Banana Production and Research in Eastern and Central Africa

Proceedings of a Regional Workshop
held in Bujumbura, Burundi
14–17 December 1983

Sponsored and organized by
Institut de Recherche Agronomique et Zootechnique
International Development Research Centre

September 1985
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BANANA PRODUCTION AND RESEARCH
IN EASTERN AND CENTRAL AFRICA

Proceedings of a Regional Workshop
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Organizing and Editorial Committee:
Roger A. Kirkby
Damien Ngendahayo

Sponsored and organized by:
Institut de Recherche Agronomique et Zootechnique (IRAZ)
International Development Research Centre (IDRC)

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PREFACE

The smallholder banana crop of the highland areas of eastern and central Africa is one of the primary staple foods of the people of the region. As in some other parts of the world, this crop has not received the attention from the research community that is warranted by its importance in subsistence and semi-commercial household economies.

These proceedings record the first meeting of the small number of active banana researchers of this region. The workshop itself was the result of a fortuitous coincidence of interest between the Institut de Recherche Agronomique et Zootechnique (IRAZ), a regional research organization of the three francophone countries bordering the great lakes of central Africa, and the International Development Research Centre (IDRC). The interest of IRAZ in banana research arises from the dominant position occupied by this crop especially in highland cropping systems of the subregion, while IDRC has been concerned with encouraging research on several other important, neglected food crops of Africa, notably sorghum, millets, cassava and sweet potato.

The workshop enabled the region's banana researchers, who work generally in isolated conditions, to share experiences and knowledge. The productivity of banana growing is declining in most areas; some constraints to maintaining and improving upon present levels of productivity are discussed in these proceedings, which should prove useful to those responsible for the difficult task of allocating scarce resources for agricultural development. Banana improvement programs in the region are recommended to include research on farmers' holdings so as to improve their understanding of local production patterns, and other recommendations concern research strategies appropriate to genetic improvement and the control of pests and diseases. The timing of the workshop preceded the recent creation of the global International Network for the Improvement of Bananas and Plantains (INIBAP), whose attention is drawn to the participants' recommendation on organizational arrangements by which INIBAP best could support their work in the future.

Many people contributed to the workshop and to these proceedings. Participants themselves made the workshop a most constructive and lively affair, and the staff of IRAZ provided an efficient, round-the-clock secretariat. IRAZ and IDRC are especially grateful to the Government of the Republic of Burundi and to the Principal of the College Polytechnique in Bujumbura for making available the facilities for the workshop. Participants appreciated the accuracy, humour and hard work of Mr. Richard Frank in providing simultaneous translation.

In the preparation of the proceedings, special thanks go to Mrs. Caroline Agola for editorial assistance and to Ms Callixta Mukayiranga, Ms Rose-Marie Mukanrutabana and Ms Joy Mukanyange for translations. We would also like to acknowledge the indefatigible work of Mrs. Margaret Muyanja at many stages, not least in word processing.
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His Excellency the Minister for Agriculture and Animal Husbandry
Republic of Burundi

It is a pleasant duty for me to open this regional workshop on banana production in eastern and central Africa.

On behalf of the Government of the Republic of Burundi and on my own behalf I should like to bid a warm welcome to all those who were kind enough to respond to our invitation. I can assure you that no effort will be spared to ensure the best possible working conditions and to make your stay a pleasant one.

Bananas, along with root crops and tubers, are one of the main crops of the humid and sub-humid tropics. In Central Africa, plantains, adapted to low-altitude and high-humidity conditions, are prevalent. This staple is the main substitute crop for cassava and maize. In eastern Africa, other types of banana are found that are adapted to high-altitude conditions. In the countries of the Economic Community of Great Lakes States (C.E.P.G.L.) plantains are dominant in the Zaire basin and beer and cooking types are dominant in the east of the country and in Rwanda and Burundi.

According to statistics for 1982, banana cultivation in Burundi occupied an area of 131,300 ha out of a total agricultural area of 752,100 ha. Yields were estimated at 9,290 kg/ha, putting bananas in first place, well ahead of other food crops such as sweet potatoes, potatoes and cassava.

Thus, although only occupying 17% of agricultural land, bananas, with a gross production of 1,220,000 tons, account for over 40% of total food-crop production.

The Government of the Second Republic, under the guidance of H.E. Colonel J.B. Bagaza, Chairman of UPRONA and President of the Republic, is well aware of the considerable contribution of banana production to national food self-sufficiency. As a consequence it enjoys an important position in our development programmes.
Since 1977, a campaign for thinning and control of plant-to-plant spacings has been pursued throughout the country. In parallel, our extension services are instructed to encourage cooking-banana cultivation which so far accounts for only 40% of overall production.

Although we do not have figures for all of eastern and central Africa, my impression is that things are much the same as has been described in the case of Burundi, whether for plantains or high-altitude banana production.

In view of the importance of this crop for our peoples, we welcome the fact that the C.E.P.G.L.'s Institute for Agronomic and Livestock Research (IRAZ) in fulfilment of one of its mandated tasks, has organized this workshop in co-operation with the International Development Research Centre (IDRC).

Let us recall that the illustrious Heads of State of our Community, concerned to pool efforts in the fields of agriculture and animal husbandry in order to ensure our peoples self-sufficiency in food, agreed to establish IRAZ and mandated it to prepare and implement Community projects in the agricultural and livestock fields, with particular emphasis on research.

Its mandate was further defined by successive General Assemblies of the Institute which, among other things, have recommended a regional banana research program. IRAZ's programme of activities for 1983 provides for preparation of a project proposal for research on this crop and, in this regard, I am happy to note that IRAZ, in the context of its agreement with FAO, has prepared a regional banana research programme proposal for Rwanda, Zaire and Burundi. I wish to take this opportunity to express to FAO, on behalf of IRAZ and on my own behalf, sincere gratitude.

In spite of its important role, banana cultivation suffers constraints of different types. One of these is the empirical state of present knowledge on this crop. In the Great Lakes sub-region, although research had been undertaken by INEAC, there was clearly less activity after 1960. At present banana research in our institutes is limited to maintaining collections of some local and exotic cultivars.
From the phytotechnical point of view there is as yet no information available on methods to improve traditional production systems, and on planting densities and ecological constraints of various varieties. In the field of varietal improvement the problem of synonymy in the Great Lakes area complicates determination of varietal production potential.

Although at present banana cultivation appears not to suffer from any disease with serious economic consequences, it would be erroneous to think that it is sheltered from possible developments leading to serious falls in yields and consequent grave losses of production. In view of this situation it is in the immediate interest of our peoples that banana cultivation be the subject of detailed studies.

This seminar will be considering all these problems. The following topics are on the agenda:

- an inventory and appraisal of research under way in each member state,
- to evaluate present knowledge and relative importance of banana cultivation in relation to overall agricultural production in the area,
- to consider strategies for improvement of varieties and of cultivation and disease, insect and nematode control techniques,
- to study and propose better extension methods for proper banana cultivation techniques, and
- to evaluate potential for regional and international co-operation in banana research.

At the end of your deliberations it is intended that the seminar should define priorities for future research work and help IRAZ to finalize its research programme for one of the main crops of the Great Lakes area.

This seminar is honoured by the presence of specialists on banana cultivation of international repute who are to share with us their extensive knowledge and experience. Their participation is a sure guarantee of success.
IRAZ, in co-operation with IDRC, has had the initiative to organize this workshop, the results of which will constitute the basis of its future research programme. We wish to encourage it on this path and urge it to press forward with support of international, regional and bilateral organizations in order to help the member states of the C.E.P.G.L. to achieve self-sufficiency in food.

It is with satisfaction that I note that the IDRC has shown its commitment to the promotion of regional banana research in the C.E.P.G.L. countries by financing this workshop. This assistance is very timely and I request that the organization's representative transmit our deep gratitude to his Director General.

I also wish to thank all participants who have been kind enough to set aside their normal activities in order to contribute to this meeting on banana research in these countries.

Finally, let me wish success to your deliberations and declare open this Regional Workshop on Banana Production in Eastern and Central Africa.
INTRODUCTION AND OBJECTIVES OF THE WORKSHOP

Roger A. Kirkby

This meeting is important for at least three reasons: the great importance of bananas and plantains in farming systems and as staple items of diet in this region; the long neglect of these crops by most institutions responsible for agricultural research; and the unique opportunity for those institutions and individuals who have taken initiatives to encourage research on bananas to share their experiences and determine collectively the needs for future research and co-operation in the region.

The importance of bananas in this region relative to other parts of the world is shown in Table 1. Half of the total production of Africa is contributed by the six countries represented at this meeting, and over large areas of the region the banana is the principal source of carbohydrate in the diet. As a long-established component of small-farm systems, the plant has other uses: for livestock feed, shade for intercropped coffee, wrapping material for other produce, and so on.

The richness of the terminology used to describe the parts of the banana plant and their uses is also indicative of the crop's pre-eminent position within farming systems of this region: Desouter's glossary (1982) of agricultural terms in the Kinyarwanda language lists 71 terms associated with the banana, 28 for sorghum and, among more recently introduced crops, only three specific to maize and two to cassava.

Some of the complementary relationships of bananas with other components of farming systems, as well as their food uses, are specific to particular geographical areas. Although bananas are generally important in those warm areas of the region having relatively high and well distributed rainfall, they can be important also as minor crops on account of adaptation to a specific ecological niche within the extensive semi-arid areas. Varieties and management practices also vary within the region. These aspects need to be taken into account in designing systems that will be improvements on the existing ones.

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Table 1. Estimated Banana and Plantain Production

<table>
<thead>
<tr>
<th></th>
<th>Annual production (1000 tonnes)</th>
<th>Production per capita (kg per person)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1969-1971</td>
<td>1980</td>
</tr>
<tr>
<td>World</td>
<td>47,068</td>
<td>60,518</td>
</tr>
<tr>
<td>Developing countries</td>
<td>46,335</td>
<td>59,718</td>
</tr>
<tr>
<td>Africa</td>
<td>14,175</td>
<td>18,122</td>
</tr>
<tr>
<td>Central and Eastern Africa</td>
<td>7,273</td>
<td>9,098</td>
</tr>
<tr>
<td>Burundi</td>
<td>810</td>
<td>972</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>53</td>
<td>73</td>
</tr>
<tr>
<td>Kenya</td>
<td>297</td>
<td>370</td>
</tr>
<tr>
<td>Rwanda</td>
<td>1,656</td>
<td>2,212</td>
</tr>
<tr>
<td>Somalia</td>
<td>136</td>
<td>78</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1,078</td>
<td>1,560</td>
</tr>
<tr>
<td>Uganda</td>
<td>2,964</td>
<td>3,520</td>
</tr>
<tr>
<td>Zaire</td>
<td>279</td>
<td>313</td>
</tr>
</tbody>
</table>

Source: FAO Production Yearbook, 1981, FAO, Rome

The importance of bananas as a staple crop for some 15 million people is not reflected, however, in the level of support that has been given to programmes of crop research and development in countries of the region. A bibliography on crop production research in East Africa (Bharqava, 1975), although not comprehensive, is reasonably indicative of resource allocations to agricultural research where it lists only six references to published work on bananas from a total listing of 1,716. Undoubtedly, a contributory factor is that nowhere in the region, except in Somalia, has the crop enjoyed export status. Another factor that may have delayed the focusing of attention on this neglected food crop during the past few years when others, such as sorghum, millets, oilseeds and rootcrops, have begun to attract modest levels of research funding, is that bananas are not grown extensively by people in the poorer, semi-arid environments. Certainly,
productivity of agricultural land is generally higher, and the levels of risk lower, in banana-growing zones of good rainfall. However, farm sizes also tend to be smaller and for many years these areas have been a source of out-migration that have contributed indirectly to the over-exploitation and erosion of adjoining semi-arid areas. National statistics also suggest that for most, if not all, countries of the region banana production per person is declining even though total production is still increasing.

This meeting provides an opportunity to conduct a comparative analysis of the production situation, its potential and the needs for research in each country, by identifying both the problems and opportunities shared across the region as well as those that are site- and country-specific.

Those of you who are engaged in establishing research programmes to assist the producers and consumers of bananas, and who are starting this from a very small or non-existent information base, have the opportunity of profiting from the experiences of longer established programmes for improving food crops. In many cases the measurable benefits in terms of increased productivity in the small-farmer sector have been disappointing in comparison with the scientific skills, effort and financial resources devoted to food-crop improvement in eastern Africa. Scientific workers have a responsibility for seeing that their results are appropriate for the people whom their research is intended to benefit, and that those people gain access to the new technology.

I would suggest that the first step in designing an efficient programme of applied research is to identify the intended beneficiaries. In our case, the beneficiaries consist of groups of people who produce and consume bananas under definable sets of conditions; it is not the banana crop, as such, which should attract our attention. However, by gaining an adequate understanding of why, where and how certain people are producing bananas, the development of banana production can be designed in a logical manner. Then, by involving farmers at an early stage in testing new technology for their circumstances, research programmes can make readjustments when necessary, identify new problems and assist farmers in their initial adoption of new cropping patterns, varieties, practices or ways of using bananas.
The objectives of this workshop are focused on small farmers in the region. The small export banana crop (i.e. in Somalia) is sufficiently different in its technical requirements that it probably does not belong in the first instance in this group, although you may want to discuss this in terms of future strategy at the regional level. Similarly debatable may be the exclusion of the enset or false banana crop (Ensete ventricosum) which is locally of great importance in southern Ethiopia.

The first objective of the workshop is to provide a forum for the comparative analysis of the present situation throughout the region with respect to the systems of production and utilization of bananas and plantains and the potential for their improvement. A status report invited from each country provides the basic information for this purpose.

The second objective is to discuss and recommend strategies for the improvement of these systems. Consideration should be given to the improvement of cropping systems and their components, including varieties, the control of pests and management of soil fertility.

The third objective is to discuss and draw conclusions concerning any future activities, at the regional level or any other, which national research programmes would like to see develop. Your deliberations will have the potential, for example, for influencing the future course of development of the proposed International Network for the Improvement of Banana and Plantain and, in particular, the type of relationship that would be appropriate between that programme and national programmes.

References


OVERVIEW OF BANANA CULTIVATION AND CONSTRAINTS
IN THE ECONOMIC COMMUNITY OF THE GREAT LAKES STATES (CEPGL)

Kabonyi Sebasigari

INTRODUCTION

The Economic Community of Countries of the Great Lakes (CEPGL) is made up of Burundi, Rwanda and Zaire. These three countries have surface areas of 27,834 km², 26,338 km² and 2,345,095 km² respectively. Their respective populations have been estimated at 4,414,830, 5,388,012 and 26,377,260 (Anon, 1983b, 1982, 1983a).

The Kivu region of Zaire which is ecological similar to Burundi and Rwanda covers 75,635 km² of mountaineous region and 180,341 km² of lowland area. The population has been estimated at 3,294,316 and 1,005,864 inhabitants respectively (Anon, 1979). These figures show that in Kivu, the lowland zone is 2 1/2 times larger yet 3 times less populated than the high altitude region which is ecologically similar to Burundi and Rwanda.

ECOLOGICAL ZONES AND AGRICULTURAL POTENTIAL

Zaire

There are three climatic zones: the equatorial zone, tropical zones and the highland area in the east which includes the Kivu region (Van den Abeele and Vandeput, 1956).

a) Equatorial zone

This zone sits astride the equator between 2° North and South. Elevations range between 350m-500m and the region has rain all year round. Annual precipitation fluctuates around 1500mm-2000mm. Relative humidity is close to saturation point and the average temperature is 25°C or higher. This is the area of dense forests and swamps. The oil palm, robusta coffee, cocoa, rubber and plantain are among the crops that are particularly suitable to this zone.

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b) Tropical zones
Two areas constitute the tropical zone, and are found on both sides of the equatorial zone. They are characterized by a dry and a rainy season but the dry season becomes longer the further away one gets from the equator, varying from a period of one to three months in the northern hemisphere and from one to seven months in the south. The vegetation is mainly lightly wooded savanna. Between 800-1500mm of rain is recorded in the rainy season. The dry and rainy seasons alternate between north and south, making the zone suitable for the cultivation of cereals, beans, cotton, groundnuts, plantain and sweet bananas.

c) Eastern mountain zone
Here the elevation varies between 500m-4500m. The vegetation is mainly savanna. It is suitable for growing Arabica coffee, pyrethrum, green peas, Irish potatoes, wheat, and various vegetables found in temperate countries. The mountain region of Kivu forms part of this zone, and like Burundi, it is characterized by the cultivation of high altitude bananas of the AAA East Africa Sub-group.

Rwanda and Burundi

The relief ranges from 774m at the level of Lake Tanganyika to more than 3000m in the north (the Virunga volcanic range). With regard to banana cultivation, the picture is clearer if the area is looked at along vertical lines, giving four major specific ecological zones (Focan, 1961 a, b and c). These ecological areas correspond to different agricultural potentialities.

a) Low altitude zone (below 1000m)
This includes areas around the shores of Lake Tanganyika and the valley of the Ruzizi river. Important agricultural crops in this zone include: cotton, rice (irrigated), maize, groundnuts, and robusta coffee. Plantains are also grown in this area unsuitable for high altitude bananas.
b) Intermediate altitude zone (1000m to 1500m)
The greatest part of this zone stretches eastwards to the banks of the Nile, that is east of the mountain range (Zaire-Nile Crest) which separates the valleys of the Nile and the Zaire. The principal food crops areas: cassava, groundnuts, sorghum, maize and peas. Coffee and cotton grow with varying success according to the region (Focan, 1961c).

c) Medium altitude Zone (1500m to 2000m)
This is the most significant zone in terms of agriculture and livestock. Average rainfall reaches 1100mm and the dry season lasts four months. Average temperatures are between 19°C-20°C. This zone is particularly suitable for growing Arabica coffee; high altitude bananas are sorghum are also important. Sweet potatoes, soybeans, Irish potatoes and maize also grow very well in the region.

d) High altitude zone (2000m to 2500m)
This is characterized by the Zaire crest, which has the coldest temperatures among the zones. It is suitable for growing wheat, barley, potatoes, vegetables, beans, green peas and maize. In this zone, Arabica coffee gives way to tea.

BANANA PRODUCTION

Types of banana

Four categories of bananas are grown, classified according to the way in which they are consumed:

- Beer bananas are used to make fermented bear.

- Cooking bananas are eaten boiled in place of sweet potatoes or Irish potatoes, and are eaten with pulses, vegetables and sauces.

- Plantains, whose unripe fruit pulps are dried and pounded into a flour to make ugali which is eaten as an alternative to cassava in Kivu (Zaire). When slightly ripe, the fruits are boiled and pounded to make a dish (lituma) that is very popular in Zaire. At this stage of ripening the pulps can also be cut longitudinally and fried in oil to be eaten as chips in place of potatoes.
Dessert bananas are eaten fresh. These bananas are genetically different and of different origins - e.g. Chinese dwarf (AAA); Ney Poovan or kamaramasenge (AB); Gros Michel (AAA), etc. The plantain type called gonja in Luqanda (Purseglove, 1982; Namaganda, 1983) are of the AAB group, hence hybrids of Musa acuminata (A) and Musa balbisiana (B) (Shepherd, 1957; Simmonds, 1959; De Langhe, 1983, Purseglove, 1981).

When raw and when cooked, the cooking bananas are sweet whereas the beer bananas are bitter. When the green banana is peeled, the beer banana produces a sticky brownish excretion all along its surface. These two types of bananas, which belong to the triple genome sub-group of Musa acuminata (AAA) (Champion, 1965, 1970; Shepherd, 1957; De Langhe 1969 and 1983), are characteristic of the high altitude regions of east Africa (Shepherd, 1957; De Langhe 1983). These bananas are not to be found anywhere else except in this east African region (De Langhe, 1983). They include the mbidde (beer) and matooke (cooking) types of Uganda (Purseglove, 1981; Namaganda, 1983).

Champion (1970) suggests that a variety which was introduced in east Africa a long time ago is probably the parent of these cultivars but they have developed into different varieties through mutations undergone on the high plateaux.

Other than these categories, we must mention the presence in our region of the three ABB Asian varieties: Pissang Awak Leqor, Pissang Awak and Montan. Pisang Awak Legor (igisubi) is the most widespread and is used for beer.

