understand the farmer's situation in order to relay problems to the research staff and he (or she) must have confidence in and respect for the research staff so that their recommendations are delivered with confidence.

Deficiencies were noted in each of these relationships. Thus, it was recommended that contacts and communication between research and extension workers be improved in order to make research more relevant and easier to communicate to farmers and vice versa. Each country will have a hierarchy of extension personnel, but the grass roots personnel must be informed of farmers' problems and communicate them to the research workers. An extension-research liason unit at research stations was considered one of the possible ways to bridge such a communication gap.

In summary, the researcher, extension worker and the farmer should be integrated at all phases of bean production in order to eliminate unnecessary delays and the waste of resources in the development and release of varieties and their economic production packages.

Defined targets. Different packages are required for small and commercial farmers. The latter have greater access to higher level extension personnel and research workers. The extension service should serve both types but should concentrate on the small farmer, who is often neglected and who makes an important contribution to increased agricultural production; that contribution should be recognized and encouraged. The importance of production for the domestic market should also be emphasized.

Cropping or farming systems. Extension workers should know the various farming systems, identify the most limiting factors, and communicate them to the research staff. Small and large farmers have different constraints the extension agent should be able to understand.

Methodology. Demonstrations in farmers' fields after variety trials should be done in various locations throughout the country. A long discussion ensued as to whether field demonstrations are the responsibility of the research worker or the extension worker, as to whether successful farmers' fields should be chosen (with possible increase in income inequality) or average farmers' fields, and the advantages and disadvantages of each. After a long discussion the following alternatives were suggested:

- The extension agent supplies inputs at cost to farmers who provide labor and follow instructions; the farmer gets crop in return;
- the extension agent provides inputs and hires labor using a farmer's field; crop pays for labor;
- a given farmer volunteers to plant the new variety in some central location providing inputs and labor; an example is the National Marketing Board in Zambia;
- the Ministry puts the demonstration plot in neutral ground hiring labor and doing its own supervision;
- demonstration plots must be supported by visual aids, literature, etc.; extension workers may need further aids including radio forums, field days, etc.

Personnel. A general discussion followed concerning the number of farmers the grass roots extension agent is expected to visit with inadequate logistic support. Both the quality and quantity of extension personnel may be inadequate; also, they may be alienated from research workers, supervisors and farmers; some are inadequately motivated and may not be respected by the farmers.

Several suggestions were made regarding this topic:

- Influential persons in the community could be utilized.
- Individuals from each village could be selected as liaison persons between extension workers and farmers and demonstrate the new packages; they could or could no receive payment for their services; different persons could be selected periodically.
- Morale could be improved by more contacts with research workers at special workshops, field days, etc.
- Should extension workers be encouraged to have their own farms?
- Alienation may stem from poor pay, lack of transport, poor supervisors, etc.
- Young extension workers could gain experience from contacts with experienced farmers and older extension workers.

Recommendations for Future Action

Regional Center for Bean Research

The delegates strongly recommended the setting up of a Regional Center for Bean Research. This center should coordinate research programs aimed at solving problems of a regional nature, particularly in the fields of breeding high quality cultivars for the different cropping systems and locations in member countries, supplying germplasm to them, and training personnel. The center should have the following staff: one breeder, one entomologist, one plant phatologist, two agronomists and one extension worker or agricultural economist.

In view of its global mandate in bean production research, CIAT should be approached to provide assistance in the establishment and operation of the center.

Biannual Regional Conference

The revival of the East African Cereals Conference, which was held biannually in member countries, was also recommended but including grain legumes. It will then be known as and called the East Africa Cereals and Grain Legume Conference, and will meet biannually in rotation among member countries. The first meeting will be held in Kenya in 1981. Tanzania -the previous host to the former conference- is supposed to make arrangements with Kenya; Zambia is willing to host in the event Kenya cannot do so.

Participants

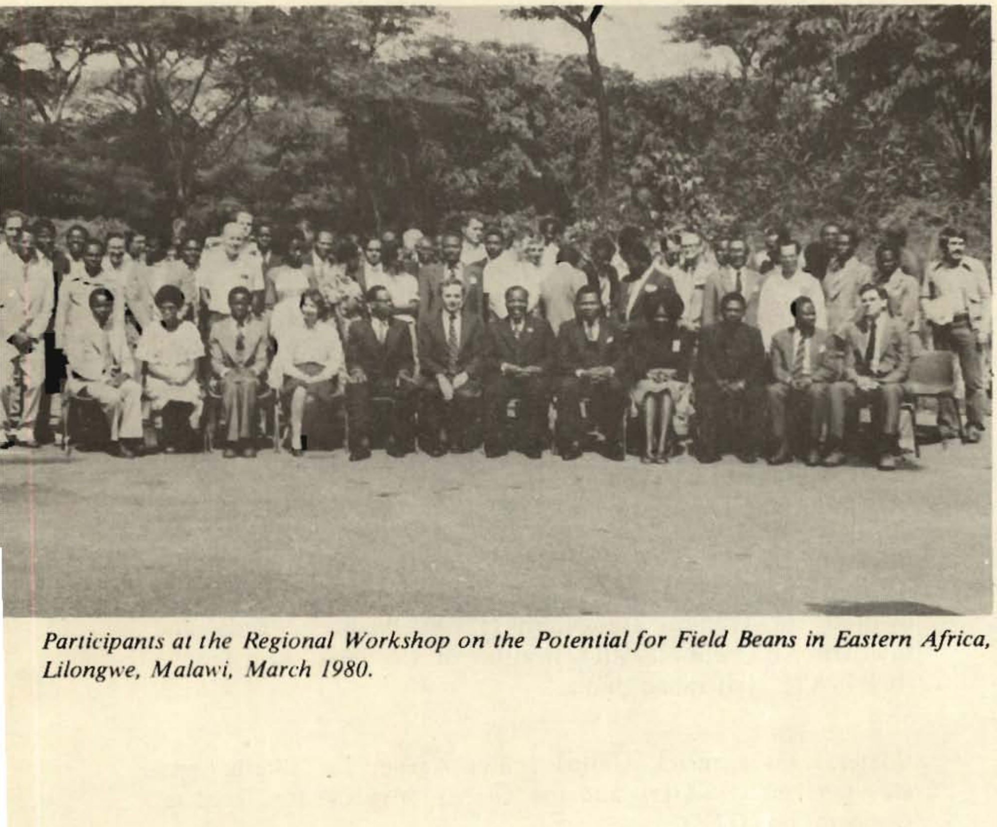
The Workshop on the Potential for Field Beans in Eastern Africa was attended by delegates from seven Eastern Africa countries, namely: Burundi, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia, and observers from the following countries and institutions:

- Cameroon and Zimbabwe;

- International research centers: Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia; International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria; and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India.

- Bilateral aid agencies: United States Agency for International Development (USAID), and the German Agency for Technical Cooperation (GTZ).

- Individual scientists from Europe, Latin America and the United States of America.



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