Production and significance

Plantain gives the best results in hot and humid climates. It does not tolerate cold and cannot adapt to conditions at altitudes higher than 500m. Within the economic community, Zaire is its principal producer (Table 1).
Table 1: Production of bananas in the CEPGL countries

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>TYPE OF BANANA</th>
<th>YEAR</th>
<th>REA (ha)</th>
<th>PRODUCTION (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zaire¹</td>
<td>Plantain</td>
<td>1981</td>
<td>315,000</td>
<td>1,438,000</td>
</tr>
<tr>
<td>Zaire (Kivu)²</td>
<td>Mainly plantain</td>
<td>1979*</td>
<td>24,386</td>
<td>53,738</td>
</tr>
<tr>
<td>Zaire (Kivu)²</td>
<td>Mainly beer and cooking banana</td>
<td>1979</td>
<td>147,638</td>
<td>318,980</td>
</tr>
<tr>
<td>Burundi³</td>
<td>Beer only</td>
<td>1982 )</td>
<td>131,324</td>
<td>(770,000</td>
</tr>
<tr>
<td>Burundi</td>
<td>Mainly cooking</td>
<td>1983 )</td>
<td></td>
<td>(450,000</td>
</tr>
<tr>
<td>Rwanda⁴</td>
<td>Mainly beer and cooking</td>
<td>1980</td>
<td>224,648</td>
<td>2,063,436</td>
</tr>
</tbody>
</table>

*Note: Figures for Kibombo, Panqi and Punia administrative regions are not included.

Source: 1. Anon. 1983a  
2. Anon. 1979  
3. Anon. 1983b  
4. Anon. 1980

In the other two countries plantains are found particularly on the shores of Lake Tanganyika at altitudes below 1000m. However, three or four varieties of this group can be found in areas of higher altitude.

The high altitude bananas of the east African AAA sub-group include beer and cooking bananas which are consumed by at least 13 million inhabitants in the highland region of Zaire, Burundi and Rwanda.

In Burundi (Anon, 1983) banana production takes first place in overall food production, followed by sweet potatoes and cassava in second and third places respectively. Approximately 17% of the agricultural area is devoted to banana production. In Rwanda, banana also comes first in terms of food crop production; it occupies 21% of the food crop production area.
Cultivation methods

a) Plantains
In the traditional agricultural system of the two low-altitude regions of Zaire, plantains are grown in separate stands in the field or around homesteads. These scattered banana stands are grown in association with other food crops (maize, beans, groundnuts, rice, pumpkins) or with cash crops (cotton, oil palm, coffee, cocoa).

b) High altitude bananas
In Burundi, Rwanda and Kivu, bananas are grown by almost every family, usually around the scattered homesteads which are located traditionally on the hillsides and ridges. Bananas growing around the homesteads (rugo) receive plenty of organic and mineral fertilizers from animal pens and household wastes. All the different varieties of bananas are grown together but beer bananas take up 85 to 90% of the area, with cooking bananas taking up only approximately 5-10%. The predominance of beer bananas is due to socio-economic factors which will be explained later.

Plantations become less dense the further away one gets from homesteads and give way to food crops in accordance with local interests. Bananas are often grown with one or two other important crops, including beans, sweet potatoes, cassava, sorghum and yam. The following intercrops, for example, are often observed in Rwanda and Burundi: banana-yam; banana-beans; banana-beans-yam; banana-cassava-beans; banana-sweet potatoes-sorghum.

Banana pure crops also exist and some of them have existed for more than 50 years. Banana gardens are usually kept in good order by cultivation, trimming the leaves and removing suckers. Bananas are harvested in whole bunches when still green.
Marketing channels

The economic system in the area we are concerned with here is such that the peasant farmer wants to be self-sufficient in food and at the same time receive some monetary revenue. In this system, excess plantain and dessert bananas are sold at local markets. From these markets traders transport the bananas to urban centres. This applies equally to banana beer, which is processed on a small scale. Beer halls are seen everywhere in the area where bananas are grown, as well as in the urban centres of Bujumbura (Burundi), Kigali (Rwanda), Bukavu and Goma (Zaire). A banana beer processing factory, using more modern wine-making methods, has been established in Kigali by the Office pour la Valorisation Industrielle de la Banane au Rwanda (OVIBAR). This organization buys bananas in rural areas and manufactures banana wine which is then bottled.

RESEARCH ACTIVITIES

Past research

The Institut National pour l'Etudes Agronomiques au Congo (INEAC) is the parent institution of the present national institutes, ISABU* (Burundi), ISAR* (Rwanda) and INERA* (Zaire). INEAC was carrying out research on the banana as early as the 1930s. This research concentrated on the export banana Gros Michel in the Mayumbe (Zaire) stations of M'vuazi, Kondo and Gimbi. There were studies on the effect of mulching and organic fertilizer and experiments were carried out to determine the optional number of suckers per stand and the correct frequency of sucker removal. Gros Michel was grown with other cash crops, particularly rubber and oil palm.

This research indicated (Sebasigari, 1983) that:
- permanent mulch is indispensable for longevity of a banana plantation;
- planting at 4m x 4m spacing and pruning to two suckers is most profitable;

*ISABU = Institut des Sciences Agronomiques du Burundi
*ISAR = Institut des Sciences Agronomiques du Rwanda
*INERA = Institut National pour les Etudes et Recherches Agronomiques
pruning is best done once a year in March.
palm and rubber trees do not hinder banana production in the first 5 years;
mixing mulch and compost improves growth and increases production, but mulch alone gives better results than compost alone.

At Yangambi (INEAC's principal station) in 1954, taxonomic work on plantains had been initiated and variety-crossing was tried in order to induce free sucker production in these bananas (Sebasigari, 1983). Highly productive varieties were identified but the research was abandoned in 1960 before the genetic improvement programme could reach its goals.

In high altitude areas, two lines had been identified from varietal experiments conducted at Muhugu (Zaire) and Rubona (Rwanda) stations. These lines still exist and a third has just been identified at the Mosso station (Burundi). A survey of research done on high altitude bananas (Sebasigari, 1983) shows that very little research has been done.

Problems for research

Particular emphasis must now be put on research on the high altitude banana which has hardly been touched in the past. This emphasis can be justified by the fact that research on plantain has been restarted at Yangambi under the aegis of the West African Regional Cooperation for Research on Plantains (WARCORP).

a) The preponderance of beer bananas

As Delepierre (1970) pointed out, banana growing in Rwanda is linked to the socio-cultural system of the people. On Rwanda, Delepierre (1970 wrote):

Beer bananas constitute an exchange item par excellence, utilized by rural people in the most diverse of circumstances. It is offered to friends as a welcoming gift, it precedes a request for a favour or a sensitive service from an influential person, and it is given as a sign of gratitude and thanks. Disputes are resolved around a pot of beer as a sign of reconciliation. Beer is offered as reward at the end of communal agricultural work... traditionally, banana beer plays a very important role during ceremonies that surround preparation for marriage.
It should be added, however, that where there are few bananas, sorghum beer plays the same role. The role of this beer accounts for the predominance of this type of banana in comparison to cooking or dessert bananas. For example, 95% of bananas in Rwandese plantations are beer bananas (Nzamurambaho, 1978) with two varieties, intuntu and intokatoke, accounting for up to 90% (Champion, 1965).

Two other reasons account for this preponderance: market price and economic revenue. A study on bananas carried out in July 1983 revealed that 4 bunches of bananas fermented and brewed into beer were sold for more money than 4 bunches of cooking bananas sold directly in the local market (De Langhe, 1983b). Furthermore the team realized that the Kibungo region (130km from Kigali, Rwanda) was the only area where many plantations contain 40% or more cooking bananas, as a result of the great demand for them from the Kigali township. It was realized also that where beer bananas do not grow well, the ABB cultivars are used for beer making. Hence, in the neighbourhood of Bujumbura and the Mosso station (Burundi), the gisubi cultivar (Awak Lego) is produced in proportions of up to 80-90%. Although this neighbourhood is suitable for growing plantain, it is not grown as this is not a beer-producing type.

This preponderance of beer bananas at the expense of cooking dessert varieties is opposed to government policy and extension programmes. In an effect to ensure self-sufficiency in staple foods, governments are encouraging increased percentages of cooking and dessert bananas in local plantations. In Rwanda, at least 40% should be of the latter types (Nzamurambaho, 1978).

b) Lack of Production Statistics

In order to understand better the economic importance of each category of bananas, it is essential that extension workers gather appropriate data and separate the figures according to the different categories (plantain, cooking, beer and dessert banana) in their reports.
c) **Limited taxonomic knowledge**

In most cases, the name given to one variety differs from region to region or even from village to village. For example, the most widespread beer variety is known as *intuntu* in Rwanda, *igitsirye* in Burundi and *ndundu* around Bukavu in Zaire. In the Bugaruma valley of Rwanda it is simply called *mazizi*; elsewhere it is known as *igikashi*. *Mazizi* and *igikashi* are generic terms implying beer bananas. In Kibungo, Rwanda, people even talk of two types of *intuntu*: *intuntu y'imbihire* (for beer) and *intutu y'inyamunyo* (for cooking). In Burundi, it is *igitsiri*, *igitsirye*, *umutsiri*, *umusirampiza*, *umubira*. The imported variety Awak Legor is called the following names in different regions of Burundi: *gisubi*, *kayinja*, *ikidamu*, *cyamadamu*, *mugomozi*.

This list could go on indefinitely. It is interesting that sometimes even farmers from the same hill do not agree on the name of a variety, particularly when it has been introduced only recently. This proliferation of synonyms for one variety is the reason why agronomists in extension work are unable to communicate effectively with each other or with the farmers they are supposed to help.

In order to overcome this problem, taxonomic work is required very urgently to establish criteria for distinguishing one cultivar from another. Then it will be possible to tell whether *ikiyove* of Bukemba village in Burundi is the same as the *intokatoke* of Bugoyi in Rwanda. If these two names refer to one variety, its performance on two soil types (Mosso red soil and volcanic soils of Bugoyi) can be evaluated.

d) **Traditional farming systems**

Field observations have shown that high altitude bananas grow better at 1200-1800m. In Burundi, for example, these bananas are rare around Bujumbura (1000m) and give way to the *ABB* (*mugomozi*) and *AB* (*kamaramasenge*). In spite of the ecological limitations, farmers in areas that are not suitable for growing these bananas still want to make beer. Consequently, the *ABB* varieties used for brewing have been introduced in the lower altitude Imbo plain and in Mosso.
On the other hand, production statistics indicate that the 9 ton/ha yield obtained in Rwanda and Burundi are not up to the expected potential. In effect, in the Mulungu (INEAC, 1959) and Rubona (Delepierre, 1970) stations, yield of up to 15-30 ton/ha have been recorded. Taking into account the problems of scarcity of land in Burundi and Rwanda and to a lesser extent in Kivu (Zaire), the policy of regional specialization in agriculture advocated by these countries' five-year plans should be implemented to increase production. If increased production is achieved, transport and distribution should be improved to enable farmers to obtain the best returns.

Besides the practice of growing bananas in unsuitable areas, low yields are caused by poor farming practices, such as inappropriate intercropping systems, cultivating within the plantations, poor management of suckers leading to development of too many stems per stand, and removal of banana leaves to mulch coffee rather than to mulch the bananas.

Reduced yields are often preceded by stunting of plants and thinner bunches, which cause farmers to increase the acreage under banana plantation at the expense of other food crops.

e) **Pests**

Up till now, pests are still not an alarming problem in banana cultivation. However, it should be noted that cercosporiosis (Sigatoka disease), bunchy-top (Cyme disease) and the banana weevil (Cosmopolites sordidus) infest banana plantations in all regions of the CEPGL countries (De Langhe, 1983).

Even though the farmers in the Buqarama plains (Rwanda) and in the Cibitoke Province (Burundi) told the team that bunchy-top disease had existed there for almost 25 years, this disease constitutes more of a menace for high altitude bananas. In Cibitoke, the team observed it on a cooking variety and the farmers remarked that it was responsible for disappearance of other varieties, including the beer variety ingoromoka.
Current Research Activities

The Institut de Recherche Agronomique et Zootechnique (IRAZ) of the CEPGL has only just been established. One of the activities provided for in its programme for 1983 is the drawing up of a 5-year research plan on bananas.

This research plan was drawn up (De Langhe, 1983) after field visits by Professor E. De Langhe (FAO consultant) and K. Sebasigari (IRAZ researcher) in August, 1983. The plan includes the following activities:

a) setting up at the IRAZ station at Giteqa, Burundi, a collection of banana cultivars from the countries of the community and studying their taxonomy;

b) maintaining initially 16 cooking and semi-dwarf varieties which demonstrate an economic potential;

c) a study of three cultivation systems representative of the systems observed in the rural areas;

d) setting up adaptation trials at 6 selected sites in the three countries, for 6 beer and cooking varieties representing the high altitude bananas characteristic of east Africa;

e) carrying out technical studies to improve understanding of the physiology of high altitude bananas;

f) training of extension agronomists.

In addition to this research to be carried out on high altitude bananas, research will endeavour, as far as possible, to identify plantain cultivars which can adapt to high-altitude conditions.

This programme is expected to start in 1984 if finances are available.
References


BANANA PRODUCTION AND RESEARCH IN BURUNDI

Baragengana Rénovat

INTRODUCTION

The scarcity of literature on banana production in the region and the fact that not much effort was previously put into research on this crop at INEAC, make this note rather incomplete. Nontheless, the banana has always wielded a great deal of prestige, comparable only to that of cattle, with the rural populations. For this reason no realistic research with the interests of the rural farmers at heart can afford not to lay emphasis on this subject.

IMPORTANCE

The edible types of banana originate from south-east Asia and their spread to other continents show signs of some form of human action. By the 15th century, slave traders found bananas growing along the Zaire River. From there, colonialists and missionaries introduced it to other regions of Zaire and Burundi round about 1918-1920.

Socioeconomic importance

The banana, more than any other crop, occupied a rather special place in the heart of the Murundi. This is because of its unquestionable economic and agricultural advantages. But beyond these tangible advantages are the socio-economic values linked to the traditions that surround the beer produced from its fruits. In effect all social events, happy as well as unhappy, take place around one or two pots of this beer.

Examples of these uses include the following:
- A pot of banana beer is presented as a gift preceeding a request for a favour or service from an influential person as a sign of gratitude and thanks;
- Conflicts are resolved around a pot of this beer

1 Director, Mosso Research Station, ISABU, Burundi
2 Murundi = singular for Barundi, the people of Burundi
For communal agricultural work (qutanga umukozi), the person receiving the communal help will prepare some beer to serve the workers at the completion of the job; Beer is served during preparation for and at wedding ceremonies.

Banana beer is very popular throughout the country and is one major source of revenue for the farmer. It contributes approximately 40% of the total monetary revenue of the farmer.

**Ecological and agricultural advantages**

Many annual crops encourage soil erosion by their inability to cover the ground and the fact that repeated cultivation leaves the ground bare.

On the contrary, the banana protects the ground against erosion by means of its large leaves and its root system which holds the soil together. The rotting leaves and trunks add humus to the soil. The large leaves provide shade for vulnerable crops that would not survive under harsh conditions.

**PRODUCTION CHARACTERISTICS**

**Husbandry**

In Burundi, bananas are grown principally around the homestead. In this way the plantation benefits from household wastes and rubbish as compost and fertilizer.

The size of planting suckers varies according to the distance between their place of origin and where they are to be planted. If they have to be carried over long distances, small suckers or even sections of the corm will be used. However, 4-6 month-old suckers are recommended.

Pits of 40 x 40cm are dug and filled with compost and other fertilizer. Spacing depends on the fertility and humidity of the soil but generally ranges between 4m and 8m between stands. The Department of Agriculture, however, recommends 10m between stands.
Before planting, suckers are carefully separated from the mother plant, the leaves removed and the roots trimmed so that the core is almost smooth. They are then planted in the pits prepared as described above. The sucker is dropped into the pit at a slightly inclined angle.

The ground is then tilled and prepared for planting other crops such as beans, groundnuts, maize and yams. Although young plantations require fertilizer and compost, mulching of banana plantations is unknown to our farmers. They only cut the dying leaves off the stems and leave them to decompose, producing rich compost.

**Ecological zones**

In Burundi, bananas are grown everywhere except above 1800m altitude (the Zaire-Nile Crest), a zone of very minor significance in relation to the rest of the country. Yields decline with altitude as banana plantations appear unable to withstand cold, strong wind and heavy rainfall. Hence, the optimal banana growing area is limited in spite of the fact that the banana is adaptable and gives satisfactory production in a variety of ecological zones.

**Production trends**

At the moment, the area devoted to banana production in Burundi is close to 170,000 ha and production is in the range of 1,700,000 tons. In an average household with 0.84 ha of arable agricultural land the banana occupies 0.15 ha, approximately 18% of the total area. In the Burundi cropping system the banana comes third in importance in terms of area, after beans (42%) and maize (24%). In comparison, coffee takes up only 500 m², cassava 140 m², sweet potato 830 m². These broad figures mask one important fact: the average yield of bananas is very low, in marked contrast with the enormous area devoted to banana production.

For a small country like Burundi, the shortage of land makes it absolutely necessary to intensify cultivation and produce more per unit area. Currently, in Burundi, yield varies between 9 and 15 tons per ha. In order to improve this, research to identify more productive cultivars has started.
UTILIZATION

Production of beer is estimated at between 5 and 6 million hectolitres per year. At an approximate price of 20 Burundi francs (USD 0.22) per litre, this beer has an estimated value of 10 billion Burundi francs (USD 110 million). As a food, the banana is cooked, roasted, eaten fresh as dessert or made into dough; however, utilization in these forms remains limited. It is estimated that 90% of the bananas are used in the manufacture of beer.

Beer is made by ripening banana fruits in closed pre-heated pits to soften the pulps. These are in turn squeezed into a clear squash (by hand or by foot). Green grass is used to filter the juice and grilled sorghum is added to the juice to initiate the fermentation process, which takes from two to three days. The beverage produced is very difficult to conserve and consequently it has to be consumed as soon as possible to avoid spoiling.

There are uses for the other parts of the banana plant. In particular, (i) dried leaf sheaths are used to thatch houses; (ii) the banana peels are used to feed pigs and goats; and (iii) when dried the sheaths are used to wrap banana fritters (chikwangue), and are also often used to make an improvised raincoat.

RESEARCH REVIEW

Present status

At the moment research on bananas is in its infancy. We started off by gathering available genetic materials into a collection. This has been hindered to some extent by the problems of transporting the suckers and of confusion of variety names.

The same varieties often have different names from one region to another, and one name may not necessarily denote the same variety. Some names that are often given are very general - for example, quisahira implies "cooking banana" in general terms, and kigurube is used for all the "dwarfs".
The origins of our cultivars are not well known but the majority come from Uganda, Tanzania and Bukirasazi (Burundi). Performance records of the collection at the station group the Ugandan strains as the superior cooking varieties, with yields up to 36 tons per ha. These Ugandan varieties are lushakara and kisahira. The local kisahira produces only 12 tons per ha on average.

Two plantain cultivars from Uganda look very promising, but no conclusive results are yet available. In the case of beer bananas, the local gihonyi has the highest yield followed by gisandugu, kiyove, and gisubi with average yields of 36 ton/ha. With regard to sweet banana, the kingurube makamba (dwarf type) is the most productive with yields of 54 tons per ha, followed by the "red" banana, "green-red" banana and mbiru (locatan) with an average yield of 33 tons per ha.

In the long-term, our cultivar collection is expected to grow. The additions will be described more precisely, with particular emphasis on cooking bananas. We hope to propagate the best varieties of cooking bananas after experiments on varietal adaptation have been completed, particularly for the promising Ugandan varieties mentioned above which are as productive and competitive as the beer bananas.

Future prospects

It is absolutely necessary to reverse the current trend in banana production. Preferably, the proportion of cooking bananas should be raised at least to 40% of production.

Although legislative measures and extension programmes can be used to help people understand the desirability of this change, success will be dependent on research to identify improved cooking varieties. Higher yielding varieties which are fast growing and are able to compete well with the beer varieties may be able to progressively replace them - particularly in older plantations. More productive beer varieties could be distributed without necessarily favouring their spread at the expense of this cooking type.

Making juice or flour out of bananas, which could be conserved in bottles or packets, would save the country the foreign exchange currently being used to import juices and wines. The export of fresh banana is not likely to be economic because of the high cost of transport.
BANANA AND PLANTAIN PRODUCTION IN KIVU, ZAIRE

Musanganyi Titebwal
and
Matungulu Kande Mutanda

GENERAL

Bananas are grown throughout the Republic of Zaire; edible bananas are found in all the markets in the country. Plantains are eaten boiled in some areas in Zaire, while green or ripe plantains, boiled and pounded, are the staple food of some tribes. Plantains also used for making flour (which is eaten in the form of porridge, fritters (chikwange), and they can also be eaten fresh in oil. Plantain peels are used in traditional medicine. Roasted and filtered in water, plantains produce an ingredient used in preparing a special dish of cassava leaves.

Beer bananas produce an alcoholic beverage and a banana juice. The trunks and leaves of banana trees, cut into small pieces, are used to feed livestock. The banana is essentially a source of calories: 100g of ripe peeled bananas contains approximately 68.8% water, 1.2% protein, 28.3% non-nitrogenous extracts 0.4% fat, 0.8% ash, 0.01% calcium and 0.01% phosphorous.

PRODUCTION ASPECTS

Ecological zones

Bananas can be grown satisfactorily up to elevations of 1800mm. Between 1800m-2100m beer bananas begin to lose vigour and above 2100m they disappear gradually. In areas with strong winds, advantage must be taken of shelter belts to avoid stem-breaking.

Production systems

Extensive areas of cash-cropped bananas entail heavy requirements for transportation to markets. This taxing job has traditionally been left exclusively to the woman. Consequently, most farmers concentrate upon subsistence farming.

1 Research Assistants, Mulungu Station, INERA, Kivu, Zaire
In forest regions and the savanna, banana production can be found far from homesteads and access roads. In these areas bananas are cut from the end of May to mid-August. Shoots with a height of 50cm-60cm and narrow leaves are used for planting. This is done in the rainy season from September to February. Spacing in monocrops varies from 3x3m to 2.5x2.5m, but in most fields where intercropping of rice-bananas, rice-banana-cassava or beans-banana are practised, spacing is irregular and usually much wider. Recommended crop husbandry practices are generally not followed by the farmers; this includes weeding and removal of suckers.

Cooking bananas are harvested when one or two fruits begin to ripen; plantains are harvested when the very last fruit is fully formed; whereas beer bananas are cut and left in the plantation until there are enough bananas for brewing.

**Trends and constraints**

Farmers tend to grow their bananas around their homes in order to reduce to the very minimum the transport requirements for a crop that is used exclusively for family consumption. This practice reduces the area of banana plantations. However, the banana is still predominant in fields around the homesteads in those regions in which the population explosion is causing serious nutritional problems. Young people are not likely to want to bother themselves with big plantations of beer bananas.

**PREVIOUS RESEARCH ON BANANAS**

**Taxonomy**

Screening trials have been carried out on a collection of 30 varieties made up of local varieties and those from the Food Crop Division of Yangambi Research Station. The following varieties were identified in this collection:

- *Musa acuminata* (15 varieties)
- *Musa sapientum* (18 varieties)
- *Musa balbisiana* (1 variety)
- *Musa ornata* (1 variety)
- *Musa textilis* (?) (1 variety)
The *Musa acuminata* group was divided into diploids and triploids. In *Musa aplantum* we were able to distinguish 12 varieties of plantains and 3 varieties of cooking bananas. Bananas have been grouped into fresh, flour, cooking, and beer types according to the way in which they are utilized.

Contrary to what was observed at Yangambi, the first bunches to be produced are heavier than subsequent bunches. Harvesting starts on average 2-2½ years after planting.

**Vegetative reproduction**

Effective propagation techniques are required for two situations: for multiplying one or a few rare and valuable individual plants, and for rapid multiplication of a variety for which a relatively large amount of material is available. With these situations in mind, four experiments were carried out with the following conclusions:

- the utilization of a propagator with substratum of river sand and a base of gravel is necessary;
- disinfect the substratum with chloropicrine to prevent rotting of the corm;
- use corms with 20cm-25cm diameter before the banana starts fruiting;
- disinfect the corm by soaking in a solution of 2% cerrosan;
- introduce the corm in the propagator in the form of three sections cut horizontally;
- young shoots cut when they reach 20cm-30cm height should be planted in the ground in rich soil at spacings of 1mx1.5cm;
- as soon as the young plants reach a basal diameter of 20cm-25cm, they can be cut and the suckers used in a nursery.

This operation is repeated until sufficient material is obtained. An average of 12.3 shoots per corm can be obtained at each cycle.
Banana root system

Observations showed that at 10cm depth, very many roots radiate from the stem. These primary roots with a diameter of 1cm penetrate weakly and bear secondary roots with 2mm diameter, which are in turn divided into tertiary and quaternary roots. However, beyond 2m from the stem, the roots start to penetrate deeply. This shows that each banana tree can draw nutrients and water from a soil volume of 56.3m³. The roots explore a radius of 3m and a depth of approximately 3m. This would explain why the banana can withstand dry conditions in spite of the enormous amount of water evaporated by its above-ground parts.

Literature consulted


BANANA PRODUCTION AND RESEARCH IN TANZANIA

A.S.S. Mbwana

INTRODUCTION

At one time Tanzania was estimated to have produced 2.01 million tons of bananas from an area of about 325,000 hectares. This was about 11.8% of world production then, ranking Tanzania as the second largest producer and consumer of cooking bananas in the world after Uganda. Average consumption was calculated at 0.77 kg per head per day.

More recently, Walker et al. (1983) mentioned the banana as being a major staple food for 15-20% of the population in Tanzania, mainly in the high altitude areas with high rainfall. In addition, the sweet banana is one of the most popular fruit for the whole population and is available throughout the year. These facts explain why the banana is considered to be important in Tanzania.

PRINCIPAL ECOLOGICAL ZONES OF PRODUCTION

The country falls into three natural ecological zones according to altitude and rainfall.

High altitude with high rainfall (above 1,000mm) zone

This zone includes areas over 1,200m above sea level which are by far the most important areas for production and consumption of bananas in the country. They comprise the areas north-west of Lake Victoria where they grow cooking bananas of the AAA group known as matoke. There are numerous matoke somatic mutants differing in size and shape of the fruit but with almost no difference in taste. So, for example, ntobe has thick, short fingers borne on a bunch of compact hands while njubo has thick, long fingers and loose hands. Other kinds are nyoya, nshakara and nshansha.

Plant Nematologist and Acting Co-ordinator of Banana Research, Agricultural Research Institute, Maruku, Bukoba, Tanzania.
Another type, mbire, is grown for brewing purposes. It resembles matoke in appearance but has a rather sour taste when cooked. Less important types in this area are the nkonjwa (AAB) which is roasted and kisukari (AA) for dessert.

Areas around Kilimanjaro and Meru Mountains (Moshi and Arusha) grow yet another AA group called mshare for cooking. They brew from kisubi which is AB group and they grow kisukari (AA) for dessert.

In the southern highlands (Tukuyu) the common cooking type is the plantain, nkonjwa, a cultivar which, surprisingly, is used for roasting in other areas.

**Low altitude with moderate rainfall (800-1000mm) zone**

In areas below 1,000m above sea level with moderate rainfall people grow maize as their main staple. However, they also grow bananas as a change for a few meals in the month. The commonest type here is the Cavendish group (AAA). Such areas are Morogoro region, Kigoma, Rukwa and Tanga (lowland).

**Low altitude with low rainfall (below 800mm) zone**

This zone comprises most of the coast and central regions of Tanzania which are dry and unsuitable for banana cultivation. Families with access to small wet valleys grow a small patch of bananas for cooking and for dessert, the commonest cultivars being bokoboko (ABB), which is drought resistant, and kisukari. Most notable of these areas are Coast region, Singida, Dodoma and Shinyanga.
PRODUCTION TRENDS

Generally in Tanzania bananas are produced and consumed within family circles and normally no records are kept. This makes the task of obtaining production figures very difficult and sometimes impossible.

Simmonds (1966) gave an estimate of the annual banana production in Tanzania in 1931 as 2.024 million tons and the production per capita as 260 kg per person. From 1969 to 1971 production stood at 1.08 million tons, only 88 kg per person (F.A.O., 1981).

Table 1 shows production estimates for Kagera region (Bukoba). This shows clearly that the production for 1980/81 was only 61% of that for 1975/76.

All this information points to the fact that banana production is going down year by year. Nobody knows the full extent of the repercussions of this trend but, whatever the case, it needs arresting to safeguard this important food crop.

Table 1. Banana production in Kagera Region 1975-1981

<table>
<thead>
<tr>
<th>Year</th>
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<th>Percentage</th>
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<td>1975/76</td>
<td>672,700</td>
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<tr>
<td>1976/77</td>
<td>700,000</td>
<td>104.0</td>
</tr>
<tr>
<td>1977/78</td>
<td>560,500</td>
<td>83.3</td>
</tr>
<tr>
<td>1978/79</td>
<td>436,500</td>
<td>64.9</td>
</tr>
<tr>
<td>1979/80</td>
<td>430,300</td>
<td>64.0</td>
</tr>
<tr>
<td>1980/81</td>
<td>416,100</td>
<td>61.8</td>
</tr>
</tbody>
</table>

Source: Kagera Regional Development Plan 1982/83
CROPPING SYSTEMS

In the high altitude areas bananas are normally intercropped with coffee. In the Kagera Region coffee-banana intercropping is carried out in a characteristic way. In the vicinity of the dwelling house there is an almost pure stand of bananas. Usually these bananas are healthier than the others, presumably due to the domestic refuse that is thrown onto them every day. Following this is a band of an almost 50-50 mixture of bananas and coffee. The bananas in this area are not as healthy and they produce smaller bunches. On the outside there lies yet another band dominated by coffee, where a few bananas are planted mainly for providing leaves for wrapping purposes.

During the rainy seasons the bananas are desuckered leaving only three plants per stool, and are detrashed to let enough light into the field. It is in this season that beans are planted. With increasing food pressure intercropping became more complicated. Maize, cassava, cocoyams and sweet potatoes became common interplants in the same banana-coffee fields. The dynamics and economics of such cropping systems are not yet very clear but apparently do not seem to favour the bananas and may partly account for the observed decline in their yield.

In the lowland areas bananas are commonly intercropped with perennials such as coconuts or cashewnuts. Maize, cassava, cowpeas and other annuals are added during the rainy seasons.

Although people are discouraged from intercropping bananas with any other crop, in practice one very rarely sees farms with pure stands of bananas.

MARKETING CHANNELS

Due to limited transport facilities, bananas cannot be transported far from the areas of production. This situation makes the nearest town (district and regional) become the main market for bananas. So, for Kagera region the market is Bukoba, for Kilimanjaro it is Moshi, etc.
Morogoro region used to dominate the Dar es Salaam city market due to its good railway and communication system of all-weather roads. After the Dar es Salaam-Lusaka highway and railway were opened, however, Mbeya bananas found an outlet in Dar es Salaam and now they dominate the market there (see Table 2).

In a recent survey many regions indicated their willingness to eat bananas if they were available at prices comparable with other staples. Hence these towns without bananas are potential markets.

Table 2. Supplies of cooking bananas to Kariakoo Wholesale Market

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbeya</td>
<td>12.8</td>
<td>1,582</td>
<td>35.4</td>
<td>2,546</td>
</tr>
<tr>
<td>Morogoro*</td>
<td>52.0</td>
<td>1,002</td>
<td>22.4</td>
<td>188</td>
</tr>
<tr>
<td>Turiani*</td>
<td></td>
<td></td>
<td></td>
<td>534</td>
</tr>
<tr>
<td>Moshi</td>
<td>21.5</td>
<td>948</td>
<td>21.1</td>
<td>622</td>
</tr>
<tr>
<td>Arusha</td>
<td></td>
<td>519</td>
<td>11.6</td>
<td>467</td>
</tr>
<tr>
<td>Ifakara*</td>
<td>11.6</td>
<td>217</td>
<td>4.8</td>
<td>264</td>
</tr>
<tr>
<td>Kilombero*</td>
<td></td>
<td>193</td>
<td>4.3</td>
<td>202</td>
</tr>
<tr>
<td>Coast</td>
<td>1.4</td>
<td>8</td>
<td>0.3</td>
<td>97</td>
</tr>
<tr>
<td>Bukoba</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Others</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>4,470</td>
<td>99.9</td>
<td>4,943</td>
</tr>
</tbody>
</table>

* = Areas in Morogoro Region


FORMS OF UTILIZATION OF FRUIT AND OTHER BANANA PRODUCTS

The most important utilization of banana fruit in Tanzania is cooking and eating of green bananas as the main part of a meal. In the major banana growing areas it is not uncommon to find families eating bananas for breakfast, lunch and supper the whole year round.
Another important form of utilization is the more international one, i.e. eating sweet ripe bananas before, during or after meals. In Kilimanjaro, Arusha and Kagga Regions brewing beer from bananas is a common use. To a lesser extent roasting the fruit and eating it with roast meat is a common practice, especially in towns. There are cultivars most suitable for each of these uses.

Other common uses include using the dry leaves for thatching houses and the fresh ones and the pseudostems for feeding to cattle. Dry leaf sheaths are used as wrapping material and are also made into various articles for decoration in houses. The customs and ritual of some tribes (e.g. the Bahaya) are so intertwined with bananas that they would not be happy to live without them.

CONSTRAINTS ON PRODUCTION

Table 1 indicates that banana production is steadily going down in the major banana growing areas and average production of 3.5 tons/ha is far below the potential production of over 20 tons/ha recorded at the Agricultural Research Institute, Maruku.

This decline has been attributed to several factors as discussed below:

Banana weevils (larvae of Cosmopolites sordidus) and nematodes (Pratylenchus goodeyi)

Although banana weevils were recorded in East Africa as early as 1940 (Hargreaves, 1940) and banana-spot infesting nematodes in 1973, there was no record of any alarming damage until 1976-1978 when more than 50% of bananas were damaged in Bukoba District, and subsequent surveys (Bujulu et al., 1981) have shown that the damage also extends to other major banana growing areas of the country, most notably Kilimanjaro, Arusha, Morogoro and Mbeya. No national surveys have been conducted so far on these pests but they are believed to cause a big loss.

Deteriorating soil fertility and poor management

Purseglove (1969) recorded the nutrients withdrawn by 25 tons of harvested bananas as:
These figures warn of the danger of mineral depletion if there is no proper regime of fertilizer application.

Both Kilimanjaro and Kagera Regions have weevil and nematode problems. In Kilimanjaro people traditionally keep one or two cows per family and they constantly apply farmyard manure to their banana fields. The bananas are healthier and they suffer relatively minor losses. Kagera Region is rather different. The custom of cattle keeping is dying out and farmyard manure is becoming increasingly scarce and expensive.

The practice now in Kagera is to apply manure and thick grass mulch at planting but thereafter no more organic matter is brought into the field from outside, except by a few people who can afford it. So there is a net outflow of nutrients from the fields through the bunches which are constantly harvested.

Manure application is not common in other regions in Tanzania, even at planting time, so deterioration of soil fertility is inevitable and may contribute greatly to the declining banana yields.

Shortage of suitable land

In Kagera Region most of the suitable forest and thick-bush areas have been cleared and planted to bananas and coffee leaving only the open infertile grassland (rweya). To establish a banana field on those grasslands one requires a lot of labour to exterminate the notorious weed, couch grass (Digitaria scalarum) and a lot of scarce manure. Often this is too expensive for the farmers. The current population increase is about 3% p.a. So the food requirement is increasing every year and the size of fields is almost constant. The tendency has been to add more annual crops like cassava, sweet potatoes and maize which seem to interfere with the superficial root systems of bananas. Such interference may be the cause of reduced vigour and hence poor yield of bananas.
Other Constraints

In addition to the factors mentioned above, drought, diseases and lack of market channels may also contribute to the decline in banana production.

SUMMARY OF RESEARCH WORK IN PROGRESS

Chemical control of banana weevils and nematodes

In the programme pesticides are being evaluated (as they become available) for their efficacy in the control of these pests. Currently the pesticides under trial are:

- carbofuran (Furadan SG)
- aldicarb (Temik 15%)
- phenamiphos (Nemacur)
- isophenphos (Oftanol)
- BHC (H.C.H.)
- dieldrin (Kynandrin 2½%)
- izasophos (Miral)

On the basis of the data accumulated so far, carbofuran has been tentatively recommended for restricted use against banana weevils and nematodes. However, more work is being conducted each year in search of a better chemical in terms of efficacy, cost and environmental safety.

Soil management trials

Bananas remove a lot of soil nutrients in the form of bunches harvested each year. If these nutrients are not returned the fields get poorer and poorer by the year until they ultimately fail to produce good bananas.

In many areas with an acute banana decline problem, farmyard manure is very scarce. This programme aims at looking into various ways of enriching the fields so that the farmers can choose the methods within their reach.
Presently we are comparing the following treatments:

(a) Farmyard manure, 1, 3, 5 tins*
(b) Coffee husks, 1, 3, 5 tins
(c) Compost manure, 1, 3, 5 tins
(d) Inorganic fertilizers (triple superphosphate, murate of potash and calcium ammonium nitrate)

Cultivar trial

A.R.I., Maruku keeps a collection of more than 350 entries obtained from Kagera, Kilimanjaro, Arusha, Morogoro Regions and Uganda. No cultivars have been brought to Maruku from the Southern Highlands areas for fear of spreading fusarium wilt disease that exists there. However a method of meristem culture is being perfected for use in collecting disease-free material from all parts of the country.

Meanwhile it has been decided to keep regional collections at Uyole Agricultural Centre in Mbeya and at the Horticultural Research Institute, Tengeru, Arusha. Also a tour of Amani - Tanga has been planned to check if anything can be salvaged from the old Amani collections.

Cultivar trials are expected to start in March 1984.

Banana management trials

These trials look into the merits of various operations that may contribute to better yields, such as mulching, weeding, detrashing, desuckering, propping and intercropping.

PLANS FOR FUTURE RESEARCH ACTIVITIES

Future research activities will concentrate on the following areas:
1. To continue searching for new pesticides which are better than the presently recommended ones.

*20-litre tinfuls per planting hole. The results are not yet available
2. To search for good herbicides, particularly for control of crabgrass (*Digitaria* sp.) to facilitate minimum tillage in banana fields

3. To identify crops resistant to banana pests and diseases which may be grown before bananas are replanted.

4. To look into the economics of banana production as compared with other staple crops.

5. To collect banana cultivars and screen them for their resistance to the existing banana pests and diseases.

When all the objectives of the Banana Research Project are fulfilled bananas are expected to take their rightful position as a staple locally produced in Tanzania.

References


F.A.O. 1981 *Production Yearbook* 33. FAO, Rome


PRESENT PRODUCTION, POTENTIAL AND RESEARCH NEEDS OF BANANAS IN UGANDA

Miss M.J. Namaganda¹ and John C.M. Ddungu²

ECONOMIC IMPORTANCE

Bananas are the staple food crop of the Baqanda, the Bagisu of Mt. Elgon, and the Bamba of Toro district. Bananas have also been adopted as a major foodstuff by some of the other peoples of south-western Uganda, particularly the Banyoro, the Batoro, the Banyankole and the Bahororo. Recently, a local brew made from bananas has gained great importance and its consumption is countrywide. Bananas are an important source of income for growers, and exported bananas are a source of foreign exchange for the country.

PRODUCTIVITY ACHIEVED

Yield depends on many factors, but with good cultivation practices yields of over 12 tonnes/hectare per annum are obtained, 7.5 tonnes/hectare being the average. Local surveys have indicated that the economic life of a well managed plantation is about 30 years, and plantations 50 or 60 years old and still giving satisfactory yields have been reported.

PRINCIPAL ECOLOGICAL ZONES OF PRODUCTION AND BANANA CROPPING SYSTEMS

The principal ecological zones of production are distinguished by differences in climate and vegetation and, therefore, in agricultural systems. Bananas are not components of the northern, the West Nile or the pastoral systems of drier regions of Uganda.

The banana-coffee system
This is practised throughout the most fertile parts of Uganda being centred on the fertile crescent of Buganda lining the northern shores of Lake Victoria, where there is no marked dry season. The system is based on the production of bananas as the main food crop, and coffee, mainly robusta, as

¹ Nematologist, Kawanda Research Station, Ministry of Agriculture
² Head, Crop Science Department, Makerere University.
the main cash crop. The main perennial crops are based on the estate type of production, surrounding the homestead. Annual crops are mainly grown in all plots, away from the homesteads. Cattle do not form a significant part of the system.

Sweet potatoes and cassava are important secondary food crops. Maize, groundnuts and beans are grown for consumption and sale. Sorghum is grown for brewing. Minor crops, a surplus of which is marketed, include onions, soybean, chillies, ginger, turmeric, capsicum and many other vegetables.

Tea is grown but assumes greater importance in the montane areas. Rotations among annual crops are very ill-defined. Beans are intercropped with any crop and any annual crop may be planted between rows of a young banana plantation.

The hand hoe is the only implement commonly used in this system and in the past a lot of hired labour was utilized. This has now decreased.

The banana-millet-cotton system
This is found in areas situated between the elephant-grass climax vegetation zone of the banana-coffee system and the short-grass system of Teso. Bananas are the main food crop, but yields are reduced since the crop is grown outside its optimum ecological zone. Finger millet is also grown and stored for dry-season use. Cassava replaces finger millet as the main subsidiary crop in the western boundaries of this area. Cotton is the main cash crop. More reliance is placed on annual crop production, including sorghum, groundnuts, cowpeas and tobacco. Crop rotation tends to concentrate on cotton and millet, and cassava in the west. Livestock is more prominent than in the banana-coffee area.

The montane systems
Except in Kigezi, these systems are based upon the production of bananas as the main food crop. The montane systems are similar to the banana-coffee system, but they are modified to some extent by altitude, relief and population densities. All montane areas, except Sebei, are heavily populated. Other important crops include finger millet, sweet potatoes, Irish potatoes, cassava, yams, beans, groundnuts, maize and, in Kigezi, peas.
(a) **Bugisu**
Large areas are devoted to the production of bananas as the main food crop and for brewing. Finger millet is also grown in the higher areas for beer making. Beans form the major protein supplement. Arabica coffee is the cash crop. In areas of high population density cultivation is often continuous and frequently the same crop is grown on the same land year after year. It is common for finger millet to be planted in the first rains of each year, the field being allowed to revert to grass during the latter part of the year. Cases are known where the same field produces two crops of millet a year.

(b) **Sebei**
Bananas are not commonly grown, and often, particularly towards the Kenya border, maize is grown as a major food crop. Sweet potatoes, yams and beans are also important.

Along the Kenya border, oxen and tractors are in common use and some very progressive farmers in the area use fertilizers, dress seed, cultivate, seed and harvest wheat mechanically.

(c) **Kigezi**
Sorghum is the main food crop, followed by sweet potatoes, finger millet and beans. Peas are also grown extensively. The storage of food for regular supplies is important. Arabica coffee was introduced many years ago but has never flourished, due to very heavy pest infestation.

(d) **Western Ankole**
Bananas are the main food crop, with finger millet forming quite a considerable portion of the diet. Sweet potatoes and beans are also important food crops. In the past finger millet was the main food crop and followed sweet potatoes in the rotation, but in recent years bananas have assumed great importance.
(e) The Rwenzori

The Bakonjo and Bamba people live on bananas and root crops, in particular cassava, which is replaced by yams in the higher areas. Finger millet and beans are also of some importance in the diet. Neither here nor in Ankole has there been a cash crop of any great importance in the past, but the growing of arabica coffee and tea is now increasing rapidly.

In the various montane systems, the practice of strip cropping is common. Plots are hoed along the contour and wash stops of grass or trash bunds are left at regular intervals. In some areas of lower population densities, alternative cropping is carried out so that cultivated fields alternate with resting strips under grass down the hillside. Livestock management varies from the normal mode of extensive cattle keeping to the more highly intensive system found in Buqisu.

BANANA PRODUCTION TRENDS

The trend is an increase in production over the years, probably due to an increase in area (1 million hectares in 1970 and 2 million hectares in 1980), but fluctuations in tonnage from year to year may be attributed to poor management, pests and disease, and other natural catastrophies such as hail storms and wind damage.

Marketing channels

Cooking bananas (matooke) are mainly sold in urban markets and some trading centres, but a small amount is also exported to Kenya.

Dessert bananas, i.e. sukali ndizi and bogoya, are sold in towns and trading centres. They are also exported to Kenya, the United Arab Emirates and the United Kingdom, but this still on a small scale.
Table 1. Production of bananas in Uganda

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (1000 metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>8,126</td>
</tr>
<tr>
<td>1974</td>
<td>8,879</td>
</tr>
<tr>
<td>1975</td>
<td>9,106</td>
</tr>
<tr>
<td>1976</td>
<td>8,137</td>
</tr>
<tr>
<td>1977</td>
<td>8,531</td>
</tr>
</tbody>
</table>

Source: The Europa Year Book 1977, Vol. II

UTILIZATION OF FRUIT AND OTHER BANANA PLANT PRODUCTS

Fruits

Locally, four groups of banana varieties are recognized according to the way the fruit is utilized:

a) Matooke (AAA)

These are the usual cooking bananas that form the staple food in Buganda and some other areas of Uganda. The group has the largest number of varieties and the fruit is invariably cooked by steaming; fingers are peeled, wrapped in fresh banana leaves and fastened using dry leaf sheaths. They are then placed in an aluminium pan with a few banana leaf midribs to keep the food above the water in the bottom of the pan. Fresh leaves, then those used for cooking the previous meal, are used to cover the food to prevent loss of steam. The cooked matooke, still bound in leaves, is hand-pressed to produce a smooth cake. It may be served with any sauce.

Examples of this group are nakitembe, namwezi, nakyetengu, nakabululu, kibuzi, muvubo, nakinnyika, siira and mbwazirume.
b) Mbidde

These are the beer producing bananas and only a few varieties are known in Uganda. The true mbidde (AAA) include varieties such as nsowe and kabula. During famine, these varieties may be eaten in the same way as matooke, but they have to be washed thoroughly after peeling since they are more acidic than matooke. They may also be peeled, sun dried, and pounded to produce flour. This flour is usually mixed with beans and sometimes a few sweet potatoes are added to produce a cake known as kgomba.

Other banana types employed in beer making are kisubi (AB) and kayinja. Mature bunches are harvested and ripened by keeping them warm for about a week, usually by burying in a pit. The ripe fruit are peeled and squashed with fresh grass, usually Imperata cylindrica or Cymbopogon afronadus, in a hollowed tree trunk shaped like a canoe. The juice is squeezed out and strained. Usually some water is added, then roasted sorghum flour is added and the mixture allowed to ferment for a day or two. In some parts of Masaka district, the male banana bud, or mpumumpu, is squashed and added instead of sorghum flour. The beer is strained into calabashes.

In Masaka district the extraction of the juice is carried out in a shallow pit lined with fresh banana leaves and fresh leaf sheaths, usually obtained from stems of harvested plants. Often the unfermented or partly fermented juice mubisi, is drunk.
c) Gonja (AAB)

These are the roasting varieties and only about five are known in Uganda. Gonja may also be cooked, but it does not form a main food. Its cultivation is still on a very small scale.

Gonja varieties may be mixed with beer producing types of bananas to produce a stronger liquor than that obtained when the beer types are used alone. Sometimes gonja chips are made. Flour may also be produced.

d) Menvu

These are sweet or dessert bananas, eaten uncooked but ripe. About seven varieties are known and these differ greatly in appearance. Some have very small fruits, e.g. sukali ndizi (AB), while others have long fingers, e.g. bogoya.

Menvu are also employed in beer production. Ripe sukali indizi mixed with cassava flour give a popular type of pancake, locally known as kabalagala.

Other uses of the banana plant

Other banana plant products are put to many uses. Fresh leaves are used in cooking (steaming), wrapping parcels and for making pads used as umbrellas. Dry leaves may be used for thatching, storage of grain crops such as sorghum, and for making scarecrows. Dry leaf sheaths are used for thatching, making pads for carrying loads and for making ropes. Dry leaf sheaths are also used in handicrafts such as mats and dolls, and differently pigmented dry leaf sheaths may be cut out into different shapes and glued together to form pictures. Banana plants are used for ornamental purposes: they are usually planted along roadsides or paths during festivals. Among the Baganda, the banana plant is used in many customs.
CONSTRAINTS ON PRODUCTION

Poor management, adaptability, pests and diseases, and lack of markets combine to reduce levels of productivity.

Poor Management
Under good management practices planting is usually done early in the rains. Selection of planting material is quite important. Best results are obtained from the use of 'maiden' suckers 1.5 to 2.2m in height. In some cases where supply of suckers is insufficient, 'sword' suckers are utilized. The spacing should be 2.5 to 4.5m, depending on soil fertility. It is a common practice in Buganda to use wider spacing in fertile soils so that more suckers are allowed to develop from each stool without decreasing the average bunch weight. Planting holes of about 60cm in depth and diameter are usually used.

A crop of beans or groundnuts can profitably be grown between young banana plants. Root crops should not be grown in a newly established plantation as the surface-rooting banana does not stand up well to deep-digging. In a well-established plantation it is customary to find 3-5 main 'stems' of different ages on each stool and a similar number of small suckers up to 60cm in height. These should be thinned out to give a good succession of fruit, so that 3-5 bunches are obtained from each stool annually.

At harvest, 'stems' of mature bunches should be cut diagonally at about shoulder height, then be gently lowered and the bunch detached. The 'stem' should then be cut off at ground level and split into thin lengths to form mulch.

The banana plantation is the dumping place for practically all household refuse. Occasionally, elephant grass may be used as mulch. In areas of low fertility, coffee husks may be used as a form of organic fertilizer, but they also provide mulch. Cattle manure is also used to improve soil fertility; use of inorganic fertilizers is expensive. Soil erosion is effectively controlled by heavy mulch and a series of shallow trenches. Paspalum bunds may also be used.
Bark-cloth trees (Ficus spp.) which used to be universally interplanted among bananas in Buganda are now confined to comparatively few areas. They serve as windbreaks and as supports for yams interplanted in established banana plantations. In a well-mulched banana plantation, weeds are rarely troublesome and only light weeding is required except where there is an incursion of couch grass.

With the development of a cash economy and the widespread use of sweet potatoes and cassava, the standard of management of banana plantations has declined seriously. Quite often weeding and thinning are not carried out regularly so that there is competition from weeds and excess suckers. Soil erosion is rarely checked. Also, the poor agronomic conditions have favoured the breeding and spread of the banana weevil.

Adaptability
Banana varieties are adapted to certain ecological conditions. At the moment, the varieties and their suitability to different ecological regions are not well defined. It is a common practice to grow any variety in any ecological zone until some die out and are abandoned in a given locality, and this sets backs productivity levels.

Pests and diseases
There is inadequate information regarding pests and diseases of bananas in the country. However, available information indicates the presence of the following:

a) Underground pests

The Banana weevil (Cosmopolites sordidus)
This is a major pest of bananas and is present in virtually all areas of the country. It is reported to have been in the country before 1918; it was probably brought in Musa plants on their introduction to the Botanic Gardens at Entebbe before 1918 (Hargreaves, 1940).
Successful control of this pest has been achieved with dieldrin 2.5% dust. The use of carbofuran is being recognized, but the chemical is very expensive.

Proper management of the plantation is also very important in the control of this pest. This involves digging out the old rhizomes and chopping them up so that they dry quickly. When a fruit has been harvested, the pseudo-stem should be cut flat at ground level and the rhizome covered with soil. This prevents adult weevils from laying eggs in the rhizome.

Nematodes
These are probably the most serious problem in the banana industry. Surveys in 1967 and 1969 revealed the presence of Radopholus similis in central Buganda, Busoga, Bugisu, Bunyoro, Ankole and Kigezi. Less important nematodes include Helicotylenchus multicinctus, Meloidogyne spp., Pratylenchus sp., Rotylenchus reniformis, and many others.

b) Fruit pests

Banana thrips (Hercinothrips bicinctus)
The pest is known to occur in East Africa, including Uganda. It causes serious blemishes on banana fingers, thus reducing the market value of dessert bananas.

Monkeys
These cause serious losses in forested areas.

c) Diseases

Various diseases are associated with bananas in Uganda, but so far they have not been found a great problem as far as production is concerned, although sometimes localized outbreaks of the following diseases occur:

Panama wilt
This is caused by Fusarium oxysporum f. sp. cubense. It has been found in Ankole and Buganda, and although no survey has been carried out during recent years, it is believed to have a wider distribution
than this. Sweet and roasting varieties have been found to be very susceptible to the disease while the cooking types are comparatively resistant.

Leaf spot diseases
These are caused by *Mycosphaerella musicola* Leach; the imperfect state is *Cercospora musae* Zimm., known as Sigatoka disease, and *Helminthosporium gibberosporum* Gurzi syn. *H. musaesapientum* Hansford. These two diseases are widespread in banana growing areas, especially Busoga. However, they are not considered serious diseases.

Fruit rots
Cigar-end rot is caused by *Verticillium theobromae*. It is common in areas with low night temperatures, such as Toro, Ankole and Kigezi. Anthracnose or 'Kiwere' disease is caused by *Gleosporium musarum*, a fungus that attacks bruised fruits or those already damaged by insects. It is found in Busoga and Buganda, especially Kyaggwe and Kyaddondo counties.

Stem rots
*Armillaria mellea* occurs in Kigezi, Bunyoro, areas near the Mabira forest and East Mengo District. *Marasmius semiustus* Berk & Curt. syn. *Marasmius stenophyllus* Mont. may be found in any banana growing area. Both stem rots have been found in plantations that have been damaged by the banana weevil, or those that have been neglected.

(d) Lack of markets
Bananas are highly perishable, therefore they require a ready market. Small farmers have a problem of transporting their surplus produce to towns where it can be sold. Large-scale farmers also have not found many openings for the sale of bananas, since co-operative societies have concentrated on coffee and cotton marketing and processing and have paid little attention to other crops. Thus the marketing system has done little to stimulate banana production.
RESEARCH ALREADY CONDUCTED IN THE COUNTRY

Matooke establishment and fertilizer experiments

These were to test the effect of mulch, farmyard manure, nitrogen, phosphorus and potassium fertilizer treatments on the establishment and growth of matooke. There were started in 1969 at Kawanda Research Station, Kamenyamiggo and Nakabango District Farm Institutes and Kabanyolo University Farm. A nitrogen fertilizer trial under irrigation was also laid down at Mubuku-Sebwe Irrigation Scheme near Kasese. The object was to determine the effects of improved practices on the establishment and early growth of a common local variety of matooke bananas. Nematodes and the banana weevil were checked by Nemagon and dieldrin treatments respectively.

Mulched plots at most centres showed better growth than those without mulch. At Kamenyamiggo mulch was the most effective treatment on the growth of mother plants, but cattle manure was the best treatment for followers. At the time this report was written, it was still too early to discuss the effects of inorganic fertilizers.

Owour and Parish (1969) found that deepest vertical roots of nakyetengu penetrated 140 cm from the corm while the longest lateral roots extended to 45 cm from the corm.

It has been observed that the clone nakyentengu, on which some research has been conducted, does not withstand prolonged drought conditions.

It is intended to assemble as many clones as possible from different parts of Uganda and from outside to study their morphological characteristics, their agronomic requirements and assess their biological and economic yield potential and eventually test them under different environmental conditions.
Phosphorus uptake by nakyetengu - a matooke variety (cooking clone) - has been investigated by Ssali (1972). He found that under wet soil conditions the highest $P_{32}$ uptake was within 15 cm of top soil. There was very little uptake below 60 cm. During the dry season, the highest uptake was near the plant within a range of 40 cm from the stool but below a depth of 30 cm.

Use of water by nakyetengu has been studied by Ndedi-Kizza (1973) who found that moisture requirement is highest at flowering time at Kabanyolo.

PROPOSED RESEARCH ON CROPPING SYSTEMS

We also propose to do some banana-based cropping systems research with a view to:

(a) examining integrated agronomic practices suitable for the crop mixture in a banana grove;

(b) studying the economic factors affecting banana growing on farms;

(c) testing suitable agronomic packages on farmers' fields under typical farm conditions;

(d) developing crop combinations in banana plantations which would boost total production per unit area;

(e) making research findings available to the extension service in Uganda for the benefit of the smallholder.

Phase One of this research would consist of assembly of background information from District Agricultural Offices, Parish Chief Offices, Co-operative Offices and Marketing Offices. An interdisciplinary team will also traverse the region to examine farmers' fields and informally
interview farmers, merchants, extension agents and chiefs familiar with farming practices in the area. This exploratory survey will give first-hand knowledge of farmers' circumstances and problems. Then hypotheses and technical solutions can be formulated.

Next, trained interviewers will administer a questionnaire to a randomly selected group of farmers in a sub-parish. When the problem are quantified, the innovations will then be formulated and tested on the farmers' banana gardens.

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BANANA PRODUCTION IN KENYA

P. Gachanja

PRODUCTION CHARACTERISTICS

Introduction

Bananas constitute part of the staple diet for most of the Kenyan population, especially in the western, Nyanza, Central and Coast Provinces. The banana is considered to be among the most important and valuable crops for implementing the drive for increased food production in order to meet food requirements in Kenya. It is generally grown as a subsistence crop, but there is also much internal trade between the banana growing areas and the main towns.

Economic Importance

The objective of the banana production programme in Kenya is to supply the markets with bananas for both fresh consumption (ripe) and cooking. According to the latest banana production survey, there are over 40,000 hectares of bananas in Kenya, in very widespread areas including the western part of the country, in Central Province on the slopes of Mt. Kenya and along the coast. These areas have the best natural conditions in regard to the high rainfall which is required for banana cultivation. It is in view of this, therefore, that bananas are ranked with other agricultural or horticultural crops as an efficient means of enhancing food production. Notwithstanding this, however, the Nairobi market is two thirds supplied by imports from Uganda. This reflects the low yields and dispersed and limited nature of the Kenyan plantings. They are planted in a scattered manner around homesteads or on the alluvial soils along rivers or streams. Selection of planting material is unknown since most farmers use degenerated clones which are commonly infected with nematodes, diseases and pests. Improved management practices (irrigation, fertilizer application, disease/pest control) are rare. Most of the cultivated local cultivars are unproductive and are of poor quality.

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Grading and packing of banana in accordance with known or accepted standards is unknown in the country. This gives rise to handling issues and reduces the number of expected marketable fruits after reaching the market, leading to eventual high prices.

Many varieties are grown to meet regional demands, e.g. shisikame is commonly grown in Western Province for cooking, while muraru is grown in Central Province for both cooking and ripening. The following are some of the popular local varieties: njuru (desert), mutahato (cooking), wangible (dessert), Uganda green (cooking), Kisumu (cooking), ndinuka and manyoke (cooking) among many others.

The introduction of superior, high yielding varieties has been initiated during the last few years. These are the varieties from triploid clones, which seem to dominate the international export markets, such as Valery, Giant Cavendish, Paya, Locatan, Robusta, Dwarf Cavendish, etc. Rapid propagation methods are being practised in order to meet the demand for planting materials. It will take some time until the varieties are tested and made available in sufficiently large quantities to enable commercial production on a large scale. When the local markets are self-sufficient, there is a good banana export potential to Europe and the Gulf region. This would only be possible, however, if standard grading and packing practices are introduced by exporters.

Principal ecological zones of production

For optimum yields, bananas require a constant supply of soil moisture. That is, it is suited to the areas where total annual rainfall is well distributed. They also require warm conditions and give best yields at altitudes between sea level and 1,800 metres. The chief regions of banana growing in Kenya are: Kisii, Kakamega, Meru and Kilifi, where over 1,000mm of rainfall are normally received. In areas of poor rainfall bananas are often grown in places which have a constant supply of groundwater, e.g. riversides, seepage lines, drains, etc. In Machakos District, where there is low and unevenly distributed rainfall, bananas are sometimes grown at the bottom of deep pits (1.5m); these concentrate the available rainfall around the roots and enable bananas to be grown in an area that would otherwise be unsuitable for them.
Drier areas with easy access by good roads, such as Garissa, lower and upper Tana, Taveta, and Sabaki Rivers are being considered for development of commercial banana plantations under intensive irrigation.

Cropping systems

The practice of planting in pure stands or interplanting with other crops depends on the locality. In western Kenya, most bananas are grown in pure stands; while in central Kenya, pure stands are rare (only a few have been started), and bananas are almost invariably interplanted with other food crops, e.g. maize, beans, potatoes, yams and sugar-cane. At the coast they are interplanted with coconuts, citrus, bixa, cotton, etc.

Production trends

Bananas begin to produce fruit between 12 and 18 months from the time of transplanting, depending on various factors (i.e. elevation of the area, and general maintenance) and require 100-120 days to mature. They should be harvested when light green and when the skin has a shiny appearance. There are no pronounced peak seasons for bananas that are grown in areas with well distributed rainfall or these from areas with a constant supply for ground water. Production is continuous and largely non-seasonal. In areas of low and poorly distributed rainfall an increase in production may occur three or four months after the rains.

MARKETING CHANNELS

Some fruit is sold within the locality of production while major markets are in Nairobi, Mombasa, Kisumu and Nakuru. About 0.31% of total production has of late gained entry to export markets in Europe and the Gulf region.

USES

Although banana fruits may be used in various ways (e.g. as banana powder, canned bananas, dried banana figs, wine, soap etc.) in Kenya bananas are primarily used as a vegetable (cooked) or a dessert (ripe). The leaves and stems are used for cattle fodder. Dry leaves may be used as mulch and are sometimes also used for making mats, lamp shades, etc.
PRODUCTION CONSTRAINTS

Development of the banana industry in Kenya is constrained by the following:

1. Lack of planting material of superior varieties for both local and export markets.

2. Lack of large nucleus plantations.

3. Lack of proper sucker selection by farmers, which eventually leads to the spread of nematodes, Panama disease, banana weevils, etc.

4. Lack of a tradition in banana grove management (pruning, irrigation, fertilizers, etc.).

5. Lack of market contacts

6. Inadequate handling practices leading to low-quality banana fruit for the markets.

RESEARCH REVIEW

In order to promote the banana industry in Kenya, various trials have been conducted:

Variety trials

(a) Cooking bananas
   The objective was to study the performance of local varieties, of which mutahata, manyoke and Uganda Green outyielded ndinuku.

(b) Dessert bananas
   The aim here was to investigate the performance of ripening bananas under uniform cultural practices. Dwarf Cavendish outyielded local varieties such as muraru, wanjæ, Ex-lela, etc.
Desuckering

Pruning is known to give greater bunch size, enhances the time of first harvest and discourages weevil attack. Despite these advantages, however, pruning is rarely practised in western Kenya where stools can often be seen with as many as 20 stems. An experiment was therefore initiated to study the yield and bunch-quality effect of reducing banana stems per stool. This experiment is in progress.

Nematode trials

A survey to determine the cause of banana production decline concluded that infestations by nematodes (Radopholus similis) contributed significantly to low yields of bananas. Investigations of various nematicides and cultural methods are being conducted to determine their effects on controlling both Radopholus similis and Pratylenchus goodeyi.

Banana weevil

It has been established that the banana weevil (Cosmopolites sordidus) is the most damaging pest of bananas in Kenya. It is found in all areas except to the east of the Rift Valley. It is for this reason that movement of planting material is restricted to prevent new outbreaks.

Spacing trials

Investigations to determine the effect of various plant densities on yield and fruit quality have shown that taller varieties such as muraru will require wider spacing (4x4m) while shorter varieties such as Dwarf Cavendish require narrower spacing (2.5 x 2.5 or 3 x 3 metres).

FUTURE RESEARCH ACTIVITIES

The most important strategy is to continue with the introduction of superior, high yielding varieties. Rapid propagation methods should be demonstrated and large-scale propagation encouraged. This would provide nucleus stock from where planting materials will be obtained for further observation, i.e. varietal trials, cultural experiments (manure, fertilizer, pruning, etc.) nematode and Panama disease screening, etc.
INTRODUCTION

The bananas are of great socio-economic importance in the moister areas of tropical agriculture. They are soil-conservative, productive, almost non-seasonal and they yield diverse foods from sweet fruits to staple starches as well as numerous useful secondary products, from fibres to wrappings. For all their importance, they have been sadly neglected in their food-crop role by tropical agricultural research systems. It is fitting that this meeting should be held in one of the great areas of banana cultivation and I hope that it may signal the beginning of improved understanding and exploitation of this marvellously useful and attractive group of plants.

EVOLUTION

General

The genus Musa contains about 30-40 species, all diploids (2n = 2x = 14, 18, 20, 22) and all native to south-east Asia, from India and Thailand to New Guinea and Queensland. Only two species are of importance for our purpose (M. acuminata and M. balbisiana) but the genus also contains Manila hemp (abaca, Musa textilis). The related genus Ensete is of great local economic importance in Ethiopia, where it is the foundation of a unique agriculture.

Musa acuminata (AA) and Musa balbisiana (BB) are both diploids with 2n = 22. The first (and crucial) step in the evolution of the edible bananas was the development, under human selection, of parthenocarpy and seed-sterility in M. acuminata. This gave rise, in south-east Asia, to the edible diploid culvars (AA), which survive in some numbers to this day though economically of little importance. Parthenocarpy is the capacity of the fruits to grow and become full of edible parenchymatous pulp without pollination. Seed sterility is due to cyto genetic factors and is also very important because banana seeds are stony and most unpleasant to encounter unawares. Edibility, therefore, is parthenocarpy plus seed sterility.
From the AA cultivars, by chromosome restitution at meiosis, there arose the AAA (acuminata) triploids, one of the three most important groups. They include both the important export cultivars but may others, too.

Another important step, also taken in south-east Asia, was the crossing of AA (and perhaps AAA) cultivars with wild Musa balbisiana (BB) to form the interspecific hybrid groups of cultivars listed in Figure 1.

**Figure 1. The evolution of the banana complex**
Musa balbisiana is a hardier and more drought-tolerant plant than Musa acuminata, so the hybrid groups not only extended the range of plant characters and quality features but also helped to extend the geographical range of the bananas, out of the wetter tropics into the seasonally drier zone.

In south-east Asia, the bananas are probably several thousand years old; we have no good dates. About 2000 years ago, they spread in the hands of travellers, eastwards to the remoter Pacific Islands and westwards to Africa (probably via Madagascar). The first European visitors to West Africa found them there and several clones were taken to the New World very soon after discovery. There, the crop spread very rapidly. The present distribution (Figure 2) is roughly 30° north and south and bananas are grown wherever there is frost-freedom and enough rain.

Figure 2. Banana geography
Classification

It has been found that systematic scoring of characters diagnostic of the two parental species and chromosome counting jointly suffice to diagnose the main cultivated groups. They are designated by genome constitution, thus: AA, AAA, AB, AAB, ABBB (Simmonds & Shepherd, 1955; Simonds, 1966; IBPGR, 1983). The other groups mentioned in Figure 1 (AAAB, AABB, - Richardson et al., 1965) have not yet been fully classified but should present no great difficulty. A descriptor list has been published (IBPGR, 1983).

Ploidy, of course, is normally established by chromosome counting but the experienced observer can usually diagnose it by eye. It does take experience to do so, however. Diploids are slimmer and have more erect leaves than polyploids.

Within each group there are clones which can formally be referred to thus when required:

- **Musa AA Group cv. 'Sucrier'**
- **Musa ABB Group cv. 'Bluggoe'**

There are also many somatic mutants that affect many characters. Sometimes they receive distinct names (as 'Highgate' is a dwarf mutant of 'Gros Michel' and 'Rajapuri' a dwarf mutant of 'Nendra Padaththi'). Occasionally, there are very many mutants, when it may be convenient to refer, for example, to AAB Plantain Subgroup (informally, the Plantain group).

Characteristics

It is generally believed that triploids preponderate among the cultivated bananas because they have been selected for superiority over diploids in terms of vegetative vigour and yield. This is probably true but has never been formally tested. Tetraploids are about as vigorous and productive as triploids and this has been tested for AAA vs AAAAA. Tetraploids must be an important feature of any banana breeding programme (Figure 4).
I said above that balbisiana genomes were important for diverse quality characters as well as for conferring hardiness and disease resistance. Broadly, genomes give starchiness and acidity to the fruit (Figure 3), characters which are features of cooking quality to many consumers. But it should be noted that starchiness depends greatly on ripeness, so potentially sweet (AAA) bananas are starchy and non-sweet if cooked green (as many people do, in fact, cook them). Again, we are rather ignorant: Figure 3 is probably correct in outline but good comparative chemical data are lacking. As to hardiness and diseases resistance, Musa balbisiana itself always looks better in drought than any cultivar and it is, in effect, disease-free: I cannot recall even having seen it infected by Panama disease, leaf spot or nematodes. Cultivars containing B genomes are not so hardy or so resistant as the wild species itself but they are, on balance, I think, better in both respects than AA or AAA clones and the ABB Group is certainly pretty tough.

![Figure 3. Relationship of genotype, ripeness and chemical composition with cooking quality](image-url)
Agricultural importance

The *acuminata* Groups, AA, AAA and AAAA, are of very unequal importance. Only one AA clone ('Sucrer') is widespread but others persist in their original haunts in south-east Asia, from Malaysia to New Guinea, with a few representatives in coastal east Africa (Shepherd, 1957). Their principal value lies in breeding potential as male parent breeding stocks (see below). The AAA Group is widespread and very important indeed. It provides the two leading export cultivars (and their mutants): 'Gros Michel' and the 'Cavendish Subgroup'; also the leading clones used in the great food-crop cultivations of upland east Africa, around Lake Victoria (Shepherd, 1957). The latter, though AAA clones, are treated as cooking bananas by the growers/consumers. A number of good AAAA clones exist but are yet unexploited.

Of the hybrid Groups, AB, AAAB, AABB and ABBB are all scarce and unimportant (so far - food-crop breeding might well change that). The AAB and ABB Groups, by contrast, are very important indeed. Several AAB clones such as 'Mysore' and 'Silk' are widespread and highly valuable as producers of fresh fruit, 'Mysore' being particularly vigorous and productive and the leading variety in India. Another important element in AAB is the Plantain Subgroup, the most complex assemblage of mutants in the bananas. The plantains are especially abundant in west Africa (and are characterised there by remarkable diversity of mutants) and also in parts of tropical America. They are unimportant in upland east Africa and uncommon in south-east Asia. One notes that, though of the same taxonomic Group as 'Mysore' and 'Silk', the Plantains are distinctively cooking bananas (Figure 3), so the AAB Group is diverse in a culinary sense.

The ABB are fairly numerous, especially in India and parts of south-east Asia and being two-thirds balbisiana are essentially all cooking bananas (Figure 3). 'Bluggoe' and 'Sabah' are widespread, locally very important and tough, hardy plants.
BREEDING

Commercial breeding

Breeding has been carried on for many years in the West Indies (Trinidad and Jamaica) and in Honduras (United Fruit Company). The object was to breed new export bananas. Both programmes produced clones that, it is believed, could have been exported but, in fact, were not. Both programmes have now been run down, so that there is no longer any active banana breeding in progress but there remains the cytogenetic knowledge, the 'knowhow' about banana breeding, to serve as a basis for food-crop breeding. General references are: Simmonds (1966); Shepherd (1968); Menendez and Shepherd (1975); Rowe and Richardson, 1975; Row, 1981, 1983).

The breeding plan developed was essentially simple: first, breed good, disease-resistant and pollen-fertile diploids (AA) and then cross them onto the semi-dwarf mutant ('Highgate') of 'Gros Michel'. Very few seeds are obtained (about one per bunch) but those few yield a small proportion of tetraploids (AAA + A = AAAA - see Figure 3) which are potentially commercial. The best are very good indeed, not too tall, vigorous, productive and disease-resistant, but often of dubious shipping quality. The key to commercial breeding lies in effective diploid improvement: hence the crucial importance of good collections of wild acuminata and edible diploid cultivars.

Dwarfness is important because tetraploids out of full-sized triploids are generally too big. By good luck, the dwarf mutation of 'Gros Michel' is semi-dominant, so the AAAA progeny are a good, middling size. We may reasonably assume that the same genetical principal will hold elsewhere, so a food-crop breeding programme will need dwarf mutants for parents.

New triploids can be made from the cross (A)A x (AA)AA but have so far not proved commercially attractive, though admittedly not yet widely explored.
The importance of good collections will be evident (IBPGR, 1978). The best are held in Jamaica and Honduras and there are less extensive ones in Brazil, west Africa, Indonesia and the Philippines. The Philippine collection is being built up as a major international centre (IBPGR, 1978, 1983). For commercial breeding, the AA bananas, wild and cultivated, are crucial; for food-crop breeding, the range of female clones must be much wider but the synthetic AA male parents remain critical (see below).

Food crop breeding

Local tastes in bananas vary widely. People prefer what they are accustomed to and are usually unwilling to change. The object of food-crop breeding must be to produce a wide range of clones, having diverse field and quality characters, that can be adapted to local circumstances. We need not assume that preferences are immutable: under, say, disease stress, new clones may be essential if bananas are to be grown at all. There is plenty of experience to say that tastes can change if they must change.

There is little direct experience of food-crop breeding but the following points are relevant: (a) most edible bananas will give at least a few seeds if pollinated and their progeny are roughly predictable as to genome constitution (Figure 4); (b) the plantains are thought to be sterile but may yet give progeny (Rowe, 1981, 1983); (c) given the wide range of fruit qualities required, the possible crosses to be explored are very numerous and the useful outcomes might be either triploid or tetraploid (anyway, probably not diploid) Figure 4); (d) disease-resistant AA male parents remain important in any programme (excellent ones already exist) but there will be need also of wider exploration of B genomes; (e) dwarfness will have to be used in many crosses to avoid the production of oversized tetraploids.

The objectives of a food-crop programme must be rather widely, perhaps even loosely, stated until enough experience accumulates to permit more precise definition. They will include: (a) yield (though not necessarily on a pure-stand t/ha basis); (b) aptitude for shade-nurse-inter-cropping use; (c) diverse fruit qualities, from sweet to acid-starchy; (d) diverse disease resistances, though not (to be realistic!) all assembled in one clone.
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Figure 4. Banana food crop breeding combinations

Notes: (1) The basic commercial banana breeding cross, the only well explored combination.

(2) Restitution, male or female, implied.

The diseases to be considered include: Panama disease (banana wilt), Moko disease (Bacterial wilt), Sigatoka disease (Leaf spot), Black Sigatoka (Black leaf streak), Burrowing nematodes and Bunch top virus. We know something about resistances but not yet nearly enough. We must assume, I think, that expensive chemical control measures against diseases will generally be irrelevant for small farmers. At this moment it looks as though peculiar threats are posed by: Black Sigatoka, which has recently become established in west Africa and central America and is certain to spread; and Bunchy-top, widely spread in south-east Asia, India and west and central Africa but not in Americas; its status is ambiguous but it is potentially very damaging.
There is a vital technical adjunct to any international food-crop breeding programme, namely, shoot-tip (meristem) culture. The technique is quite simple and readily well proven. It will be very useful for multiplication of new clones and extremely useful, even critical, for the international dissemination of clones through plant quarantine systems. Since the sensible first step is any banana food-crop programme must be the wide dissemination of the many useful bananas that are not already generally dispersed, the practical importance of shoot-tip culture can hardly be over-emphasised.

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**Figure 5.** A suggested scheme for cooperation in banana food-crop improvement
The cultivated bananas are derived from two wild species native to south-east Asia: *Musa acuminata* (AA) and *M. balbisiana* (BB). Pathenocarpy and seed-sterility, evolved under human selection, jointly constitute edibility. The edible bananas evolved in south-east Asia from edible diploid (AA) progenitors and spread thence through the tropics to the moister areas between 30° North and South.

Bananas constitute a hybrid-polyploid complex and are classified by genome constitution thus: AA, AAA,AAAA, AB, AAB, AAAB, ABBB. Broadly, *balbisiana* (B) genomes confer hardiness, disease resistance and acid-starchy fruit quality.

The scientific bases of commercial banana breeding, aimed at export clones, are fairly well understood, though neither of the two major programmes has been successful. Fairly good collections are available and excellent diploid male parents (AA) have been synthesized.

The established scientific principles can be carried over into food-crop breeding programmes, with much broader objectives and genetically much more diverse outputs of potentially useful varieties, all polyploid and mostly hybrid. Shoot-tip culture, already a well-established technique, will be of great value for multiplication and dissemination of clones, both existing ones and newly-bred ones, in due course.
References


RESEARCH ON EFFICIENT BANANA-BASED PRODUCTION SYSTEMS

Edmond de Langhe

COMPOSITION OF BANANA GROVES IN THE EAST AFRICAN HIGHLANDS:
HISTORICAL AND SOCIO-ECONOMIC SIGNIFICANCE

In the high altitude regions of east Africa (eastern Kivu, Rwanda, Burundi, Uganda, Tanzania), the composition of banana groves is very different from that in central and western Africa. There have been no accurate and detailed studies on the subject, so the following are only rough estimates on the relative frequency of cultivars.

An average banana plantation would comprise the following:

Set 1: Group AAA, comprising of the brewing subgroup (70%) and the floury subgroup (15%)

Set 2: Group AAB, the plantains subgroup (1-5%);

Set 3: Heterogenous, including the "dwarf banana" (AAA, dessert), the kamaramasenge (AB, dessert), the "red banana" (AAA, dessert), a few AAB and ABB (dessert and floury).

There are various reasons for the variation in this composition: soil, altitude, climate, market accessibility and tradition - some communities are well-known for the quality of beer that they produce.

The three cultivar sets have very different origins and history and this is highly significant for agricultural research. Set No. 2 (plantain) is the oldest and was introduced to Africa many thousands of years ago (de Langhe, 1964). It dominates all bananas in the humid tropics of Africa. It does not tolerate either dry weather or altitude and this explains why it is so little grown in east Africa. Set No. 3 was not introduced until the last few centuries, an introduction which is linked successively with the Arab influence and the arrival of Europeans and Asian traders. The composition of this set is extremely variable from location to location.

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Set No. 1 is not found anywhere else in the world. Some of these cultivars resemble bananas grown in India and Indonesia but the synonyms have never been firmly established. Some 10 diploids (AA) found in Tanzania, particularly in the coastal region (Shepherd, 1957), could be the origin of this set since some of them produce seeds. There are indications that seed of these sub-groups could have been introduced into the region by people coming from Indonesia some 2000 years ago (de Langhe, 1964).

Considering that Bantu-speaking people settled in the east African highlands some 2000-3500 years ago, we can conclude that it is they who introduced these cultivars, integrated them in the agricultural systems over a long period, and spread them over the region. This led to the utilization of multiple mutations which assisted the cultivars' adaptation to altitude. We believe it is a question of adaptation, because cultivars of this sub-group introduced at the Yangambi research station (Zaire) could not survive there beyond an initial vegetative phase.

Set No. 1 therefore forms an integral part of the eastern African socio-economic agricultural nucleus. The farming systems include also some other tuber crops, Colocasia and Xanthosoma species and certain cereals such as sorghum and millets (Hek et al., 1963). Besides the brewing and starchy cultivars, this group has potential also for some dessert cultivars of excellent taste (e.g. nyirabahema). The strong domination by AAA (90% in these countries) makes this subject easier to tackle.

In conclusion, the bananas we are dealing with here are well integrated in the rural system and probably include all the variation required for effective adaptation of cropping systems to various ecological and economic conditions in the country.

CROPPING SYSTEMS AND THEIR PROBLEMS

Changes in the system

Farming systems characteristic of the east African highlands, as well as the organization of rural production, have been subject to various studies which have produced a number of hypotheses (Hek et al., 1963). One weak point in this knowledge can be summarized by the following question:
What is the long-term influence of a system on the soil potential and what modifications (e.g. intensification) of these cropping systems are compatible with good maintenance of this potential? The answer would lie in finding production techniques that lead to maximum pluri-annual production and an optimal production system.

Evaluation of the production system and its possible future modification must be tackled with great care. Since, in the countries we are looking at, the banana has been an integral part of the farming systems for many years, any modifications suggested are likely to have more complex implications than if, for example, cassava were involved. Cassava, being a relatively new crop, occupies a relatively flexible position in the socio-economic system.

Because the peasant farmer seems to have managed to maintain his basic subsistence production throughout the centuries, there is great temptation to conclude that nothing need be changed. This view is opposed by two factors.

Firstly, during the past one or two centuries, many new crops have been introduced into this system: cassava, sweet potato, beans, coffee, tea, rice. It is not clear whether these new crops have been integrated successfully in the traditional system or whether they interfere with the system. Interference would indicate that perhaps the overall system is not yet properly balanced and that research is still necessary order to help peasants in their efforts to integrate these new crops.

The second factor involves population growth. Because of this growth, in Rwanda for example, the area covered by banana plantations has grown by 63% in a single decade and has reached the limit of available area for expansion. On the other hand, for the same period there has been an average reduction of 23% in yield per ha at the national level. Here a modification in the negative sense (at least with regard to bananas) has taken place in the overall farming systems.
This situation prompts the following questions:

1. Can we understand the mechanism of the change which brought about this reduction in yield?

2. Was this mechanism set off simply by population growth, by the introduction of new crops, or by a combination of both these two factors - and how?

Clearly, then, understanding this mechanism would lead to more effective research programmes.

**Morphology of the banana**

Before going into details of research on the process of modification that we have just outlined above, we must refresh our minds on the rather special morphology of the banana tree (Figure 1).

It is important to note that generally 90% of the root system is found in first 15cm of soil. The roots found lower have a different morphological structure. (Figure 2; Table 1). The surface layer then plays a central role in the nutrition of the banana tree. What is the most significant part of the root then?

Primary roots, spectacular though they are, play only an architectural role: they "place" the secondary and tertiary roots in the best place. A tropism that is very ill-understood is that roots emerging from the corm at less than 20cm will grow upwards. In comparison to root systems of graminaceous crops, on the other hand, the tertiary network is not well-developed. Branching habits also vary among cultivars (Figure 3).
Figure 1. Schematic view of a bearing banana with suckers

(Source: Champion 1962).
Figure 2. Schematic view of the two types of primary root

Table 1. Proportion of primary, secondary and tertiary roots as a percentage of total root length

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Primary roots (%)</th>
<th>Secondary roots (%)</th>
<th>Tertiary roots (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA + AAA (bananas)</td>
<td>0.32</td>
<td>22.40</td>
<td>77.29</td>
</tr>
<tr>
<td>AAB (plantain)</td>
<td>0.68</td>
<td>53.44</td>
<td>45.88</td>
</tr>
<tr>
<td>AAB (bananas)</td>
<td>1.45</td>
<td>72.46</td>
<td>26.09</td>
</tr>
</tbody>
</table>
Figure 3. Branching habits of six Musa cultivars

A. Musa velutina (AA);  B. Pisang lilin (AA);
C. Pisang nangka (AAA);  D. Dwarf Cavendish (AAA);
E. Agbagba (AAB);  F. Horn plantain (AAB)
Nutritional development of the banana

The situation at ground level or near the surface determines the nutritional development of the banana tree. In this connection the harmful and beneficial factors are as follows:

a) Factors harmful to development

- high temperatures (e.g. bare ground);
- weeds with superficial roots (e.g. graminaceous plants);
- physical disturbance to the soil (e.g. tilling - which destroys sometimes entire secondary and tertiary root zones;
- soil too compact;
- dry soil.

b) Factors beneficial to development

- ground covered or protected: controls temperature and humidity variation;
- sufficiently light and homogeneous soil structure;
- easy accessibility to nutrients: soil not too hard.

How can we attain the positive conditions? Would mineral fertilizers be effective in this context? Figure 4 indicates that the ratoon crop is more responsive to fertilizer and that genotypic effects occur. But in all cases, organic matter is important. Decomposition mulch, relatively undisturbed (microbiological life?), assists in the dry season through a sealing effect and in the rainy season through nutritional enhancement. The cumulative effect of mulching is shown in Figure 5.
Figure 4. Percentage of plantain and banana plants surviving from first crop and ratoon crop growing under 4 fertility conditions

Note: Plantain = mimi-Abue and Agbaqba; Banana = Kparanta

Figure 5. Cumulative yield of unthinned medium-sized False Horn plantain, grown under mulched and fertilized conditions

Note: The results of the last 2 years only are represented. Planting: March 1977; suckers thinned until 1980; thereafter no thinning took place.
OPTIMAL PRODUCTIVITY OF A BANANA PLANTATION: RULES TO OBSERVE

In a pure banana crop, the ideal system for perennial crop with a consistent production level can be described as follows.

After planting, the leaves of neighbouring stands must close in as quickly as possible, without at the same time making the density exceed 1,000 stands/ha at spacing of 3m x 3m. Canopy closure can be achieved in one year. From this moment the plantation must be kept in such a way that bunch-carrying stems stay approximately 3m apart. This would mean that each stand would contain one bunch-carrying tree, a maiden shoot that has passed the mid-height level, and a vigorous sucker system. After many years there will no longer be any trace of the original stands and the stems will often be one or metres away from their original position, but the density should always be kept at 1,000 bunch-bearing stems a year.

The destruction of this kind of plantation comes with the often inevitable drying of the corms - because suckers have a tendency to grow at a higher level than the mother plant. This is likely to lead to a reduction in yield. Regeneration of the plantation is then required, preferably by replanting suckers.

The expansion of stands by survival of concentric circles of suckers, which is a common system on small holdings, is a seemingly less productive choice, over the years, for the following reasons:

- stands that contain several bunch-carrying stems in a ring compete with each other for access to sunlight as well as for root nutrition;

- within the stands, barren zones are formed and grow continuously larger; healthy suckers are not found because it is only on the periphery that the suckers find space and soil to develop their roots and the light intensity inside the stands is obviously inferior.
Later, when the circles have extended and the older stems have decomposed, a sucker can be planted in the centre. However, such a system seems to be inferior in terms of productivity per hectare. In addition to the strong competition between the plant circles, intermediate stands cannot develop and usually disappear.

In order to attain the balanced plantation described in the first paragraph above, the following factors are central:
- fertility of the soil: if below standard, organic fertilizer (rich in potassium) should be applied;
- the soil must be protected: as the roots are superficial, they suffer from heat in the upper layer of bare ground, particularly during the dry season;
- microbiological life: necessary to decompose all the waste (dead leaves, mulch, etc.)

Once the balance has been created, a cycle is established in the plantation in which dying leaves, cut regularly, return certain elements to the ground, while at the same time protecting it from heat. The biological complex is a powerful decomposing factor and these elements together with those of the soil are soon made available for the plant to use.

The banana harvest (e.g. 20kg/stem/year) is a nutrient loss which is easy to overestimate. The dry matter, only a fraction of the total weight, is largely composed of starch and sugars, both direct products of photosynthesis. The rest is made up of poly phenols, partial but indirect products of photosynthesis, and some vitamins. The metabolism leading to all these products mobilizes enzymes (containing nitrogen) and elements including potassium, calcium, etc. But these elements make up only a tiny fraction of the fresh weight. This loss can be easily made up for by occasional application of either fresh organic matter or mineral fertilizer.

A banana plantation in equilibrium as described above is an almost self-sufficient ecosystem. If the ground is rich enough (volcanic soil or primary rock soils), its reserves in minerals are generally sufficient and will for a long time keep the ecosystem perfectly self-sufficient.
MEASURES FOR COMBATTING DEGRADATION OF THE SYSTEM

From the above premises, it is easy to pick out the practices that hinder or destroy the system.

Practices that stop the system from becoming properly established

- bare ground in the dry season, exposed to the physical impact of sun and rain;
- very wide spacing (e.g. 4m x 4m.), because this increases the period before the closing of the canopy and because it allows dry winds to accelerate evaporation;
- repeated tilling of the ground (e.g. intercropping over several years) which not only destroys the superficial root system, but also hinders the development of microbial life;
- failure to cover the ground, particularly during the dry season with yellow or dead leaves, either when they have been left on the stems or have been used as mulch.

Practices that partially or totally destroy the system

- uprooting suckers to cultivate intercropped food crops;
- proliferation of bunch-carrying stems which brings about etiolation already described;
- tilling the soil.

Almost all these practices bring accelerated reduction in potential minerals in the soil, particularly when the ecosystem is not allowed to establish at the beginning. The soil itself becomes degraded, chemically (rapid reduction in fertility) and physically (destruction of original structure and texture). Furthermore, it has been proven (INEAC experiment at Kondo, Zaire) that a deteriorated system cannot be rehabilitated until after many years (seven at Kondo) of massive application of mulch (50 tons/ha).
In other words, in a typical rural system, it is impossible to rehabilitate a banana plantation once it has deteriorated, and the term irreversible damage is not far from the truth.

**PROBLEMS WITH INTERCROPPING**

In a plantation with spacing of 3m x 3m, and as long as the foliar canopy has not yet closed (about 2 seasons), it is not harmful to cultivate food crops between bananas as long as the following precautions are taken:
- avoid planting sweet potatoes in the second season (competitive superficial roots) or cassava (competitive for light, according to IITA);
- the ground should not be left bare during the dry season;
- all graminaceous plants should be eliminated (aggressive root system and difficult to eliminate without tillage).

Constraints force farmers to continue mixed-cropping to grow food crops for many years, and in such circumstances they plant banana trees far apart (4m x 4m. or more). Scarcity of land is the most common constraint. The relative proximity of the crop to the homestead presents another problem. The effort to combine beer banana production with food security can lead the farmer into a lot of problems. The large number of banana trees near the homestead and fewer bananas and food crops away from it, leads to expansion of the acreage devoted to banana growing, with doubly negative results: too high a concentration of banana trees around the homestead, and underdeveloped bananas elsewhere. The long-term effect thus seems injurious to us. An explanation of the yield reduction observed in Rwanda can be found here.

We therefore suggest that an effort be made at the national level to encourage specialization in crops according to suitability of the soil. In cases of flat or valley-bottom land, the farmer should be able to concentrate on growing coffee and bananas (including also the inoffensive taro); these two together would ensure him some revenue. The practice of selective cultivation exists to some extent: potatoes and wheat, for example, are cultivated less at lower altitudes. Now that means of communication are being improved, it is probably the right time to extend this specialization further. At any rate, this practice is best for the future conservation of the soil, which is the most important resource.
As for the short-term effect, i.e. the profit-earning capacity per year per unit area, the relative advantage is difficult to judge, in view of the mixed production of bananas and food crops. Only a systematic experiment comparing the different systems would give more exact implications.

**SUGGESTIONS FOR APPROPRIATE RESEARCH**

**Objective**

To compare the production of a plantation in three systems where the banana plays a more or less important role. The same experiment could be combined with experiments on farming systems for studies of profitability; the ultimate objective is in fact to find a system which would make it possible to maintain good productivity on a limited acreage.

**Treatments**

a) **Control**

   Pure banana crop, spacing of 3m x 3m. This is a reference treatment giving maximum expression of the banana's potential.

b) **Intercropping with food crops for two seasons**

   This system is practiced traditionally by farmers who are primarily interested in bananas. After planting (always during the first rainy season), food crops are inter-planted for two seasons (sorghum, beans, taro). After the first year, the banana leaf canopy will be closing in and only taro can survive.

c) **Intercropping food crops on a long-term basis**

   This is the most common system currently found in many places. Spacing between banana trees: 4m x 4m. Food crops (excluding taro) in rotation: beans, sorghum, sweet potatoes and cassava.
Obviously, the experiment suggested is only a model and a number of variations are to be expected according to local situations. However, one cardinal rule should be observed: it takes time to evaluate the results. This kind of experiment does not produce spectacular results on a short-term basis but will provide the basic formation needed to improve production systems holistically. The results would be relevant for the majority of regions where smallholder banana production will always have an important role.
COMPETITION BETWEEN BANANAS AND COFFEE ON SMALLHOLDER FARMS IN TANZANIA:
A CASE STUDY OF THE KAGERA REGION

Anna Tibaijuka¹

INTRODUCTION

The execution of Tanzania's development programmes has been affected adversely by both internal and external events. Internally, a population growing at 3.3% per year, unfavourable weather conditions through the 1970s and inefficiencies in agricultural/rural administration have caused considerable declines in production and in foreign exchange earnings from agriculture. The importation of food has also become necessary. Externally, the increase in petroleum prices, poor export prices and increases in the price of imports exacerbated the difficult internal economic situation. Indeed the internal situation was partly precipitated by adverse effects from the hostile international environment (United Republic of Tanzania, 1981).

The problem of declining agricultural production and productivity is of concern. Poor performance has been linked to the lack of price incentives and inefficiencies in the state run agricultural services, particularly marketing and input distribution (Ellis and Hanak, 1980).

Tanzania's leading export crop, coffee, is beset with serious production and marketing problems which seem to be worsening. Of coffee's competitors, bananas are the most important. Ninety five per cent of the total area of 220,336 ha under coffee (1981/82) is found on small holdings heavily interplanted with banana plants. Bananas are the most important staple food crop in all major coffee areas in the country. Recently, ability of coffee to compete with bananas and other food crops for labour and land on smallholder farms appears to have declined. It is this increasing threat to coffee by other crops which has alarmed the Government and necessitated a closer examination of banana-coffee-based smallholder farming systems.

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OBJECTIVES OF THE STUDY

This paper examines banana and coffee production on smallholder farms in Tanzania in order to suggest some technical directions and policy recommendations. We shall try to establish the nature of the competition between the two crops and factors that have increased this competition. Our hypothesis is that land pressure resulting from rapid population increase, coupled with declining banana yields because of the spread of banana pests, have led to food shortages. In turn, these shortages have necessitated the uprooting of coffee trees to create room for the cultivation of more bananas and other subsistence crops. Low producer prices as well as declining marketing services have further reduced the attractiveness of coffee to the farmer. We insist, however, that the institutional factors, while important, are far outweighed by the need to assure food supply.

AREA OF STUDY AND METHODOLOGY

Kagera region is Tanzania's most important banana producing area. It also produces about 90% of the country's robusta coffee, which contributes about 30% of coffee export earnings, the rest of the crop being arabica coffee produced mostly in Kilimanjaro and Arusha regions. Kagera region is also facing a serious and growing food shortage because of the rapid spread of the banana weevil and nematodes.

The study design required a cross-section of villages located in one broad agro-economic zone with banana, beans and coffee as the major crops. The number of villages was restricted to ten by the financial resources available and the sample comprised 20 households in each village, adding up to 200 in total. The villages were in Bukoba, Muleba, Karagwe and Ngara districts (see Map 1).

Information on farm activities and inventories was collected by enumerators using structured questionnaires and record sheets. The sampled households were put under a one-year continuous survey in which daily records on labour utilization, harvest of major crops and incomes and expenditures were kept. A resident village enumerator was recruited in each village. Data processing and analysis was conducted with the aid of an electronic computer at the University of Uppsala.
Establishment and maintenance of a banana holding on which coffee is
interplanted is the most important capital formation activity for the
average household in the research area. The banana-coffee holding is
called a kibanja. Farmers also interplant on the kibanja a few fruit trees
such as mango and orange.

Establishment of a kibanja involves thorough cultivation, planting
banana and/or coffee trees and thereafter maintaining the field intensively
through weeding, mulching and manuring using household wastes. Where
livestock is owned manure is applied. Such intensive soil management
slowly raises soil fertility and land so developed becomes a special land
resource on which beans (the second most important food crop after bananas)
are grown. In the greater part of the region soils are not fertile and
beans can only be grown on kibanja land.

Each sample household had at least one kibanja holding and 60% of the
sample owned two or more. The average size of a kibanja was 1.6 ha but
there was wide variability in size, both within and between villages. For
example Murugina had the lowest average kibanja size of 0.8 ha while
Kayanga reached an average of 4.8 ha. But within Kayanga village
variations also existed. The smallest kibanja was 0.7 ha while the largest
was 22 ha, and only 7 households out of 20 (35%) had more than 4 ha of
kibanja land. Kibanja holdings tended to be smaller in the more densely
populated areas.

It was difficult to assess the monetary value of kibanja holdings. The kibanja
has such high socio-economic and cultural value that it was
difficult to determine the value of the holding in purely economic terms.
Farmers could not put a value on kibanja land because all of them
maintained that they were not likely to sell their holdings. Besides, the
demand for kibanja land varied with the location of the village,
particularly its distance and accessibility from the regional and district
headquarters and from main roads. The modernity of the area also seemed to
increase land prices.
The condition of the holding (i.e. the state of the bananas and coffee) influenced the value of land, but this was a less important factor than its accessibility. Taking these factors into consideration and using information on prices paid by individuals who had recently acquired a kibanja, we arrived at an average value of T.Shs. 8,000 (USD 670) for each hectare of kibanja. Land upon which annual crops are grown is owned communally and individual households have no claim on it.

Kibanja land is a very scarce resource. This was listed by farmers as one of the most important production problems, since almost all suitable land is already occupied. As far as kibanja is concerned, land rather than labour appears to be the limiting factor.

In Bukoba and parts of Muleba districts where land is most scarce because of population pressure and farms very small because of subdivision among sons, scarcity of kibanja land is extreme. Rich farmers have started establishing kibanja even on rweya soils, which are heavily leached. Their cultivation needs heavy investment in farmyard manure, which can only be afforded by rich farmers—often those with incomes outside agriculture. Observations at Ibura village (12 km from Bukoba town), where this kind of farming started in the 1960s, indicate that even with heavy manuring converting rweya soils into permanent kibanja is not easy. Farmers in this village reported that they were spending between T.Shs. 800 and 1,000 per ha on manure annually.

Coffee

Coffee was grown on 95% of the sample farms, and in five sample villages it was grown on all the holdings. The mean number of coffee trees per household was 295, growing at a density of 163 trees per hectare. This represents a wider spacing between trees than the recommended figure, due to interplanting.

Yields of coffee have declined drastically because of (i) the old age of the trees, (ii) neglect by farmers and (iii) increasing pest damage. Farmers are now uprooting coffee without replanting.
Although the survey indicated that 37% of coffee trees have already exceeded their economically productive lifespan of 30 years, the neglect of tree management observed on 61% of farms seems the more important factor in yield decline. Many plots were neither weeded nor pruned, and the recommended coffee pesticides were either not purchased or were being diverted for use on bananas.

**Bananas**

Bananas are the traditional staple food and are now also an important cash crop. They are grown by all the smallholders in the study area. The average number of plants per household was 1,382, although considerable variation existed within and between villages.

The biggest problem facing the industry is attack by weevils and nematodes. This was rated as the most important agricultural production problem in the region, exceeding even the scarcity of land. Pests have drastically reduced yields and decreases of between 20 and 95% have been reported.

Traditionally, banana weevils were controlled by dieldrin, recommended as a standard insecticide for the pest in east Africa. However, after a few years of application farmers complained that the chemical was actually killing the bananas! Subsequent research at the Maruku Agricultural Research Station near Bukoba established that Dieldrin application gave rise to resistance to the insecticide. Nematodes were only identified as major pests in the area as late as 1973 (Cumming et al. 1981).

As a result of the farmers' outcry and after it was obvious to the administration that there would be total collapse of the industry if something was not done, a special team to review research on banana weevils and nematode control was selected and a pesticide screening programme started in 1979. Carbofuran gave the best overall performance in controlling both pests. The current recommendation is to apply carbofuran 5% granules at the rate of 60 g per stool three times a year.
The chemical is costly so it is only recommended in areas with heavy infestations. It should also be accompanied by good husbandry to ensure efficient utilization of the pesticide. Cumming reported that with annual yields of 30 tons per hectare, as are currently achieved using intensive husbandry at Maruku, the cost is equivalent to T.Shs. 0.12 (USD 0.01) per kilogram of bananas. With yields of 4 tons/ha/p.a., which is the estimated mean yield for Bukoba District, the cost of the pesticide rises to T.Shs. 0.90 (USD 0.09) per kilogramme of banana. In areas with minor infestations emphasis is put on cultural control and cultivar selection, although work on these methods has only just been initiated.

There is an acute shortage of the recommended pesticide, not to mention its high price which the average farmer cannot afford. The only insecticides readily available in the region are endosulphan and fenitrothion. They are supplied for the control of coffee pests but farmers have begun using them for the control of banana pests. Both chemicals are recommended by manufacturers for banana weevil and/or nematode control. Their efficacy in controlling these pests is not yet completely determined but Cumming reported that endosulphan was giving 'the poorest banana weevil control of those products tested'. If one takes into account the fact that these chemicals are actually diverted from the control of coffee pests the implications are obvious. The banana is the king of crops as far as the farmer is concerned.

**BANANA PESTS AND THE UPROOTING OF COFFEE TREES**

By reducing banana yields pests have forced farmers to divert labour from coffee production to the production of food crops, including bananas and root crops. Paradoxically banana cultivation has even received increased attention as yields have declined. In an effort to improve falling banana yields farmers have come up with a number of cultural innovations, including uprooting coffee trees both to reduce competition with banana plants for nutrients and to create additional space for planting more bananas.
Coffee yields are reduced by interplanting with bananas and vice versa (Acland, 1975). This is particularly true for the unpruned robusta coffee bushes found in Kagera region. The bushes have an average height of 4.5 m and a radius of 3.0 m, thus occupying space which could otherwise be occupied by banana plants. All these factors are known to the farmers. When soils were fertile, the negative yield effects of coffee interplanting on bananas were not significant and were tolerated because coffee was the only crop with a defined market and hence the most important source of cash. Since there was a shortage of suitable land on which to establish pure coffee plantations, coffee trees were planted among the bananas. Realizing this, in 1916 the German colonial administration had made it compulsory for each family to plant 100 coffee trees among the bananas. This was the start of the practice of interplanting coffee with bananas. It has been an accepted tradition in the area until now when it seems to be becoming outdated by the combined effects of declining soil fertility, new markets for traditional crops and low coffee prices. Coffee is no longer the most important source of cash on smallholder farms in the area.

The uprooting of coffee trees has caused alarm in the nation. It is obvious that the consequences of this will be economic doom to the country since coffee is the most important export crop, contributing about a third of Tanzania's annual export earnings. But from the producer's point of view, uprooting is rational, at least in the short and medium term.

Food shortages, particularly of bananas, have caused banana prices to rise thus converting bananas into a cash crop. A large banana market has arisen within the region, particularly in the heavily populated lake zone of Bukoba district. Thus it has become very profitable for farmers in areas less affected by the weevil to export bananas to the seriously affected areas in Bukoba district. Therefore, in the banana exporting areas, coffee has become a less important cash crop because of its low price in comparison to bananas. In the banana importing areas, on the other hand, farmers have concentrated their efforts on the production of bananas and other food crops because incomes earned from coffee are too low to support families on purchased food.
Other effects of banana pests

Attack by weevils and nematodes has also resulted in (i) the modification of cropping patterns (product mix); and (ii) the acceleration of outmigration from the heavily infested areas in Bukoba district to other, less populated, areas in the region.

Changes in cropping pattern

To make good the banana shortage, root crops such as cassava, yams, and sweet potatoes have become more important in the diet, particularly in north Bukoba district -- Bugabo, Kiziba, Kyamutwara and Maruku Divisions. These crops, traditionally grown to supplement banana diets, are now becoming dominant in the diet. However, in spite of their relative high yields in comparison to the bananas, farmers still consider these as supplementary crops. They are mostly grown by women, but with the increasing food shortage men have started cultivation of these crops since food production in the heavily infested areas can no longer be left to the women alone. Our earlier observation that banana cultivation is given top priority still holds, although out of sheer necessity farmers have been forced to diversify food crops.

Perhaps a more important change in cropping pattern that has occurred in the heavily infested areas has been the introduction of new banana varieties more resistant to the pests. There are a number of such varieties, a complete list of which should be worked out by crop scientists. Field observations, however, indicated a general trend towards varieties locally termed kishubi, kishukali and gandu. These varieties can be cooked but they are less palatable and are mostly used to brew the local beer orubisi. Respondents confirmed our suspicion that the increasing trend to brew pombe and to make spirits (gongo or konyagi) has some correlation with the increased cultivation of these new banana varieties. One farmer put it this way, 'We now survive on orubisi both for food and cash'.
These new varieties appear to be resistant to both pests and are high yielding. Brewing is a profitable business for farmers. It is actually these brewing varieties which have made coffee production relatively unattractive to smallholders. There is an assured local market for brewing bananas. Farmers identified these as the most important source of cash on the farm, and even in remote areas there is an assured local market for brewing bananas.

Unfortunately it was difficult to count how many brewing-type bananas were grown on each sample farm. However, farmers estimated that on average they made up about a quarter of the total banana population. Brewing varieties were increasing, however, as they were replacing coffee as a cash crop. Farmers recognized that incomes from bananas are not only high in relation to those from coffee but they are evenly spread over the year so 'with kishubi one cannot get totally broke or in bad debt'. Brewing varieties were also used as security to obtain loans from local money lenders. Coffee is no longer accepted as collateral security because of the increasing uncertainty of coffee incomes.

Outmigration

Finally, banana pests seem to have influenced the rate of outmigration from the heavily infested areas in Bukoba District to other less populated areas in the region, especially to Karagwe and Muleba districts. Migration has also been caused by increasing population and accompanying land pressure. But one could argue that the most important factor has been decline in kibanja productivity because this meant that the possibility of increasing banana yields (i.e. intensifying production) was limited for an average household. Besides, declining productivity of kibanja land also led to more intensive cultivation of the rweya land where annual crops needed to supplement banana diets are grown. The result is reduced land fallow periods and hence further loss of fertility on these poor soils. Furthermore, as land for grazing cattle has also become scarce the possibility of increasing banana yields by applying more manure has not been feasible.
What have been the effects of outmigration? Obviously they have slightly eased the increasing land pressure. But they have also created new problems, including:

(i) Spread of weevils and nematodes to other areas because migrants (unaware of what they were doing) had taken planting materials with them;

(ii) Deterioration of old kibanja land in cases where the outmigrant has not sold the plot or not left someone to take care of it. This new form of absentee ownership leads to underutilization of kibanja land in areas where it is most scarce. Since kibanja land is also a form of capital this is a type of capital erosion. However, most outmigrants are reluctant to sell their old holdings when moving to new areas because of social pressure and the high risk to the individual.

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

In summary, the banana-weevil and nematode problems have started a vicious circle in the farming system in the region. By decreasing banana yields drastically they have robbed the people of their much loved staple food and forced them to work harder but harvest less of the crop. Desperate measures to raise yields have included the uprooting of coffee trees to raise banana yields or to free space for cultivation of additional subsistence food crops. This trend has been aggravated by the increasing attractiveness of banana as a cash crop for export to heavily infested, food-deficit areas, and by the deteriorating arrangements for coffee marketing.

It is recommended that the drastic decline in banana production should be arrested by designing and implementing a banana-coffee improvement programme, rather than by reverting to desperate and unconcerted administrative measures such as new by-laws to stop peasants from uprooting coffee trees. In the long run by-laws cannot be enforced, and even in the
short run by-laws are detrimental because they are seen as direct coercion which increases farmers' determination to uproot or neglect the trees. As one farmer put it, 'Will the Government come here to maintain my coffee trees now that I am no longer allowed to cut them down?' In any case, most of the trees are too old and extension officers recommend they be uprooted and replaced by young ones: how will desirable and non-desirable uprooting be distinguished? Regional authorities need to look at these by-laws more closely and re-evaluate their wider implications. What is desired is to encourage the farmer to uproot old trees and plant new ones.

The proposed banana-coffee improvement programme should focus on the agronomy and marketing of the two crops. It should be broad based but emphasis should be placed on the improvement of farming techniques on the kibanja which lead to control of the pests and improvement of soil fertility. If banana yields were to improve on all or most of the farms the price would fall drastically because the main market is within the region. Farmers in peripheral areas would soon find out that there is a limited market for their crop so would soon put more effort into coffee production and/or the production of preferred staples, i.e. cereals and legumes.

In a wider context the continued cultivation of the banana crop is also necessary to diversify staple foods in the country. Encouraging one major staple, as is being done with maize, has the potential disadvantage of causing a country-wide shortage in the event of a disease or pest outbreak. It should be a policy of the Government to encourage and support the cultivation of important traditional foods in the regions. It is indeed surprising that up to the present no development programme has ever been designed and implemented to promote banana cultivation in any of the regions where it is important, namely Kagera, Kilimanjaro, Mbeya, Tanga, Songea and Kigoma. Despite the increasing spread of the crop to other regions (i.e. Coast, Morogoro, Arusha and Tanga) and the demand for bananas in towns, the banana industry is still without an independent development budget.
References


Map 1: Kagera Region: Location and Administrative Division
THE THREAT OF BLACK SIGATOKA (MYCOSPHAERELLA FIJIENSIS) TO BANANA/PLANTAIN PRODUCTION

G.F. Wilson¹

As the institute mandated to stimulate food crop production in the humid tropics, IITA regards itself as being responsible for bringing to the attention of all nations within the region any serious threat to a major staple crop. In this instance the institute wishes to call attention to the serious threat to bananas and plantains (Musa spp.).

The threat is from black sigatoka (Stover, 1981) or black leaf streak (Meredith, 1970) caused by the fungus Mycosphaerella fijiensis. The disease was first reported in Fiji by Rhodes (1964). By 1969 the disease was reported in Tahiti, Samoa, Tonga, New Britain, Papua New Guinea, Philippines, Taiwan, Singapore and Malaysia (Meredith, 1970). The disease was first observed in Honduras, Central America in 1974 and has since spread to many Central American and South American countries (Stover, 1981). The disease is now known to be present in the Caribbean and West Africa (Gabon), but not yet widespread. Stover (1981) emphasizes that before the advent of black sigatoka, there was no major leaf disease of plantains in Honduras. However, since 1974 the disease has effectively destroyed the plantain export trade reducing it from 500,000 boxes of 23 kg each per year prior to 1974 to nil in 1979 when exportation ceased (Bustamante, 1981).

The disease is virulent in nearly all dessert bananas and most food bananas but a high degree of resistance has been observed in the cultivars Saba (ABB) and Pelipita (ABB), in some wild diploids, some synthetic diploids and possibly in synthetic tetraploids (Rowe, 1981, Stover, 1981).

Chemical control by spraying is possible but more chemical is required than for the more common yellow sigatoka (Mycosphaerella musicola) and consequently is more expensive. Thus, the problem is more serious for peasants where spraying is not usually a feasible proposition.

¹International Institute of Tropical Agriculture, Ibadan, Nigeria
The major solution appears to be the development of resistant clones. Breeding in *Musa* is very complex, but in both Jamaica and Honduras, where major breeding projects are located, there have been reports of resistance in collected germplasm and improved synthetic diploids. Both projects are optimistic on the development of resistant cultivars through tetraploid breeding and by chemical ploidy manipulation.

At the second conference of the International Association for Research on Plantains and Other Cooking Bananas (IARPCB) held at IITA, Ibadan, Nigeria in 1981, it was unanimously agreed that until new resistant cultivars become available, the resistant but usually less acceptable cultivars (Saba and Pelipita) should be distributed as a standby in threatened areas. The conference also urged the revitalization of the banana breeding project in Jamaica, with a redirection of its effort to include improved plantains and cooking bananas as one of its objectives.

IITA is willing to devote itself to preventing the devastation of these major staples and is co-operating with other agencies in the development of an international network to develop and disseminate resistant materials. It is also prepared to train Africans in the meristem culture technique necessary for the production of disease-free propagation materials used in international exchanges.

Having alerted you to the problem, IITA hopes that you will take all possible measures to prevent the introduction of the disease into this region. We also hope that you will initiate research that will improve production efficiency and enhance the contribution of bananas and plantains to the economy of these countries.
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FAO, 1981. Production Yearbook 33. FAO, Rome


PLANTAIN RESEARCH IN WEST AFRICA: AN EXAMPLE OF REGIONAL COLLABORATION

G.F. Wilson

IMPORTANCE

In west Africa, as in most developing tropical regions that were once ruled by colonial powers from temperate regions, agricultural research has traditionally focused on export crops. Those crops that were basic staple foods were given low priority or neglected. Since the advent of independence, a decline in the importance of many of the export crops and the desire of most developing countries to become self-sufficient in food production have led to the staple foods receiving a larger proportion of resources allocated to agricultural research. But the distribution has been biased towards the grain crops and most other staples have remained neglected. Plantains (Musa spp.cv AAB) are possibly the most outstanding example of neglect where the proportion of research resources allocated to them falls far below their proportional importance in the diet.

Plantains and bananas are natural crops of the humid tropics, especially in areas where rainfall is evenly distributed throughout the year. Figure 1 shows the countries in west Africa where Musa spp. are among the major staples. However, in many of these countries that stretch over different climatic zones covering the humid forest, the humid Guinea savannah, the "Sudan savannah and the semi-arid Sahel, plantains are produced and consumed most in the humid forest and the Guinea savannah.

The relative consumption of major starchy staples in the region (Table 1) shows that plantain ranks second to cassava in overall importance. Plantain is first in importance in two countries, second in eight and third in four. Thus it ranks in the top three in all the 14 countries.

1 International Institute of Tropical Agriculture, Ibadan, Nigeria
Fig 1  Map of Africa showing countries where plantain and banana are major staple foods
Table 1. Consumption of major starchy staples in west and central Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>Plantains/ Bananas</th>
<th>Cassava</th>
<th>Yam</th>
<th>Rice</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>30.8</td>
<td>192.3</td>
<td>-</td>
<td>5.0</td>
<td>44.8</td>
</tr>
<tr>
<td>Benin</td>
<td>3.6</td>
<td>132.2</td>
<td>-</td>
<td>-</td>
<td>53.3</td>
</tr>
<tr>
<td>Cameroon</td>
<td>76.5</td>
<td>104.0</td>
<td>39.8</td>
<td>28.0</td>
<td>48.6</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>21.2</td>
<td>15.2</td>
<td>-</td>
<td>9.2</td>
<td>106.1</td>
</tr>
<tr>
<td>C. Afr. Republic</td>
<td>51.6</td>
<td>128.1</td>
<td>67.5</td>
<td>3.7</td>
<td>8.5</td>
</tr>
<tr>
<td>Gabon</td>
<td>124.9</td>
<td>89.7</td>
<td>47.0</td>
<td>11.7</td>
<td>10.7</td>
</tr>
<tr>
<td>Ghana</td>
<td>93.6</td>
<td>91.8</td>
<td>38.6</td>
<td>5.3</td>
<td>27.4</td>
</tr>
<tr>
<td>Guinea</td>
<td>47.5</td>
<td>73.2</td>
<td>11.7</td>
<td>57.4</td>
<td>41.9</td>
</tr>
<tr>
<td>G. Bissau</td>
<td>37.5</td>
<td>-</td>
<td>-</td>
<td>99.5</td>
<td>17.3</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>92.6</td>
<td>81.3</td>
<td>163.2</td>
<td>23.4</td>
<td>24.7</td>
</tr>
<tr>
<td>Liberia</td>
<td>54.2</td>
<td>8.6</td>
<td>8.4</td>
<td>101.1</td>
<td>-</td>
</tr>
<tr>
<td>Nigeria</td>
<td>19.6</td>
<td>7.8</td>
<td>125.4</td>
<td>3.7</td>
<td>14.0</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>5.2</td>
<td>25.2</td>
<td>-</td>
<td>108.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Zaire</td>
<td>43.7</td>
<td>169.3</td>
<td>6.0</td>
<td>5.3</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Source: FAO, 1977
Table 2. Regional production and consumption of plantains in comparison to other starchy staples in Ivory Coast

<table>
<thead>
<tr>
<th>Region</th>
<th>Plantain production (tons)</th>
<th>Per capita consumption (kg/annum)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plantains</td>
<td>Root Crops</td>
</tr>
<tr>
<td>North</td>
<td>3,000</td>
<td>-</td>
<td>215.0</td>
</tr>
<tr>
<td>Centre</td>
<td>166,000</td>
<td>65.0</td>
<td>557.0</td>
</tr>
<tr>
<td>East</td>
<td>143,000</td>
<td>160.0</td>
<td>434.9</td>
</tr>
<tr>
<td>West Central</td>
<td>185,000</td>
<td>128.0</td>
<td>128.6</td>
</tr>
<tr>
<td>West</td>
<td>77,000</td>
<td>90.0</td>
<td>118.2</td>
</tr>
<tr>
<td>South</td>
<td>326,000</td>
<td>220.0</td>
<td>269.6</td>
</tr>
</tbody>
</table>

Source: Guillemot, 1976

Table 3. Regional production of plantains and other major starchy staples in Cameroon (tons)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Plantain</th>
<th>Cocoym</th>
<th>Cassava</th>
<th>Maize</th>
<th>Sorghum/Millets</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Central</td>
<td>275,000</td>
<td>185,000</td>
<td>235,000</td>
<td>40,000</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>120,000</td>
<td>5,000</td>
<td>100,000</td>
<td>25,000</td>
<td>-</td>
</tr>
<tr>
<td>Littoral</td>
<td>110,000</td>
<td>240,000</td>
<td>80,000</td>
<td>15,000</td>
<td>-</td>
</tr>
<tr>
<td>West</td>
<td>90,000</td>
<td>180,000</td>
<td>55,000</td>
<td>145,000</td>
<td>-</td>
</tr>
<tr>
<td>North</td>
<td>20,000</td>
<td>-</td>
<td>130,000</td>
<td>25,000</td>
<td>375,000</td>
</tr>
<tr>
<td>Total</td>
<td>615,000</td>
<td>610,000</td>
<td>600,000</td>
<td>250,000</td>
<td>375,000</td>
</tr>
</tbody>
</table>

Source: Melin and Djomo, 1972
It is important to remember that these overall country figures do not represent the eating habits of the entire population. Two examples from Ivory Coast (Table 2) and Cameroon (Table 3) show the production patterns as influenced by climate. In both cases plantains are of little importance in the drier north. The figures for Ivory Coast show that consumption and production are positively correlated and that consumption is low outside the production areas. There are, however, indications that as road networks improve plantain distribution and consumption spread.

**ORIGIN AND HISTORY**

Plantains, like most crop species, reach their highest level of production and usefulness outside the area of origin. All edible *Musa* spp. originated from two wild diploids, *M. acuminata* Colla and *M. balbisiana* Colla (Cheeseman, 1948). These two species are natives of south-east Asia where natural hybridization occurred with *M. acuminata* supplying the restituted female diploid gamete (AA) which was fertilized by a haploid male gamete (B) from *M. balbisiana* to form the triploids (AAB) that are the important plantain cultivars of Africa. Both *M. acuminata* and *M. balbisiana* are native to Asia and it has been theorized that the interspecific hybridization that gave rise to plantains occurred in south India (Simmonds, 1959).

There is no dispute that plantains came from Asia, possibly India, to east Africa from where they spread to central and west Africa, but there is much disagreement on how and when this occurred. De Langhe (1964) does not accept the theory of introduction by Arab traders, as such introduction would be too recent to justify the widespread production and utilization and above all the large variation now present in the African continent. The variation in Africa is greater than that in India or other parts of Asia. The variation are indicative of evolutionary change which would most likely have required a longer time than introduction by the Arabs would have allowed.

De Langhe (1964) believes that plantains came to Africa some time before the Bantu migration (800 - 700 B.C.). These questions may not be answered until archaeological studies of the role of the crop in various cultures are carried out.
RESEARCH

Plantains have been neglected by research for the reasons given above but also because of their close relationship to the banana, which has received much attention, and the common but erroneous belief that plantains and bananas are similar in physiological patterns.

Possibly the earliest research on plantains in Africa began in the 1950s at the INEAC station at Yangambi, Zaire. This effort was short-lived, however, because of political unrest in that country. The next major group to show interest in the crop was the French fruit research group KFAC or IRFA which initiated research on plantains as part of its research on bananas in Ivory Coast and Cameroon and later in Gabon. The work at the Kade Research Station of the University of Ghana appeared to have started some time in the 1950s. Work at IITA began in 1973 after certain members of the Board of Trustees insisted that the crop was too important to humid Africa to be left out. Thanks to a grant from the Belgian Agency for Development Cooperation (ABCD), a special project was initiated at IITA in 1975. Soon after IITA's project began, the nearby University of Ibadan attempted to start a project but the staff member to whom the project was assigned left and went to the University of Nigeria where he continued the project. In 1976 the newly formed Nigerian Institute for Horticultural Research (NIHORT) decided that plantains would be one of its major study crops.

All along, these organizations carried out research with limited staff and funding. There was little contact between groups and little transfer of material and information. The first attempt to bring plantain researchers together was the symposium on plantains and cooking bananas sponsored by ABCD and IITA and held at IITA, Ibadan, Nigeria in January 1976. At this meeting interested researchers came from Africa, Asia, Central and South America and the Caribbean. The group realized the need for a forum to share views and results and at that meeting formed the International Association for Research on Plantains and other Cooking Bananas. This association has remained very active. Its second meeting was held in 1981 and a third is planned for 1984.
Until 1981 plantain research in west Africa was based mainly on individual effort. Except for projects in Ivory Coast and Cameroon no institution has a major research programme on plantains. NIHORT in Nigeria had ambitious plans, but a shortage of funds prevented the full development of the project. IITA's project was progressing but because plantains were not among the crops stipulated in the mandate, activities on plantains maintained a low profile. However, following the arrival of the new Director General, Dr. E.H. Hartmans, more emphasis was placed on plantains as an important crop of the humid tropics, the environment in which IITA was mandated to develop methods for increasing agricultural production.

Soon after this decision was taken, a proposal for an enlarged plantain research project was prepared and presented to the International Fund for Agricultural Development (IFAD) which approved and funded the project. In that project there was a section for the formation of a working group on plantain research in west Africa (IITA, 1980).

WARCORP

The West African Regional Cooperative for Research on Plantain (WARCORP) was formed within IITA's (IFAD funded) projects for research on plantains in Africa. The first meeting was held at IITA, Ibadan, Nigeria. The participants were scientists working on plantain research. They represented Ivory Coast, Nigeria, Cameroon, IRFA and IITA. Many of the persons or institutions invited were unable to come or send representatives to that first meeting but they indicated their willingness to participate. Thus the group was formed with experiments assigned to IRFA and the University of Abidjan in Ivory Coast, IRFA/IRA in Cameroon, the Université Nationale du Zaire in Zaire, NIHORT, and the University of Nigeria and IITA from where the group has been co-ordinated. Since 1982 the group has expanded to include SONADECI in Gabon, the University of Science and Technology in Ghana and another project at the University of Nigeria. The present organization is shown in Figure 2. Some other organizations are being considered as participants and are likely to be accepted when adequate funds become available.
Other donor organizations have shown an interest in WARCORP and funds for special activities have been received from IDRC and the Ford Foundation.

**WARCORP objectives**

The overall objective is increased production and utilization of plantains in the region. This objective will be achieved through:

1. Creating awareness of the importance of plantains in the region;

2. Identifying the constraints to increased production and improved production efficiency;

3. Setting out research priorities and strategies;

4. Encouraging national and international support and funding for research and development;

5. Strengthening national research capability;

6. Co-ordinating research activities to avoid repetition and duplication, thus assuring efficient resource utilization;

7. Disseminating information, especially research results and recommendations throughout the region;

8. Training of research and extension workers;

9. Providing facilities for the rapid transfer of research findings to farmers;

10. Advising governments and other interested bodies on plantain production and utilization.
Composition

The co-operative is formed of a group of research institutions located in west and central Africa, and in which there is active research on plantains. The countries covered are Cameroon, Ivory Coast, Gabon, Ghana, Nigeria and Zaire. IITA is the major international participant. Interested donor agencies are welcome to participate. The temporary restriction on the number of participating organizations and countries was deemed necessary so that the limited available resources could be used to establish a good foundation. As more funds are made available other institutions and countries in need of plantain research capabilities will be invited to join the co-operative.

Participating institutions include government research stations, parastatal bodies, universities, international research bodies and donor agencies.

All participating scientists must be attached to one of the institutions listed above. Grants donated through the co-operative may be directed to the work of a particular scientist, but must be administered and accounted for through the financial organization of the associated institution.

All equipment purchased from funds contributed through the co-operative belong to the associated institution and must be left with that institution when the scientist concerned leaves.

Funding

Participants are expected to have some support from their local government or sponsoring body. Where possible, the co-operative seeks funds which will be distributed to the participants on the basis of merit, need or the wishes of the donating government or organization. Members are required to submit financial statements accounting for all funds granted through the
co-operative. They should also declare all funds received from local government, sponsoring bodies or from donor agencies outside the co-operative. Funds are released to participants half yearly. The release of funds depends on the submission of financial statements accounting for all funds received previously. Detailed financial reports must be submitted in June and December.

Financial support may be withheld or withdrawn if a participant fails to submit financial or technical progress reports, or submits reports deemed unsatisfactory by the co-operative. Unsatisfactory field inspection reports may also lead to withholding of funds. In some instances funds denoted through the co-operative may be linked to matching amounts made available locally.

The co-operative may, under special circumstances, initiate and fund projects in institutions where there is no plantain research but where such research could eventually lead to some improvement in the local community.

Monitoring and Evaluation

Work is monitored periodically to ensure that funds are used for designated projects, guidelines are followed and standards maintained. On-the-spot inspection may be done by experts selected from within the co-operative, from other scientific bodies or special representatives from donor agencies.

At the annual meeting (December) participants present up-to-date technical reports. An oral presentation may be requested. Plans for proposed experiments are also presented and discussed at this meeting.
Publications

Scientists have the right to publish their results in journals of their choice, but copies of all papers submitted for publication should be sent to the co-ordinator.

Paradisiaca, the newsletter of the International Association for Research on Plantains and other Cooking Bananas, serves as the main information outlet for the co-operative. Reports submitted to it may be published fully or in part.

Co-ordination and Administration

IITA as the major international organization interested in plantain research and one of the sponsors of the co-operative, provides the co-ordinator and support facilities. This institute has the ideal infrastructure for co-ordinating this type of regional (international) organization.

The approval of the Director-General is required for all experiments that receive funds from the co-operative.

Funds donated to the co-operative are handled through IITA. IITA's Head of Budget and Finance is the treasurer of the co-operative.

The co-ordinator liaises between the members of the co-operative. He arranges all meetings, records and distributes the minutes of meetings and handles all correspondence. The co-ordinator arranges the dissemination of reports and technical papers resulting from the work of the co-operative.

IITA as an international body, guides the activities of the co-operative so as to achieve maximum impact in the region. From time to time it seeks and brings new institutions and countries into the co-operative.
PLANTAIN/BANANA RESEARCH IN AFRICA

In 1981 a consultant hired by IDRC to evaluate plantain research in Africa found the WARCORP concept ideal for west African conditions, but regarded the existing part-time co-ordinator position as inadequate for the needs of the region (Edmunds, 1981). This recommendation has been accepted and a proposal for a full-time co-ordinator for plantain/banana research in Africa is under consideration. It is proposed that two regional groups be established. The west African group, now known as WARCORP, would continue with its present structure and emphasis on plantains. A new group to be formed in east Africa would emphasize cooking bananas. Activities in central Africa would be linked to east or west Africa according to whether emphasis was on cooking bananas or plantain (Figure 3). The groups would operate independently and would meet annually on a regional basis. Both groups would come together every three years, possibly at a symposium within the tri-annual conference of the International Association for Research on Plantains and other Cooking Bananas (IARPCB).

CONCLUSION

Results from WARCORP activities clearly show that for developing countries with limited resources, research co-ordinated on a regional basis, especially with the assistance of a neutral international organization, can be effective and efficient. There are plans to extend the WARCORP method not only throughout the plantain/banana growing regions of Africa but to Asia, the Caribbean, Latin America and the Pacific islands. The concept appears feasible not only for research on plantains/bananas but also on other crops and production systems.
Fig. 2. Organization and activities of West African Regional Cooperative for Research on Plantain. (WARCORP)
Fig. 3: A proposed organization for coordinating plantain/banana research in Africa
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THE ROLE OF THE INSTITUTE FOR AGRONOMIC AND LIVESTOCK RESEARCH (IRAZ)

Ngendahayo Damien

GENERAL

The meeting of Heads of State of the Economic Community of Countries of the Great Lakes States (CEPGL) (Burundi, Rwanda and Zaire), at Lubumbashi on 9 December 1979, analysed the food situation in the sub-region. A pooling of efforts in the area of agriculture and livestock development was considered necessary, including heavy reliance on research. The meeting decided to set up an agricultural research institute (L’Institut de Recherche Agronomique et Zootechnique, IRAZ) as a specialized agency of the CEPGL.

According to Article 2 of its establishing agreement, the objective of IRAZ is to carry out studies and undertake community projects in matters of agriculture and livestock development. Within the framework of this agreement the meeting of heads of states held in Bujumbura on 6 and 7 December 1980, decided that IRAZ should make research its priority, although not at the expense of other projects.

IRAZ provides an answer to two problems expressed by the Heads of State, by:

(a) setting up community mechanisms for appropriate decision-making to increase yields and to improve the quality of basic food products

(b) rationalizing agriculture and livestock research within the CEPGL area.

The last question is particularly important as national institutes in the region, working with practically the same objectives, were doing so in isolation and with inevitable overlap. It is for this reason that IRAZ has been charged particularly with directing investments for certain research programmes, to harmonise experimental procedures and the implementation of research results and to promote the exchange of research results.

1 Director of Research, Institut de Recherche Agronomique et Zootechnique (IRAZ), Gitega, Burundi.
information and materials among national institutes. IRAZ also was given the mandate to initiate certain research programs of its own, to develop central support services and to ramp up or establish certain technical and research services in the member countries.

In order to accomplish its mission, the Institute is called upon to exercise the following functions:

- to keep a community inventory of agricultural and animal husbandry resources, to analyse related problems and to set up a data bank of all information required for the realization of its objectives;

- to undertake feasibility and implementation studies of community projects in agricultural and animal husbandry;

- to supply to member countries results of studies and surveys from the different activities assigned to the institute;

- to collaborate with member states in strengthening their research programmes and in utilizing their agricultural and livestock resources in such a way as to make their economies more complementary;

- to establish and strengthen relations with national and international agencies in the area of agriculture and livestock development and to increase the exchange of information and of plant and animal material for research;

- to organize meetings of experts and to seek assistance from international, regional and bilateral organizations.

ORGANIZATIONAL STRUCTURE

The institute is administered and managed by a General Assembly and a Management Committee. The General Assembly is made up of those Ministers and State Commissioners of the member states who hold agriculture and livestock in their portfolios. The Management Committee is the executive arm of IRAZ, and is composed of the Director General, the Director of Research and the Director of General Technical Services.
In 1981, a report was produced by national and expatriate consultants defining the area of intervention by IRAZ in the member states of the CEPGL.

At the 4th General Assembly in Kinshasha in January 1983, the Institute presented a draft Five Year Plan. In the course of 1983, IRAZ focussed its attention on the following topics which already form part of the research by national institutes: maize, sorghum, rice, wheat, triticale, cassava, sweet potatoes, potatoes, beans, soybean, fast-growing oilcrops, ticks and the diseases that they transmit, transmissible viruses and bacteria, fodder crops and small ruminants.

General support services

A survey of the general technical services of national research institutes has just been completed. This covered the following services: registration of institutions and their programmes and researchers within the region (in collaboration with CARIS); an agricultural documentation centre; phytosanitary inspection; collection and conservation of plant genetic resources; animal quarantine; a bromatology laboratory; and other agricultural and veterinary laboratories in the Community.

Recommendations for research and the current state of general technical services of the national research institutes have been forwarded to national institutes and laboratories for consideration. IRAZ is waiting for comments on these documents.

Documentation Centre

A regional documentation centre is being set up at our Institute. A microfilming project for documentation of existing material in the CEPGL countries has been proposed.

Plant genetic resources project

A collaborative proposal with the International Board for Plant Genetic Resources (IBPGR) to collect and conserve plant genetic resources has been prepared and will be submitted to the next General Assembly for approval. An IRAZ scientist is away on training so that he can set up this project.
Seed project

In collaboration with ECA/MULPOC, IRAZ has carried out studies on the propagation, production and distribution of rice, soybean and bean seed. A document detailing results of these studies will be reviewed at our next General Assembly.

Exchange of plant and animal material

A document on the standardization of phytosanitary and animal health policy of the region will be presented to our three governments in the near future.

Research

The most recent General Assembly of January 1983 requested IRAZ to initiate research programmes on banana, farming systems and trypanosomiasis. To this end the Institute, in collaboration with FAO, has completed research project plans on these topics. Following a mission of the International Livestock Centre for Africa (ILCA), two projects on small ruminants have been drawn up. These projects will be submitted for approval to the next General Assembly in January 1984.

FUTURE ACTIVITIES IN RESEARCH

IRAZ's own projects will be set up once approved by the coming General Assembly. Research plans will be finalized taking into consideration ideas and suggestions from national institutes and research laboratories.

Information contained in the research survey will be analyzed to define IRAZ's own programs and improve those of national institutes.
SUMMARY OF DISCUSSIONS

COUNTRY PRESENTATIONS

Discussion of the presentations on the status of banana production and research in Burundi, Kenya, Rwanda, Tanzania, Uganda and Zaire confirmed that the medium to high altitude areas of each country share many of the same production problems and research opportunities. The very extensive lowland areas of Zaire are distinct, and have more in common with the humid lowlands of western Africa, where plantains predominate. While bananas are very important food crops for small farmers throughout the high-altitude areas and often contribute to their income, only the Kenya report regarded the cash crop element as the most important for future development. Somalia, not represented at this meeting, has developed commercial production of bananas for export. National research institutions of the region are fairly similar also in the small proportion of resources that has been directed towards improving this crop.

Perhaps unsurprisingly, differences in banana production systems were noted between countries, and these differences were not related in all cases to ecological variation. For example, intercropping bananas with coffee is widespread in Tanzania but not in Burundi and Rwanda, due probably to differences in agricultural legislation and extension policies. Discussion of the intercropping situation and its significance in Tanzania served also to demonstrate the value of on-farm, agro-economic studies in understanding the evolution of existing systems. Although coffee-banana intercropping normally reduces the yield of one or both crops, the two crops are complementary in satisfying overall household requirements for food and cash income, so the present cropping system may be a profitable and logical compromise.

Population density in the high-altitude areas of these countries, estimated to be in the range of 300 to 500 persons per square kilometre, is the highest in rural Africa. Consequently, intensity of cropping has increased generally, with a tendency for bananas to be displaced by increased plantings of maize, beans and other annual crops. Intercropping of annual crops in banana groves may be one symptom. Although changes in
production practices of this kind may have absorbed some of the increased supply of labour as population pressure increased on the severely limited area of cultivable land in the highlands, the productivity of that labour is declining. Migration, particularly to urban areas, already has become relatively more attractive and seasonal shortages of labour for agricultural production are common despite the superficial appearance of a labour surplus. Participants feared that this trend would accelerate in the future with further involution of the farming system: increased hand-hoeing of annual crops within banana groves was leading to a decline in soil fertility and increasing erosion on steep hillsides.

This prediction stands in marked contrast to the view, still commonly expressed within these and other countries, that bananas in this region do not warrant much research effort because their production systems have evolved over a very long period of time and are relatively stable. Banana researchers from the region are convinced that the decline in productivity can be halted and reversed only by increasing the allocation of resources for the development of the crop. Effective research should lead not only to improve subsistence in highly populated rural areas and increased food production for urban populations, but also to a slowdown in the rate of population drift to the cities and towns.

Research strategies for implementing these ideas were discussed and are summarized in the following sections.

GENETIC IMPROVEMENT

It emerged that there were two main elements in an appropriate strategy for genetic improvement of bananas:

1) local collections assembled, assessed and reduced by synonymy, with the object of really understanding the local varieties already available; and
2) international banana breeding which, for reasons of expense and expertise, would have to be concentrated in one place, the products being thereafter widely diffused for local exploitation.
There was generally support for the idea that local understanding of varieties already in use was a basic first step which should be made as soon as possible. The importance of regional 'network' type development for the dissemination of ideas, information and materials was emphasized and agreed.

Local 'working' collections were an essential first step but it was clear that they could be relatively expensive and should be transitional to a well-maintained, well-researched and highly accessible regional 'working' collection (or collections adapted ecologically). Element (1) above should be directed towards the assembly of working regional collections as quickly as quarantine restrictions would permit.

It was generally accepted that banana breeding was a complex matter but that the essential scientific bases were fairly well understood. The products would mostly be either triploid or tetraploid and would mostly contain at least some *balbisiana* (B) contribution to confer hardiness, disease resistance and cooking qualities.

The objectives of the international breeding program (Element (2) above) should take account of the great diversity of local needs and should therefore aim to produce a wide spectrum of field characters, consumption qualities and disease resistances in the products. It should be highly responsive to users' interests.

Meristem culture was repeatedly emphasized as a critically important technique for the safe transmission of banana materials.

**IMPROVEMENT OF PRODUCTION SYSTEMS**

The highland production areas for banana in this region are, on the whole, of relatively high agricultural potential. In many places bananas were grown traditionally as sole crops, with fertility being maintained by applications of manure or household refuse and by mulching. Increased pressure on land has led to intercropping of bananas with annual food crops, many of which are more recently introduced species. This form of intercropping can reduce banana yield per plant by destroying superficial roots during cultivation, by reducing the self-mulching characteristic of the banana plant and by affecting soil structure adversely.
However, it was generally agreed that too little is understood in banana-based farming systems for logical planning of agronomic studies on research stations or for prescriptions to be made with any confidence. The following elements would be needed in each national research programme in order to intervene to improve existing systems while respecting farmers' needs and values:

1) improve understanding of existing systems and their constraints through agronomic and economic studies at the farm level, in order to identify the most promising lines of research on innovations that farmers will want to adopt;

2) on-farm experiments should be started, initially to determine the local utility of existing recommendations and later to test promising innovations and to exploit new varieties, a strategy which will also increase opportunities for developing Element (1) above and for linking research and extension activities with farmers; and

3) increased attention on research stations to the understanding of technically optimum production systems, including component technology (e.g. fertility management) and interactions among components (e.g. among intercropped species).

The variation in banana production systems across the region may provide opportunity for transferring practices to new areas. Research is needed to determine whether the banana-coffee interplanting systems are more resilient than intercropping with annual food crops, and whether other food crops such as taro would be more suitable for intercropping. Another Tanzanian practice may permit more successful intercropping with annual food crops: on sandy soils in Kagera Region, farmers remove weeds in these crops by hand-pulling, and are said to be aware of the deleterious effects of heoing upon bananas.

It was agreed that a farming systems perspective is required, rather than singleminded efforts to raise, or even to maintain, the productivity of bananas over that of other enterprises. Careful analyses of alternative opportunities for economic inputs and for agricultural by-products would be important. For example, manure may be in demand for other crops in addition to bananas; banana leaf trash is currently used in some areas for mulching monocropped coffee; and the use of cut Pennisetum grass for mulching bananas would be dependent upon the availability of labour.
CROP PROTECTION

The dominant pests and diseases of bananas in this region are considered to be the weevil (Cosmopolites sordidus) and nematodes, especially Radopholus similis. However, it is not clear to what extent these pests, rather than changes in husbandry, are responsible for the decline in banana productivity; only in Zaire were pests not considered to be of economic importance. Some minor diseases, particularly cigar end-rot and bunchy-top virus, may be important in some localities. The field visit by workshop participants to Cibitoke, Burundi, recorded symptoms of bunchy-top disease further eastwards than any previous record in Africa.

Undoubtedly, the greatest immediate threat to production is posed by black sigatoka disease, Mycosphaerella fijiensis. This leaf disease has spread through west Africa from Gabon to Cameroon and Congo, and its reported appearance in northern Zambia is an indication of how soon this wind-borne disease may reach the main producing countries of eastern and central Africa. Gabon is assisting its WARCORP partners by screening germplasm for resistance, and while some cooking banana varieties show promise in this respect, changes in food preparation and taste preferences may be necessary for adoption of these varieties in central and eastern Africa. Moreover, the ecological adaptation of these genotypes to high-altitude areas is unknown.

Preventive measures for controlling the spread of banana diseases were discussed. The importance of recent work by Prof. De Langhe's laboratory at Leuven, Belgium in developing meristem culture procedures for introducing disease-free germplasm into Africa, and of IITA in training staff in these techniques, was recognized. Plant quarantine staff in Kenya have been trained in anticipation of their serving as a possible regional introduction point. The likelihood of a strong central African research program on bananas being mounted by IRAZ may make this program a natural primary focus for germplasm introduction to the central and eastern Africa region, although there is at present no organized quarantine facility in the CEPGL area.
The importance of measures to prevent transmission of pests and disease within the region was emphasized. Local restrictions on movement of planting material appear to have prevented the spread of banana weevil from western to eastern provinces of Kenya. The local spread of weevil and nematode can probably be most effectively limited by campaigns to educate farmers on the nature of the problem and on the need to take simple phytosanitary precautions, particularly the trimming of soil and debris from planting material.

The weevil and nematodes appear not to become serious pests where bananas are well grown and are fertilized with household refuse. The initial strategy for introducing pest management and reducing the present reliance upon the use of pesticides would contain two main elements:
1) establish the relationship between infestation levels and yield losses under a representative range of specific environmental and crop management conditions; and
2) determine whether improvements in the making and in the use of compost to assist plant nutrition would constitute a feasible method of minimizing crop losses to these pests.

Other cultural control methods may include the fencing of chickens around banana plots, a practice claimed by some farmers in the Kagera Region of Tanzania to control weevils. Cases of cultural control methods need to be sought, documented and evaluated for wider economic applicability.

REGIONAL COLLABORATION

Not only have the various banana-based farming systems in the region remained relatively isolated from others, but also banana research programs have lacked effective means of communication across national boundaries.

Collaboration among the national programs of eastern and central Africa that work on cooking and brewing bananas is highly desirable for several reasons, including the following:
1) to distinguish among the numerous local banana varieties, for which their traditional names often serve as much to confuse as to assist;
2) to assist one another in understanding what factors most limit banana production systems;
3) to develop methodology appropriate for on-farm research with a vegetatively propagated, perennial, tree-like food crop with multiple uses;
4) to economize on scarce resources for research by developing a regional reference collection of germplasm and regional quarantine facilities for introduction of new genetic material; and
5) in achieving the above, to enhance the enthusiasm and skills of banana researchers and to increase awareness in the agricultural research and development community of their contribution to common objectives.

In addition to future regional meetings similar to this one, working visits or monitoring tours to one another's programs would rapidly improve communication among banana researchers. A working group should comprise only those technically involved with bananas at the field level. The particular form of network exemplified by WARCORP in west Africa is attractive to researchers in this region also because modest external financial support for activities in countries having a nucleus research staff could be provided. However, it was recognized that major growth of national programs would require increased allocations from national governments, which could also lead to requests for bilateral external assistance.

A strong desire was expressed that the proceedings of these discussions be presented to the new International Network for the Improvement of Banana and Plantain (INIBAP).
RESOLUTIONS

RESOLUTION 1

Having regard for the facts that the banana crop occupies a position of considerable importance in the nutrition and economy of a large number of people in central and eastern Africa, that this crop contributes to the conservation of fragile soils and that the country reports and workshop field visits indicated a general decline in banana productivity, the workshop participants recommended that:
the Governments of Uganda, Tanzania, Kenya and the CEPGL member countries devote more attention to their banana research and development programs.

RESOLUTION 2

Having regard for the facts that our knowledge of the banana varieties of central and eastern Africa is yet very imperfect but the need for improved knowledge and for new varieties to meet new problems is great, the meeting resolved that:
a) local banana collections be assembled and amalgamated into a good regional working collection as expeditiously as possible; and
b) every possible encouragement be given to the development of food-crop banana breeding on an international basis.

RESOLUTION 3

Having regard for the overwhelming need for better understanding of banana-based production systems, the meeting resolved that:
a) national programs be recommended strongly to develop on-farm research at carefully selected locations, whereby present systems and innovations can be evaluated and modified;
b) national policymakers be advised that this on-farm research will require additional funds for specific operations such as training and travel of personnel; and
c) on-farm research be complemented with a restricted number of long-term experiments on banana production systems, to be conducted at a regional or international location where specialized monitoring and control of environmental conditions would be provided.

RESOLUTION 4

Having regard for the facts that for banana improvement new plant material will be required from within the region and outside, and that pests and diseases constitute an increasing menace to banana production, the meeting resolved that:

a) quarantine facilities be provided to IRAZ on behalf of central and eastern Africa so that plant material can be exchanged while pests and diseases are excluded;
b) phytosanitary regulations be enforced and be supported by educational campaigns; and
c) national research and extension services give attention to the incorporation of cultural and biological methods, in addition to chemical methods, to ensure the control of pests and diseases.

RESOLUTION 5

Having regard for the facts that the requirements for adequate financial support for the improvement of banana production in our respective countries are large and beyond the financial resources of each individual state, that more efficient use can be made of limited resources through regional cooperation, that IITA is prepared to obtain funds to improve the productivity of the crop and that WARCORP has enabled significant progress to be made towards solving production problems in west Africa, the meeting resolved that:

the establishment of a regional network for eastern and central Africa be promoted, as a matter of urgency, along the lines of the west African model.